

- [54] **GATING NETWORK FOR IMAGE
INTENSIFIER**
- [75] Inventors: **John T. Hall**, Woodbridge; **Donald
Nichols**, Alexandria; **Peter W.
Vanatta**, Woodbridge, all of Va.
- [73] Assignee: **The United States of America as
represented by the Secretary of the
Army**, Washington, D.C.
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250/213 VT; 178/DIG. 29**
- [51] Int. Cl.² **H05B 37/02**
- [58] Field of Search **315/149, 150, 157-159;
328/2**

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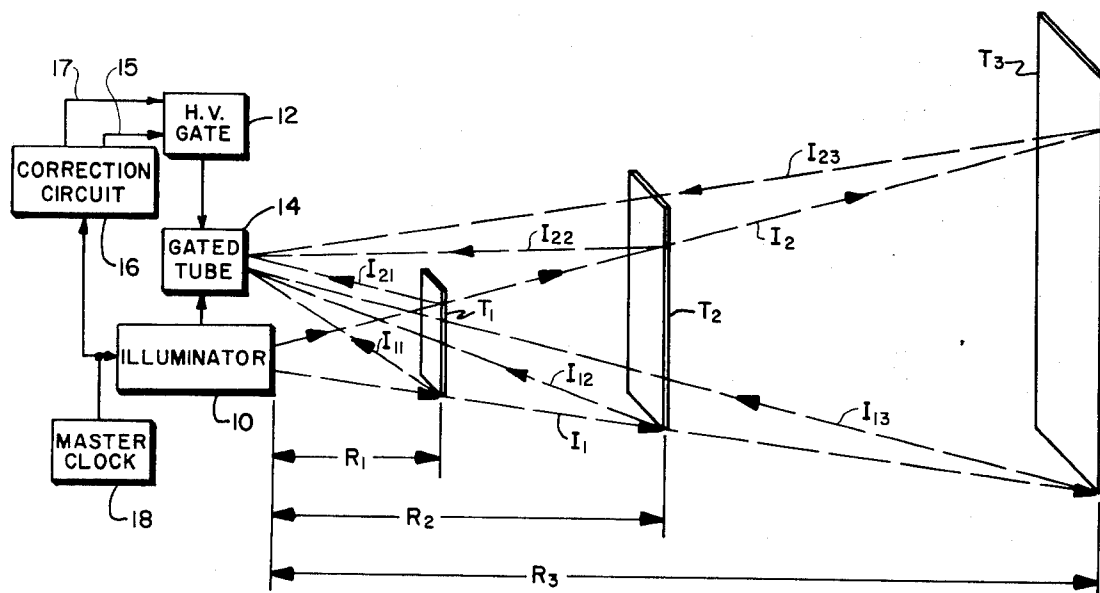
Attorney, Agent, or Firm—Max L. Harwell; Nathan Edelberg; Robert P. Gibson

[57] **ABSTRACT**

An electronic analog gating means for an image inten-

sifier in which transmitted pulsed illumination that is returned from targets down range are gated through the image intensifier in an analog manner according to the inverse square law in illumination drop off in distance. The image intensifier is enabled in distinct incremental time elements which correspond to and are inclusive within the time that it takes for illumination to travel to and from corresponding incremental depths of range. The distinct incremental time elements are produced by comparing a series of linear ramps, which are produced at the same frequency as the transmitted pulsed illumination, with an increasing parabolic square function curve that repeats every one-tenth of a second to produce at least ten viewings per second on the nearest target to eliminate flicker but producing an increasing number of viewings of increasing distant targets. The electronic analog gating means is duty cycled to permit illumination reflected from these targets to be amplified in proportion to the square of the distances to the targets, and thus provide an effective equal illumination of all targets down range. By changing certain portions of the parabolic curve, the effective illumination reflected from a selected range, represented by one of the incremental time elements, may be emphasized by gating the image intensifier on more often than normal at that specific incremental time element.

7 Claims, 3 Drawing Figures



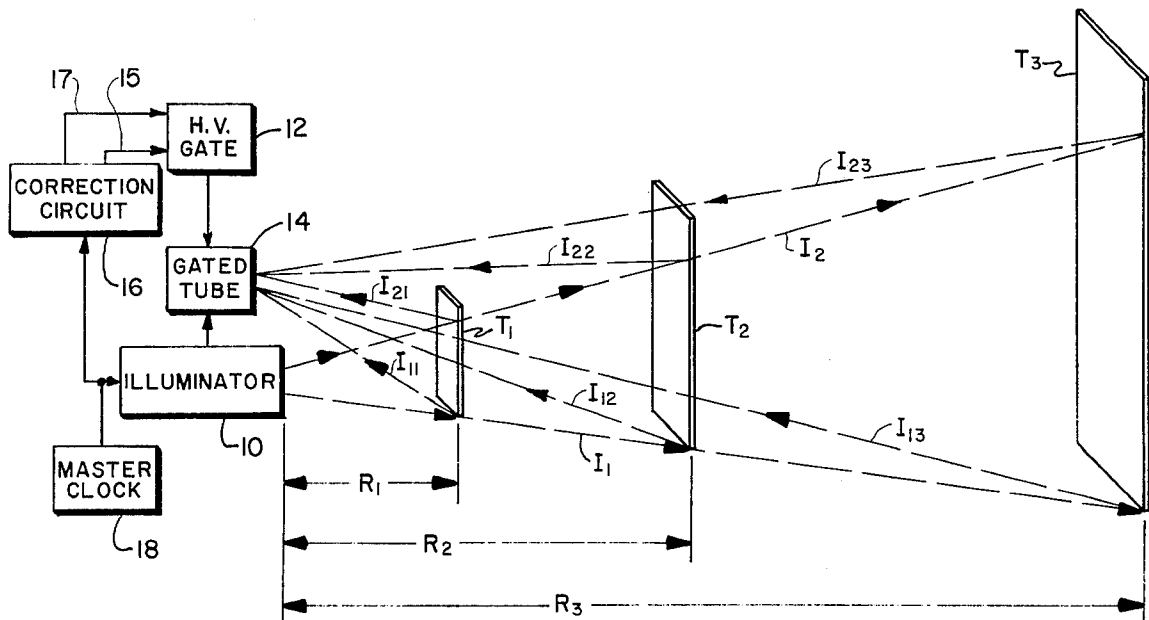


FIG. 1

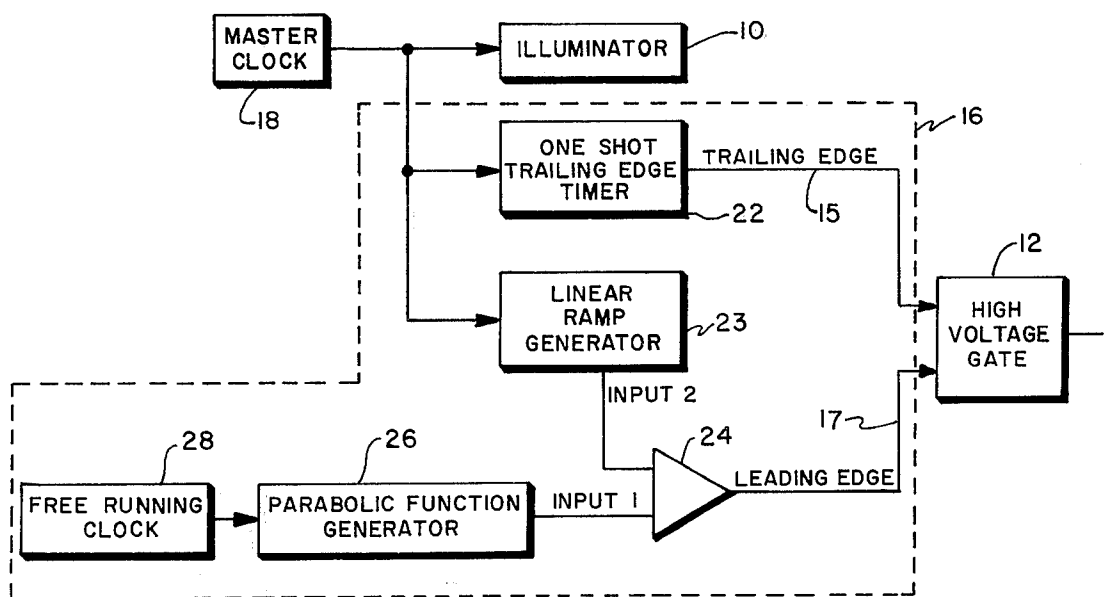


FIG. 2

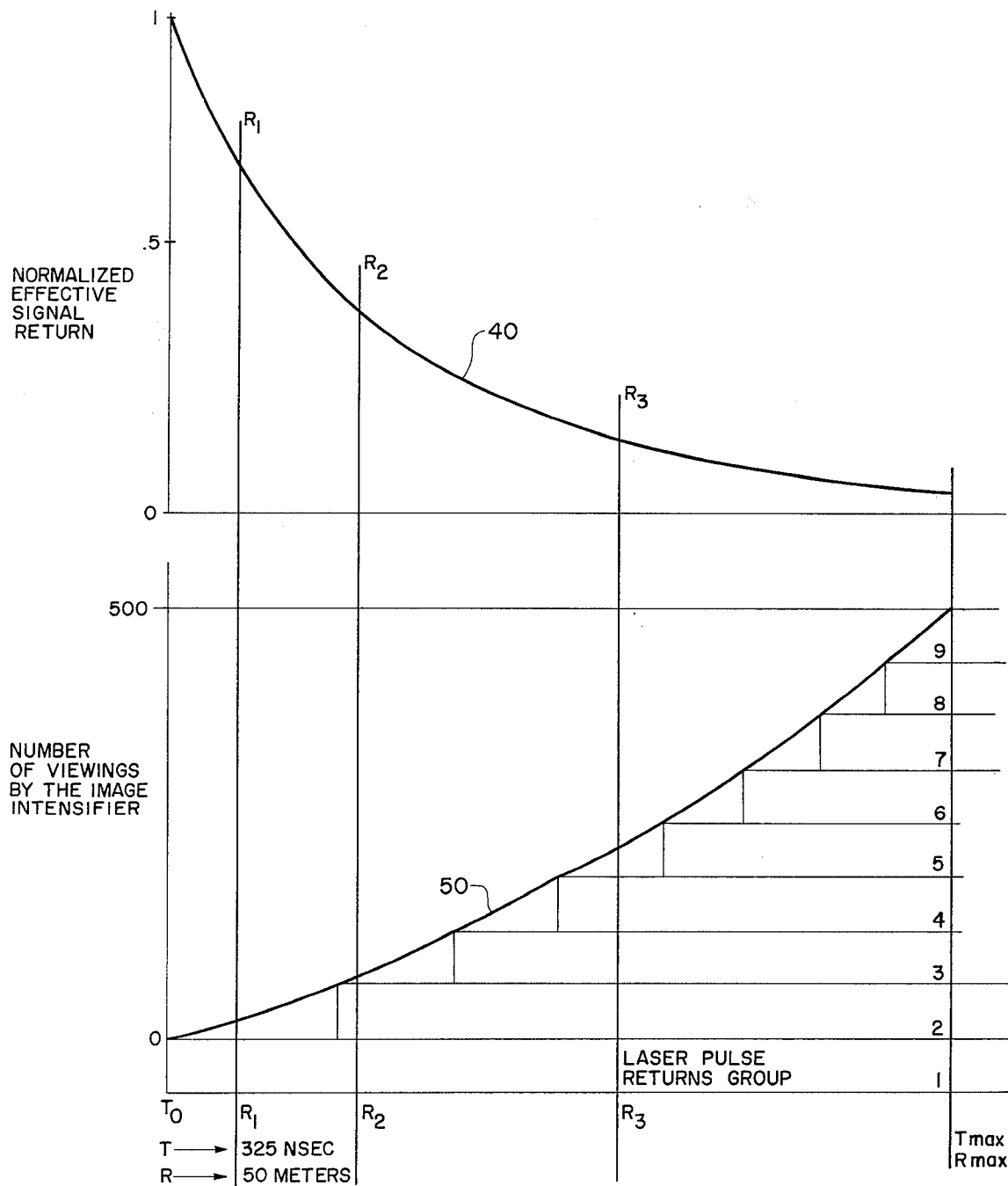


FIG. 3

GATING NETWORK FOR IMAGE INTENSIFIER

BACKGROUND OF THE INVENTION

This invention is in the field of electronically controlled gating means for an image intensifier in which a pulsing illuminator is synchronized with the gating means such that the inverse square drop off in reflected illumination from down range targets is compensated for by increasing the number of times that the image intensifier is gated on as the time of pulse illumination travel increases to and from downrange targets.

The effect of natural illumination from such distant sources as starlight, moonlight or sky glow causes all targets down range from an image intensifier to appear evenly illuminated. However, when supplemental illuminators are used, these illuminators are usually close to the observer viewing through the image intensifier so that total reflected illumination on targets down range decreases inversely with the square of range. The reflected illumination also decreases inversely with the square of range. Nearby targets appear rather bright and more distant targets appear much less intense. This effect is common to both continuous and pulsed illuminators.

In some of the ranging image intensifiers in existence today, returned illumination is viewed at all ranges by manual adjustment of a pulse delay to vary the on and off time of the image intensifier such that a pulse of illumination is accepted by the image intensifier for selected depths of field during one light pulse cycle. Also, supplementary illumination of a target with either visible or infrared sources has been used to increase return ambient illumination and thus increase the useful range of image intensifier viewers. The disadvantage of the manual method is obvious in that an operator needs as little distraction as possible while observing returned illumination from targets down range.

SUMMARY OF THE INVENTION

This invention relates to an electronic analog gating means for cyclically controlling the enable time of an image intensifier wherein the effective brightness of returned illumination from all targets down range appear to be at the same intensity. The image intensifier is enabled in distinct incremental time elements, or cyclically controlled periods, in which the total number of reflected pulses of illumination within each time element are integrated in an increasing analog manner in proportion to the square of increasing distances in range. The electronic analog gating means comprises an effective brightness correction, or compensation, circuit having a trailing edge producing circuit, such as a one shot-multivibrator, and a leading edge producing circuit. The trailing edge is produced at a fixed time from the time the pulse of illumination is produced and corresponds to the time for a light pulse to travel to maximum range and return. The trailing edge disables the image intensifier while the leading edge enables the image intensifier. Therefore, the total enable time of the image intensifier is controlled by summing the occurrences of the plurality of leading edges to their corresponding trailing edges. The leading edge producing circuit comprises a parabolic function generator producing an increasing parabolic square function curve that is applied to one input of a comparator circuit and a linear ramp generator producing a plurality of ramps at the same frequency as the pulsed illumination that

are applied to a second input of the comparator. The maximum amplitude of each of the plurality of ramps are equal to the maximum amplitude of the parabolic curve, such that the comparator, in comparing the plurality of ramp within one cycle of the parabolic curve, produces an output that is the plurality of leading edge pulses which are advancing in time toward their corresponding trailing edge pulse. The repetition frequency of the parabolic curve is chosen to be above that frequency which could cause flicker and is presented as ten cycles per second.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a block diagram schematic of the gating circuit showing three targets in range;

FIG. 2 shows a schematic block diagram further illustrating the gating circuit of the present invention; and

FIG. 3 illustrates the effective signal return compared in time and range with the increased number viewings of target returns.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The overall circuitry of the present analog gating system for an image intensifier is shown in FIGS. 1 and 2. Targets T1, T2, and T3 are indicated as being at progressively longer distances away from both the illuminator 10 and gated image intensifier tube 14, which are generally integral with each other. These distances are respectively represented as R1, R2, and R3. The outer edges of a pulsed light beam from illuminator 10 are shown as I1 and I2. Returned illumination from target T1 to tube 14 is represented as I11 and I21, from target T2 as I12 and I22, and from target T3 as I13 and I23. This section of FIG. 1 is discussed merely to emphasize the drop off in per unit area of illumination to the more distant targets in accordance with the inverse square law. That is, concentrated illumination on a per unit area of targets T1, T2, and T3 is decreased as the square of distance from the illuminator.

The present invention comprises an analog gating circuit for duty cycling the image intensifier "on" for progressively longer periods of time as the known time it takes for illumination to be returned from targets at progressively greater distances away from the image intensifier. Therefore, the image intensifier is enabled in real time according to the familiar inverse square law of illumination drop off for total distance of radiation travel to and from a target. An effective brightness correction, or compensation, circuit 16 is designed to operate for the useable range of the image intensifier, i.e. the time required for a pulse of radiation to travel to the farthest useable range and then back to the image intensifier. Compensation circuit 16 provides leading edge pulses that move forward in time over cyclical periods and regularly timed trailing edge pulses which will be discussed hereinbelow.

A master clock 18, that is assumed for explanation purposes to be operating at 5 kilo-Hertz but may be other frequencies, triggers illuminator 10 at the repetition rate of 5 kilo-Hertz. Simultaneously, the 5 kilo-Hertz signal from the master clock 18 feeds into compensation circuit 16, shown inside dashed lines of FIG. 2, and triggers one shot trailing edge timer 22 and linear ramp generator 23. Timer 22 may be a one shot multivibrator. The illuminator 10 may comprise either a visible or an invisible light source, but preferably em-

plays a laser such as gallium arsenide laser diode array so that the illuminator 10 may be kept small and of light weight. Either flash lamps or lasers may be used since both have the desired high peak power. One shot multivibrator 22 produces a repetition of precisely timed trailing edges at the 5 kilo-Hertz frequency and with a delay from the pulse of illumination equal to the time required for the illumination pulse to travel to the maximum range and return. A free running clock 28, chosen to be operated above the perceptible flicker rate or in this discussion 10 cycles per second, triggers parabolic function generator 26 which produces an increasing square function parabolic curve that is recycled every one-tenth of a second by clock 28. Generator 26 may produce the square function parabolic curve by using various circuits. One circuit that may be used is a unit step function that is integrated twice and is triggered every one-tenth of a second by clock 28. Another circuit may comprise a resistor-capacitor integration circuit shunted by either an NPN or PNP transistor that is base triggered every one-tenth of a second by clock 28. A signal generator may be used that produces an integrating curve which has certain portions of the curve repeatedly accentuated during the one-tenth of a second cycle.

Linear ramp generator 23 produces precisely timed ramp outputs at the 5 kilo-Hertz repetition rate and essentially with no delay from the time of the pulse of illumination emanated from illuminator 10. Comparator 24 is used to produce a plurality of leading edges according to the coincidence of the parabolic square function curve at the output of the parabolic function generator 26 and each of the plurality of ramp voltage curves at the output of the linear ramp generator 23. The parabolic curve is applied as input 1 and the plurality of ramps as input 2 to comparator 24. All of the ramp voltages have the same maximum amplitude while the parabolic curve builds up through the one-tenth of a second from a low voltage to an amplitude equal to the maximum amplitude of the ramp voltages. The repetition frequency of the parabolic curve is therefore 10 cycles per second as controlled by the free running clock 28 and the changing amplitude of the parabolic curve voltage has been compared with 500 ramp curve voltages to produce 500 distinct leading edge signals that are advancing in time during one cycle of the parabolic curve. Each of the distinct leading edge signals at the output of comparator 24 is applied to high voltage electronic gate 12 to enable the image intensifier. Each trailing edge signal at the output of one shot multivibrator 22 is applied to gate 12 to disable the image intensifier. High voltage gate 12 is of the electronic type so that it will have fast switching times between the on and off tube voltages.

The period of free running clock 28 corresponds in time to the maximum allowable period to avoid flicker between viewings at the minimum range. This period is chosen as one-tenth of a second. Therefore, 500 evenly spaced trailing edge pulses, which occur 200 microseconds apart, have 500 different leading edges associated respectively therewith with each subsequent leading edge advancing in time within the 200 microsecond periods. To better explain the effect of the periodically advancing leading edges, consider 500 incremental range bins existing outward from the image intensifier to the maximum range being viewed. Further assume that reflected signals from the first pulse of illumina-

tion, or laser pulse, returns from targets in all 500 range bins. Now, on the occurrence of the second laser pulse the leading edge has been advanced slightly in time such that the image intensifier focus electrode that was turned "off", or disenabled, by the trailing edge associated with the first laser pulse is now turned on, or enabled, but only after the reflected signals from targets in the first range bin has returned past the image intensifier. However, the image intensifier is enabled by the second leading edge from comparator 24 to accept reflected signals from all the targets in the remaining 499 range bins and the remaining 499 range bins are viewed for a second time. After occurrence of the third laser pulse the third leading edge is advanced by the increased amplitude of the parabolic square function curve being compared with the third ramp such that reflections from the first two range bins have past the image intensifier before the focus electrode is enabled again, but signals from the targets in the remaining 498 range bins are viewed for a third time. This process continues through the 500 laser pulses until there are 500 viewings of the targets in the maximum range bin during each one-tenth of a second while only one viewing is made of the nearest targets during this one-tenth of a second. Therefore, even at the nearest targets the decay time of the returned signals on the phosphor and on the eye of the observer does not noticeably droop, or flicker, until another reflected pulse is received. The range bins are not identical in size, but are larger at the beginning of each cycle in accordance with the inverse square law. The larger range bins at the beginning of the cycle are needed as shown by the lower part of FIG. 3.

FIG. 3 shows on a time and range scale from left to right the effective signal return from targets downrange represented by numeral 40 as the top graph and the required number of viewings by the image intensifier to produce a smooth compensating curve, or integrated curve to equalize the light reflected from the targets downrange, represented by numeral 50 as the lower graph. The time and range scale is used for illustrative purposes as will be discussed below. Ranges R1, R2, and R3 in FIG. 3 correspond to these same range discussed for FIG. 1. Range R1 is assumed to be at 50 meters from both the illuminator 10 and the gated image intensifier tube 14. The time scale for pulsed illumination travel to and from R1 is therefore about 325 nanoseconds. The rightmost vertical line represents the last of a series of 500 trailing edges, and the maximum range Rmax of the image intensifier. Conversely, the leftmost vertical line represents the first of the series of 500 trailing edges and starts at the very minimum range, which is at the image intensifier. The period for these 500 trailing edges is one-tenth of a second as explained above. Compensation curve 50 is thus triggered back to zero after each subsequent one-tenth of a second by the free running clock 28 recycling function generator 26. Curve 50 is an integrated curve that represents the sum of all the 500 distinct incremental time elements through which the image intensifier is enabled. Since all of the 500 leading to trailing edge outputs applied to the high voltage gate 12 during the one-tenth second cannot be shown, a representative condensed grouping of the enabling leading to trailing edge pulses are shown. These groupings are shown as laser pulse returns group number 1 through number 9. These groupings, and likewise the leading to trailing edge

pulses, become closer together from number 1 toward number 9 to provide the required increasing number of viewings in time and in range from T_0 to T_{max} . These returns groups are also representative of the differing size range bins mentioned above. This increase in viewings toward T_{max} is provided by the increasing parabolic curve from function generator 26 that is compared with the 500 ramps from generator 23. In summary, two periods are running in the present analog gating system. One of these periods is the time required for each individual emitted light pulse to travel to and from the target in the maximum range of which the image intensifier will receive the returned light pulse. The other period is the repetitive 0.1 second cycles that the independently operating correction circuit samples reflected returns from continuous groups of 500 of the individual emitted light pulses wherein the image intensifier is enabled once every 0.1 of a second for the very nearest target and up to 500 times per 0.1 of a second, in a square function manner, for targets at the range limit of the image intensifier.

It is to be understood that although the invention has been described with specific reference to a particular embodiment thereof, it is not to be so limited since changes and alterations therein may be made which are within the full intended scope of this invention as defined by the appended claims.

We claim:

1. An electronic analog gating system for cyclically controlling the enable time of an image intensifier over repetitive cyclically controlled periods of returned illumination pulses to provide viewings of the nearest target at a repetitive rate just above the perceptible flicker rate and increasing the number of viewings of target to the maximum range of the image intensifier in accordance with the inverse square law of drop off in illumination, the system comprising:

a master clock for producing a train of trigger pulses therefrom;

light pulse producing means comprising a pulsed illuminator having an input connected to said train of trigger pulses and an output producing a train of light pulses at the same frequency as said trigger pulses wherein said train of light pulses are directed parallel to the optical axis of said image intensifier;

an effective brightness correction circuit having an input connected to receive said train of trigger pulses and a first and a second output therefrom, wherein said correction circuit includes at said first output a trailing edge producing means for producing plurality of evenly spaced trailing edge pulses that are delayed by the time required for said pulsed illumination to travel to and from the farthest target downrange and includes at said second output a leading edge producing means for producing a plurality of leading edge pulses that are advancing in time between each subsequent trailing edge pulse over said repetitive cyclically controlled

periods; and

a high voltage electronic gate having a first and second input and an output connected to the image intensifier control voltage with said first input receiving said plurality of evenly spaced trailing edge pulses to disable said image intensifier and said second input receiving said plurality of leading edge pulses to enable said image intensifier wherein the total enable time of said image intensifier is cyclically advancing in time of light pulse travel to and from downrange targets and is the integrated sum of all the leading edge to trailing edge enable times through each of said cyclically controlled period whereby integrated viewings of targets downrange are increased according to the inverse square law of illumination drop off.

2. An electronic analog gating system as set forth in claim 1 wherein said effective brightness correction circuit comprises a timer that produces said plurality of evenly spaced trailing edge pulses and wherein said plurality of leading edge pulses are produced by a circuit comprising a comparator circuit having a first and a second input and an output, a ramp voltage producing means having said train of trigger pulses applied to an input and a plurality of equal amplitude ramp voltages that are produced at the same time and repetition rate as said trigger pulses are applied to said second input of said comparator, a parabolic square function generator having an input and an output, and a free running clock having a pulsed output therefrom at the repetitive cyclically controlled periods that is applied to said input of said parabolic square function generator whereby a parabolic curve having a maximum amplitude of said plurality of equal amplitude ramp voltages and a period of said cyclically controlled periods is produced at the output of said square function generator and is applied to said first input to said comparator in which the output to said comparator has a plurality of leading edge pulses moving forward in time between subsequent trailing edge pulses over said repetitive cyclically controlled periods.

3. An electronic analog gating system as set forth in claim 2 wherein said train of trigger pulses, said train of illumination pulses, said evenly spaced trailing edge pulses, and said plurality of equal amplitude ramp voltages are at a frequency of 5 kilo-Hertz and the frequency of repetitive cyclically controlled period is ten times per second.

4. An electronic analog gating system as set forth in claim 3 wherein said timer is a one shot multivibrator.

5. An electronic analog gating system as set forth in claim 4 wherein said pulsed illuminator is a laser.

6. An electronic analog gating system as set forth in claim 5 wherein said laser is a gallium arsenide laser.

7. An electronic analog gating system as set forth in claim 4 wherein said pulsed illuminator is a flash lamp.

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