

ELECTRONIC FLASH APPARATUS

5 The present invention relates to electronic flash apparatus and, more particularly, to electronic flash apparatus which produces a signal indicative of the readiness of the apparatus to produce a second flash after a first flash.

10 Many commercially available electronic flash units monitor the voltage on a main storage capacitor and, via a ready lamp or by enabling a shutter release mechanism in an associated camera, inform a camera operator when there is sufficient energy for a flash exposure. In some electronic flash units, the capacitor voltage selected as the threshold value for production of the readiness signal is the minimum
15 voltage required to ignite the flash tube.

Typically, the selected voltage will produce flash illumination that will result in an underexposure of about one half to two thirds of a stop from that which would be produced by the maximum possible flash
20 illumination. Units in which the selected voltage is the minimum voltage needed for ignition, have the advantage of permitting the taking of flash exposures in rapid succession but suffer the risk of underexposure when photographing a subject at greater
25 distances because the capacitor is not charged to the maximum value. In other electronic flash units, the capacitor voltage level selected as the threshold value is in the region of the maximum possible flash operating voltage.

30 Units in which the selected voltage is near the maximum voltage have the advantage of ensuring adequate flash illumination for subjects at all flash distances but suffer the disadvantage of eliminating the opportunity for the operator to take
35 flash pictures in rapid sequence.

U.S. Patent No. 4,258,991 discloses an electronic flash unit having a plurality of light

emitting diodes (L.E.D.s) which successively and stepwise emit light as the charging voltage across the flash capacitor increases to predetermined levels. Subject distances are marked in association with the L.E.D.s so that the distance indicated at the time that an L.E.D. is energized is approximately the subject distance at which the operator can take an adequately exposed picture. The disadvantages of this system are that (1) the operator must be an accurate judge of distance, and (2) if the photographic subject is located between the distances marked by two successive L.E.D.s, the operator must wait before taking a picture beyond the minimum time necessary to provide proper flash illumination.

According to the present invention there is provided an electronic flash apparatus including a capacitor, a flash tube energizable by the capacitor to produce a flash of radiation, and series type quench means actuatable to terminate the discharge of the capacitor and, hence, radiation by the flash tube, evaluating means, connected to the capacitor, for evaluating a flash-firing operation which occurs during a first exposure to determine whether the capacitor retains adequate remaining energy at termination of the discharge during that exposure to produce in a subsequent exposure a flash which would produce acceptable illumination of a scene having substantially the same exposure parameters as those of the scene photographed during the said first exposure.

By such evaluation, apparatus in accordance with the present invention allows flash exposures to be made at the most rapid rate possible without significant risk of unacceptable underexposure. The assumption is that scene conditions, such as range, reflectivity and ambient luminance, will not be significantly different between two exposures made in rapid sequence. Such apparatus thus differs significantly from the above described prior art in

that it allows a shutter operation to occur or otherwise informs the operator, on the basis of flash energy consumed for the preceding exposure and of the anticipated flash energy requirement for the next exposure, rather

5 than merely informing the operator that the capacitor charge is at or above some arbitrary level. When a plurality of flash exposures are taken in rapid sequence, for example less than one second apart, controlling the flash ready mechanism(s), in
10 accordance with the teachings of the present invention, on the basis of the energy used in the immediately previous flash will almost always provide an acceptable, although perhaps not optimum, photograph.

15 An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawing which illustrates, in partly schematic and partly box form, a series quench type electronic flash unit incorporating a preferred
20 embodiment of the flash exposure control apparatus of the present invention.

 Because electronic flash units are well known, the present description will be directed in particular to elements forming part of, or
25 cooperating directly with, the present invention. It is to be understood that elements not specifically shown or described herein may be selected from those known in the electronic flash unit art.

 Referring now to the drawing, an
30 energy-saving, or series quench type electronic flash unit, generally indicated by the reference numeral 10, includes a flash tube 12 for emitting a flash of radiation, a storage capacitor 14 for supplying energy to the flash tube and a battery-powered
35 charging circuit 16 for charging the capacitor 14.

 When a trigger pulse is applied to a trigger

electrode 12a of the flash tube 12, the gas within the flash tube is ionized which decreases the impedance between the flash tube electrodes. With the impedance lowered, the stored charge in the capacitor 14 is discharged through the tube 12 causing the tube to emit a flash of light. The trigger pulse is produced from a conventional trigger circuit 18 when a synchronous contact 18a interlocking with a camera shutter (not shown) is closed.

When the contact 18a closes, a timer 20 is activated and produces a high level signal for a predetermined time interval of, for example, one second. Closing the contact 18a also enables a sample and hold circuit 22. At the moment the trigger pulse is applied to the trigger electrode 12a, the circuit 22 samples and stores voltage, V_t which then exists across the capacitor 14. The sample and hold circuit 22 applies the voltage V_t to a squaring circuit 24. The square (V_t^2) of the voltage V_t is applied to the positive input of a subtraction circuit 26 which, in this embodiment, is a differential amplifier. Because the energy E stored on a capacitor C is equal to $1/2 CV^2$, the signal V_t^2 supplied to the subtraction circuit 26 is directly proportional to the energy stored on the capacitor 14 at the moment the trigger pulse is applied to the flash tube 12, i.e., at the time of initiation of the flash.

When the flash tube 12 is ignited by the trigger pulse, a gate 28 activates a light-sensitive quench circuit 30 which detects the intensity of the light reflected by an object to be photographed. When the quench circuit 30 has received a predetermined quantity of light, it applies a control signal to a high-speed electronic switch 32, such as

an SCR, located in series with the flash tube 12 and the capacitor 14. The control signal causes the switch 32 to rapidly switch from a conductive condition to a non-conductive condition which causes the termination of both the discharge of the capacitor 14 and the light radiation by the flash tube 12.

The control signal applied by the quench circuit to the switch 32 also enables a sample and hold circuit 34 which samples and stores the voltage, V_q , then existing across the capacitor 14. Thus, the voltage V_q is the capacitor voltage at flash termination. From the sample and hold circuit 34, the voltage V_q is fed to a squaring circuit 36. The voltage V_q^2 is then applied to the negative input of the subtraction circuit 26. For the same reason previously mentioned, the output signal V_q^2 supplied to the subtraction circuit 26 by the squaring circuit 36 is directly proportional to the energy stored on the capacitor 14 at the moment of termination of the flash.

The output of the subtraction circuit, i.e. $V_t^2 - V_q^2$, which is fed to one input of a comparator 38, is thus directly proportional to the amount of energy delivered to the flash tube 12 during the flash, i.e., the result of the subtraction is representative of the energy used in the flash. The output signal V_q^2 of the squaring circuit 36, which is directly proportional to the amount of energy remaining stored in the capacitor 14 at the instant the flash was quenched, is fed to the second input of the comparator 38. When the output signal of the subtraction circuit 26 is equal to or greater than the output signal of the squaring circuit 36, the comparator 38 produces a low level output. Conversely, when the output signal of the squaring circuit 36 is greater than the output signal of the

subtraction circuit 26, the comparator 38 produces a high level output.

5 The sample and hold circuits 22 and 34, the squaring circuit 36, the subtraction circuit 26 and the comparator 38 form evaluating means for evaluating the flash-firing operation.

The instantaneous voltage on the capacitor 14 is monitored by a voltage divider consisting of a fixed resistor R_1 and a variable resistor R_2 .
10 The voltage drop across the fixed resistor R_1 is fed to one input of a comparator 40. The second input of the comparator 40 receives a reference voltage representative of the minimum voltage required to fire the flash tube 12. When the voltage
15 across the resistor R_1 is greater than the reference voltage, the comparator 40 produces a high level output. When the voltage across the resistor R_1 is equal to or less than the reference voltage, the comparator 40 produces a low level output.

20 The outputs of the timer 20 and the comparators 38 and 40 are fed to the three input terminals of an AND gate 42. When these three inputs are simultaneously at a high level, that is to say when (1) the energy remaining stored on the capacitor
25 14 at flash quench is greater than the energy consumed in that flash exposure; (2) the remaining capacitor voltage is greater than the minimum voltage required to fire the flash tube 12; and (3) a time interval of not more than one second has elapsed
30 since the last previous firing of the flash tube 12, the AND gate 42 provides an output signal to a voltage sensitive switch 44, which may be, for example, a Schmitt trigger. When the voltage sensitive switch 44 receives an output signal from
35 the AND gate 42 it produces a low level output signal. This low level output signal can be used to

inform the operator that the flash unit 10 can provide sufficient illumination for the next exposure, by turning on an indicating lamp 46, for example an L.E.D., and/or by enabling a camera shutter mechanism 48. The shutter mechanism may be enabled, for example, by activating a shutter electromagnet 54 which releases a trigger blocking mechanism or which actuates the shutter itself if the camera is provided with an automatic "burst mode" selector for repeating the picture taking cycle.

If a second photograph is not taken during the set period (e.g. one second) of the timer 20, then, at the end of that period the timer produces a low level signal. This low level signal turns off the AND gate 42 which in turn causes voltage sensitive switch 44 to produce a high level output signal that turns off indicating lamp 46 and/or disables shutter mechanism 48.

As previously noted, when a plurality of flash exposures are taken in rapid sequence it is not likely that the photographic subject will have changed enough to alter significantly the flash energy required for each exposure to be satisfactory. In this circumstance, therefore, controlling the flash ready mechanism(s) on the basis of the energy used in the immediately previous flash does not introduce a significant risk of underexposure.

As described above, the timer 20 and the comparators 38 and 40 provide control for a flash ready mechanism when the electronic flash unit 10 is operated in a rapid sequence, for example less than one second between two consecutive exposures. When the time interval between consecutive flashes is beyond that established by the timer 20 for the rapid picture mode, the operator is informed, in the

preferred embodiment of the invention, that another flash exposure can be taken whenever the voltage stored on the capacitor 14 is at or above the minimum level required to ignite the flash tube 12. This is accomplished by the addition of a second timer 50 and a second AND gate 52. The comparator 40, as previously described, provides a high level output whenever the instantaneous voltage on the capacitor 14 is greater than the minimum voltage required to fire the flash tube 12. The timer 50 is enabled when the output of the first timer 20 falls to a low level, i.e., after a one second interval, and produces a high level output after a predetermined time interval, for example one second, after enablement of the timer 50. A longer time interval before the production of a high level output by the timer 50 will allow the charging circuit 16 to more fully charge the capacitor 14 and thereby reduce the risk of underexposure. The disadvantage of a longer charging time interval is, of course, that the opportunity to take some flash exposures is lost. Conversely, a shorter time interval before the production of a high level output by the timer 50 decreases the wait before another flash exposure can be made but also increases the risk of underexposure.

The outputs of the comparator 40 and the timer 50 are fed to the two input terminals of the AND gate 52. When these two inputs are simultaneously at a high level, that is to say when (1) the voltage remaining stored on the capacitor 14 after flash quench is greater than the minimum voltage required to fire the flash tube 12; and (2) a time interval of at least two seconds has elapsed (the one second high level interval of the timer 20 plus the one second low level interval of the timer

50), the AND gate 52 provides an output signal to the voltage sensitive switch 44. The voltage sensitive switch 44, in response to the output signal from the AND gate 52, produces a low level output signal which is used to turn on the indicating lamp 46 and/or the shutter electromagnet 48.

In another embodiment of the present invention, another input to the AND gate 42 is supplied by a camera focussing mechanism which may be automatic.

10 The focusing mechanism provides a disabling low level signal or changes the reference voltage representative of the minimum voltage required to fire the flash tube, whenever the camera's focus is changed to a longer range setting during the first one second "rapid picture" interval. Still another input to the AND gate 42 could be supplied by a third comparator which receives a reference signal and an exposure value signal representative of film speed, camera lens aperture, and the distance of the photographic subject from a rangefinder. Furthermore, proportioning means could be provided for the inputs to the comparator 38 so that an enabling high level signal is provided to the AND gate 42 whenever the stored energy remaining on the capacitor can provide a predetermined fraction of the energy delivered to the flash tube 12 during the previous flash operation, such predetermined fraction being sufficient to produce an acceptable underexposure.

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Claims

1. An electronic flash apparatus including a capacitor, a flash tube energizable by the capacitor to produce a flash of radiation, and series type quench means
5 actuatable to terminate the discharge of the capacitor and, hence, radiation by the flash tube, evaluating means, connected to the capacitor, for evaluating a flash-firing operation which occurs during a first exposure to determine whether the capacitor retains adequate remaining
10 energy at termination of the discharge during that exposure to produce in a subsequent exposure a flash which would produce acceptable illumination of a scene having substantially the same exposure parameters as those of the scene photographed during the said first exposure.

15 2. An electronic flash apparatus as claimed in claim 1, wherein the evaluating means includes energy measuring means for measuring the energy in the capacitor at the initiation, and at the termination of a flash.

20 3. An electronic flash apparatus as claimed in claim 2, further including a trigger circuit for triggering discharge of the capacitor through the flash tube to cause energization of the flash tube by the capacitor, and wherein the energy measuring means includes means actuated by the trigger circuit at the time of
25 triggering the discharge of the capacitor for measuring the energy in the capacitor at the time of initiation of the flash, and means actuated by the quench means at the time of termination of the flash for measuring the energy in the capacitor at the termination of the flash.

30 4. An electronic flash apparatus as claimed in claim 3, wherein the energy measuring means includes means for subtracting the measured value of the energy in the capacitor at the termination of the flash from the measured value of the energy in the



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-11-

capacitor at the initiation of the flash to give a result representative of the energy used in the flash and means for comparing the said result with the measured value of the energy in the capacitor at the termination of the flash.

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5. An electronic flash apparatus as claimed in claim 2, 3 or 4, wherein the energy measuring means includes sample and hold means for sampling and storing the voltage on the capacitor 1) at the initiation of the flash and 2) at the termination of the flash.

6. An electronic flash apparatus as claimed in claim 4 or 5, including flash exposure ready means, timer means for establishing a time interval, and comparator means coupled to the flash exposure ready means, said timer means and said evaluating means enabling the flash exposure ready means whenever, within the time period established by the timer means, the said remaining energy is greater than the energy used in the immediately preceding flash.

7. An electronic flash apparatus as claimed in claim 6, adapted for use with a photographic camera including a shutter having electrically-actuated means for enabling and disabling operation of the shutter, said flash exposure ready means being so formed as to provide a signal to said electrically-actuated means.

8. An electronic flash apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawing.