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(54) ELECTRONIC FLASH APPARATUS AND METHOD
OF OPERATING SAME

(71) We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America, of 343 State Street, Rochester, New York 14650, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to electronic flash units and to conserving battery power during operational intervals when the flash device is used infrequently.

An electronic flash unit operates by discharging a firing capacitor through a gas-filled flashtube. To fire the flashtube, 250 volts or more may be necessary, and many commercially available flash devices use a low-voltage battery for charging the firing capacitor, and a voltage converter to convert the low voltage of the battery to a sufficiently high voltage to charge the capacitor. Such a charging circuit is described in Research Disclosure, Number 132, April 1975, pages 37 and 38, in an article entitled "Electronic Flash Unit for Cameras Adapted to Receive Flashbulbs". Such charging circuits, in general, continue to draw some battery current even after the firing capacitor is fully charged. This wastes battery power and may shorten battery life.

Monitor circuits are known that conserve battery power by turning the charging circuit off, when the voltage across the firing capacitor reaches a predetermined level, and turning the charging circuit on again, when the firing capacitor charge leaks away when the flash unit is not fired, and the voltage across the firing capacitor falls. Such monitor circuits are disclosed in, for example, U.S. Patents 3,105,170; 3,316,445; and 3,532,961.

The charging circuit draws battery current when the firing capacitor is being charged, and over an extended period of time, a significant amount of battery power may be wasted even with a monitor circuit, because of the leakage of charge from, and periodic recharging of the firing capacitor.

In accordance with the present invention there is provided an electronic flash unit comprising a flash tube, a flash tube firing capacitor, a charging circuit for the capacitor and a power conserving circuit arranged to switch off the charging circuit if the flash tube is not fired during a preset interval after the charge on the capacitor has reached a predetermined upper level, and is not switched on again until the flash tube is fired or until the charging circuit is manually re-energised.

There is further provided an electronic flash unit as above further comprising a monitor circuit for monitoring the charge on the capacitor whereby the charge on the capacitor is cyclable between the upper and lower level during the preset interval.

In accordance with a preferred embodiment of the present invention there is also provided an electronic flash unit wherein the power conserving circuit comprises a counter arranged for counting the number of charging cycles of the capacitor and for providing an output to switch off the charging circuit when a predetermined number of cycles occur before the flash tube is fired.

In accordance with a second preferred embodiment of the present invention there is provided an electronic flash unit wherein the power conserving circuit comprises a voltage-sensitive switching circuit and an RC timing circuit providing an input thereto, the voltage-sensitive switching circuit being arranged to switch off the power supply from the power source to the firing capacitor after a time predetermined by the RC timing circuit.

There is further provided a method of conserving the power from a power source in an electronic flash unit, comprising the steps of charging a flash tube firing capacitor to a predetermined upper level and switching off the charging circuit until the flash tube is fired or until the charging circuit is manually re-energised, if the flash tube is not fired during a preset interval after the charge on the capacitor has reached the upper level.

The invention will now be described, by

way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a schematic circuit diagram, partially in block form, of a first embodiment of the present invention; and

Fig. 2 is a schematic circuit diagram, partially in block form, of a second embodiment of the present invention.

Electronic flash units being well known, the present description will be directed in particular to elements forming part of, or cooperating more directly with, apparatus in accordance with the present invention. It is to be understood that elements not specifically shown or described may take various forms well known to those skilled in the art.

There is shown in Fig. 1 an electronic flash unit 10, comprising a power source such as a low voltage battery 12, a flashtube firing capacitor 14, a converter or charging circuit 16 for charging the firing capacitor 14, a gas-filled flashtube 18 having an external trigger electrode 19, a trigger circuit 20 for supplying a trigger signal to the trigger electrode 19 to initiate ionization of the gas in the flashtube, and a switch SW1 which when closed applies power from the battery to the flash unit 10.

The switch SW1 may be a manually operated switch or a switch that automatically closes and opens when the flash unit 10 is mounted on or removed, respectively, from a camera (not shown).

The flash unit 10 further includes a monitor circuit 22, that automatically operates a switch circuit 32 to (1) de-couple the battery 12 from the charging circuit 16 when the firing capacitor 14 is charged sufficiently to fire the flashtube 18, and (2) to couple the battery 12 to the charging circuit 16 when the firing capacitor 14 is insufficiently charged. To operate in this manner, the monitor circuit 22 includes a voltage-sensitive flash-ready lamp 23, such as a gas discharge lamp, in series with a resistor 26. The series combination of the lamp 23 and the resistor 26 is shunted by a resistor 27. The resistor 27, and a resistor 28 constitute a voltage divider circuit in parallel with the firing capacitor 14. The resistance values of resistors 27, 28 are selected such that when the firing capacitor 14 is charged to a predetermined level sufficient to fire the flashtube 18, the voltage at the junction between the two resistors 27, 28 energises the lamp 23 to indicate that the voltage across the firing capacitor 14 is sufficient to fire the flashtube 18. Circuits for indicating whether an electronic flash unit is ready to fire are disclosed in, for example, the aforementioned article in Research Disclosure and U.S. Patents 3,105,170; 3,316,445 and 3,532,961.

The monitor circuit 22 further includes an OR gate 30. The first input 30a of the

OR gate 30 is connected to the connection between the lamp 23 and the resistor 26 and the second input 30b of the OR gate 30 is connected to the output of a control circuit 34 which is described in detail hereinbelow. The input terminal 37 of the switching circuit 32 is connected to the output of the OR gate 30, and its output 36 is connected to charging circuit 16 as shown. The switching circuit 32 is voltage-sensitive and may be a Schmitt trigger circuit that is normally conducting and becomes non-conducting in response to an appropriate input signal. When the output of the OR gate 30 produces a signal, switching circuit 32 becomes non-conductive. When this occurs, battery 12 is effectively disconnected from the charging circuit 16, and the charging circuit 16 is turned off.

The operation of the monitor circuit 22, the switching circuit 32, and the control circuit 34 will be described in terms of an operating cycle. An operating cycle is defined as consisting of a "charging portion" and a "non-charging portion". The charging portion constitutes the interval during which the charging circuit 16 charges the firing capacitor 14 to a level at which the flash-ready lamp 23 is energized and the non-charging portion constitutes the interval following the charging portion during which the charge leaks from the firing capacitor 14 until the voltage across the firing capacitor 14 is reduced to a level at which the ready lamp 23 is de-energized, indicating that the voltage across the firing capacitor 14 is insufficient to fire the flashtube 18.

The monitor circuit 22 and switching circuit 32 operate as follows: During the charging portion the lamp 23 is off and the output 36 of the switching circuit 32 is energized, the charging circuit 16 therefore being energized to charge the firing capacitor 14. Once the latter is charged to an upper level sufficient to fire the flashtube 18, the voltage at the junction between the resistors 27 and 28, which voltage is proportional to the voltage across the firing capacitor 14, turns the lamp 23 on. Current flows through the lamp 23 and resistor 26 to produce a signal at input 30a, which causes the OR gate 30 to produce an output. When this happens, the switching circuit 32 turns off, whereby the charging circuit is de-energized and no additional charging of the firing capacitor 14 occurs. At that instant, the charging portion terminates and the non-charging portion commences.

During the first part of the non-charging portion, the lamp 23 remains on. However, during this interval charge gradually leaks from the firing capacitor 14. Eventually, if the flash unit 10 is not fired, the charge on the firing capacitor 14 is reduced to a lower level at which the lamp 23 turns off.

(12)

When this happens, the voltage across the resistor 26 drops to zero and the OR gate 30 is turned off. When this occurs, the output 36 of the switching circuit 32 is energized, and the charging circuit 16 is energized. At that instant, the non-charging portion terminates and the charging portion re-commences.

In accordance with a preferred embodiment of the present invention, the control circuit 34 automatically maintains the battery 12 disconnected from the charging circuit 16 after an interval during which the flash unit 10 is not fired. In doing so the circuit 34 includes means for effectively disabling or overriding the monitor circuit 22. Accordingly, the circuit 34 provides means in addition to the monitor circuit 22 for further conserving battery power and lengthening effective battery life.

The circuit 34 includes a resettable counter 42 having its input connected to the output 36 of the switching circuit 32, its output 42a connected to the input 30b of the OR gate 30, and its reset terminal connected to a conductor 47. The counter 42 can be pre-set to a required count and operates as follows: Each time the output 36 is energized, i.e. when the charging portion commences, the counter 42 increases its count by one. When the pre-set count has been reached, the output 42a is energized and a signal is applied to the input 30b. Counter circuits of this general type are known and an example is disclosed in U.S. Patent 3,526,181.

The period during which the monitor circuit 22 operates to permit the switching circuit 32 to allow the charging circuit 16 to periodically charge firing capacitor 14 is related to the pre-set count at which the counter 42 is set, and the leakage rate of the firing capacitor 14, such leakage being principally through the resistors 27, 28. The period is thus predetermined. When the counter 42 has increased its total count to the pre-set value, the output of the OR gate 30 is energized, the output 36 of the circuit 32 thus being de-energized to de-energize the charging circuit 16. In effect, the counter 42 operates to override the monitor circuit 22 by maintaining the output of the OR gate 30 energized once the counter 42 counts to its pre-set value, regardless of the state of the flash-ready lamp 23.

The counter 42 may be reset, to return its registered count to zero, either automatically or by means of an RC reset circuit 44 consisting of a capacitor 45 in series with a resistor 46, or manually by means of a normally open reset switch SW2. The reset circuit 44 supplies a reset signal via the conductor 47 when the trigger circuit 20 is actuated to apply a signal to the trigger electrode 19 to trigger flashtube 18. The

circuit 44 reduces the voltage from the trigger circuit 20 so that the counter 42 will not be damaged. Closure of the reset switch SW2 permits a reset signal to be applied from the battery 12. When the counter 42 is reset, its output 42a is de-energized. When this occurs, monitor circuit 22 is enabled to permit periodic charging of the firing capacitor 14 in accordance with the state of the flash-ready lamp 23.

The control circuit 34 limits the number of operating cycles, and thus the associated drain on battery 12, of flash device 10. In doing so the control circuit 34 conserves the battery power, since once the monitor circuit 22 is overridden, the current drained from the battery 12 is a small, quiescent current required to energize the input stage of the trigger circuit 20 (by means not shown) and to bias the counter 42 on. This quiescent current is much less than the current necessary to charge the firing capacitor 14 as the result of the battery 12 being periodically coupled to the charging circuit 16.

Referring now to Fig. 2, there is shown a flash device 50 that includes another preferred embodiment of a control circuit, generally designated 52, that lengthens effective battery life by disconnecting the battery 12 from the charging circuit 16 after a predetermined interval during which the flash device 50 is not utilized. Components and circuits previously described in connection with the embodiment shown in Fig. 1 are identified by the same numerals as were used in Fig. 1. The control circuit 52 operates a switching circuit 54 and includes a voltage-sensitive switching circuit 54 whose input 55 is connected to the junction between a capacitor 25 and the reset circuit 44, and whose normally non-conducting output 56 is connected to the input of the switching circuit 32, and to an RC delay circuit 57 comprising a timing capacitor 58 and a resistor 60.

The voltage-sensitive switching circuit 54 includes a path from its output 56 to a conductor 62, that is normally open. When the amplitude of the signal at the input 55 exceeds a predetermined level, the circuit 54 switches such that the path from the output 56 to the conductor 62 conducts. This switching operation occurs either (1) when the flash-ready lamp 23 is initially turned on, or (2) when current flows through the reset circuit 44 as the result of the energization of the trigger circuit 20.

As shown, the junction between the resistor 60 and the capacitor 58 is connected to the junction between the switching circuits 32 and 54 and one terminal of the reset switch SW2. As long as the voltage on the capacitor 58 is less than a predetermined voltage and the switch SW1 is closed the output 36 of the circuit 32 is energized

and the charging circuit 16 charges the firing capacitor 14. The resistance and capacitance values of the resistor 60 and the capacitor 58 are selected so that the time constant of the RC circuit 57 corresponds to the interval that the charging circuit 16 may be energized by the battery 12 to charge the firing capacitor 14 without the flash device 50 being utilized. The time constant of the RC circuit 57 is long relative to the time necessary to charge the firing capacitor 14 so the firing capacitor will always be fully charged prior to the voltage at the junction 65 becoming sufficient to cause the output of the circuit 32 to be de-energised.

In operation, closure of the switch SW1 energizes the flash device 50. The charging circuit 16 charges the firing capacitor 14. The capacitor 58 is also charged, but at a slower rate, through the resistor 60. Once the firing capacitor 14 is charged to a level sufficient to flash flashtube 18, the lamp 23 is turned on. When the lamp 23 turns on, a positive pulse is coupled through the capacitor 25, to the input 55 to establish momentarily the aforementioned electrically conducting path from the output 56 to the conductor 62. Accordingly, any charge on the capacitor 58, accumulated during the period during which the firing capacitor 14 is charged, discharges through the switching circuit 54. The capacitor 58 then commences charging to a full charge in timed relation to the occurrence of a full charge on the firing capacitor 14. The charge on the capacitor 58 will gradually rise until the aforementioned predetermined amount is reached. At that time the output of the switching circuit 32 is de-energised. When this occurs, the battery 12 is disconnected from the charging circuit 16 to prevent further battery drain due to the charging of the firing capacitor 14. Thus, it can be seen that the time constant of the RC delay circuit 57 determines the time that the battery 12 is coupled to the charging circuit 16 when the flash device 50 is operational but is not utilized.

WHAT WE CLAIM IS:—

1. An electronic flash unit comprising a flash tube, a flash tube firing capacitor, a charging circuit for the capacitor and a power conserving circuit arranged to switch off the charging circuit if the flash tube is not fired during a preset interval after the charge on the capacitor has reached a predetermined upper level, and is not switched on again until the flash tube is fired or until the charging circuit is manually re-energised.

2. An electronic flash unit as claimed in Claim 1, further comprising a monitor circuit for monitoring the charge on the capacitor whereby the charge on the capacitor is cyclable between the upper and a

lower level during the preset interval.

3. An electronic flash unit as claimed in Claim 2, wherein the monitor circuit comprises a voltage-sensitive flash-ready lamp in series with a resistor, the flash-ready lamp being illuminated when the charge on the firing capacitor rises above the upper level, and extinguished when the charge on the firing capacitor falls below the lower level.

4. An electronic flash unit as claimed in Claim 2 or 3, wherein the power conserving circuit comprises a voltage-sensitive switching circuit in series with the power source and the charging circuit.

5. An electronic flash unit as claimed in Claim 2, 3 or 4 further comprising an RC reset circuit for resetting the power conserving circuit on firing of the flash tube.

6. An electronic flash unit as claimed in any one of Claims 2 to 4, wherein the power conserving circuit comprises a counter arranged for counting the number of charging cycles of the capacitor and for providing an output to switch off the charging circuit when a predetermined number of cycles occur before the flash tube is fired.

7. An electronic flash unit as claimed in Claim 6 further comprising an OR gate having as inputs the output of the monitor circuit and the output of the counter, and providing an output to the power conserving circuit.

8. An electronic flash unit as claimed in any one of Claims 1 to 3 or 5 wherein the power conserving circuit comprises a voltage-sensitive switching circuit and an RC timing circuit providing an input thereto, the voltage-sensitive switching circuit being arranged to switch off the power supply from the power source to the firing capacitor after a time predetermined by the RC timing circuit.

9. An electronic flash unit substantially as hereinbefore described, with reference to and as illustrated in Fig. 1 or Fig. 2 of the accompanying drawings.

10. A method of conserving the power from a power source in an electronic flash unit, comprising the steps of charging a flash tube firing capacitor to a predetermined upper level and switching off the charging circuit until the flash tube is fired or until the charging circuit is manually re-energised, if the flash tube is not fired during a preset interval after the charge on the capacitor has reached the upper level.

11. A method as claimed in Claim 10, wherein the preset interval is defined by the occurrence of a predetermined number of firing capacitor charging cycles during which the flash tube is not fired.

12. A method as claimed in Claim 10, wherein the preset interval is determined by an RC timing circuit couplable to the power source.

and the charging circuit 16 charges the firing capacitor 14. The resistance and capacitance values of the resistor 60 and the capacitor 58 are selected so that the time constant of the RC circuit 57 corresponds to the interval that the charging circuit 16 may be energized by the battery 12 to charge the firing capacitor 14 without the flash device 50 being utilized. The time constant of the RC circuit 57 is long relative to the time necessary to charge the firing capacitor 14 so the firing capacitor will always be fully charged prior to the voltage at the junction 65 becoming sufficient to cause the output of the circuit 32 to be de-energised.

In operation, closure of the switch SW1 energizes the flash device 50. The charging circuit 16 charges the firing capacitor 14. The capacitor 58 is also charged, but at a slower rate, through the resistor 60. Once the firing capacitor 14 is charged to a level sufficient to flash flashtube 18, the lamp 23 is turned on. When the lamp 23 turns on, a positive pulse is coupled through the capacitor 25, to the input 55 to establish momentarily the aforementioned electrically conducting path from the output 56 to the conductor 62. Accordingly, any charge on the capacitor 58, accumulated during the period during which the firing capacitor 14 is charged, discharges through the switching circuit 54. The capacitor 58 then commences charging to a full charge in timed relation to the occurrence of a full charge on the firing capacitor 14. The charge on the capacitor 58 will gradually rise until the aforementioned predetermined amount is reached. At that time the output of the switching circuit 32 is de-energised. When this occurs, the battery 12 is disconnected from the charging circuit 16 to prevent further battery drain due to the charging of the firing capacitor 14. Thus, it can be seen that the time constant of the RC delay circuit 57 determines the time that the battery 12 is coupled to the charging circuit 16 when the flash device 50 is operational but is not utilized.

WHAT WE CLAIM IS:—

1. An electronic flash unit comprising a flash tube, a flash tube firing capacitor, a charging circuit for the capacitor and a power conserving circuit arranged to switch off the charging circuit if the flash tube is not fired during a preset interval after the charge on the capacitor has reached a predetermined upper level, and is not switched on again until the flash tube is fired or until the charging circuit is manually re-energised.

2. An electronic flash unit as claimed in Claim 1, further comprising a monitor circuit for monitoring the charge on the capacitor whereby the charge on the capacitor is cyclable between the upper and a

lower level during the preset interval.

3. An electronic flash unit as claimed in Claim 2, wherein the monitor circuit comprises a voltage-sensitive flash-ready lamp in series with a resistor, the flash-ready lamp being illuminated when the charge on the firing capacitor rises above the upper level, and extinguished when the charge on the firing capacitor falls below the lower level.

4. An electronic flash unit as claimed in Claim 2 or 3, wherein the power conserving circuit comprises a voltage-sensitive switching circuit in series with the power source and the charging circuit.

5. An electronic flash unit as claimed in Claim 2, 3 or 4 further comprising an RC reset circuit for resetting the power conserving circuit on firing of the flash tube.

6. An electronic flash unit as claimed in any one of Claims 2 to 4, wherein the power conserving circuit comprises a counter arranged for counting the number of charging cycles of the capacitor and for providing an output to switch off the charging circuit when a predetermined number of cycles occur before the flash tube is fired.

7. An electronic flash unit as claimed in Claim 6 further comprising an OR gate having as inputs the output of the monitor circuit and the output of the counter, and providing an output to the power conserving circuit.

8. An electronic flash unit as claimed in any one of Claims 1 to 3 or 5 wherein the power conserving circuit comprises a voltage-sensitive switching circuit and an RC timing circuit providing an input thereto, the voltage-sensitive switching circuit being arranged to switch off the power supply from the power source to the firing capacitor after a time predetermined by the RC timing circuit.

9. An electronic flash unit substantially as hereinbefore described, with reference to and as illustrated in Fig. 1 or Fig. 2 of the accompanying drawings.

10. A method of conserving the power from a power source in an electronic flash unit, comprising the steps of charging a flash tube firing capacitor to a predetermined upper level and switching off the charging circuit until the flash tube is fired or until the charging circuit is manually re-energised, if the flash tube is not fired during a preset interval after the charge on the capacitor has reached the upper level.

11. A method as claimed in Claim 10, wherein the preset interval is defined by the occurrence of a predetermined number of firing capacitor charging cycles during which the flash tube is not fired.

12. A method as claimed in Claim 10, wherein the preset interval is determined by an RC timing circuit couplable to the power source.



* C L M S *

13. A method as claimed in Claim 10
and substantially as hereinbefore described.

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