

- [54] **ELECTRONIC FLASH DEVICE WITH
AUTOMATIC LIGHT CONTROL**

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- [22] Filed: **Aug. 27, 1973**

- [21] Appl. No.: 392,077

Related U.S. Application Data

- [63] Continuation of Ser. No. 202,559, Nov. 26, 1971, abandoned.

[30] Foreign Application Priority Data

- Nov. 14, 1968 Japan..... 43-84325

- [52] U.S. Cl..... 315/151; 315/159; 315/241 R;
315/241 P

- [51] Int. Cl. H05b 37/02

- [58] **Field of Search** 315/151, 159, 241 P, 241 R

- [56]
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Assistant Examiner—Lawrence J. Dahl

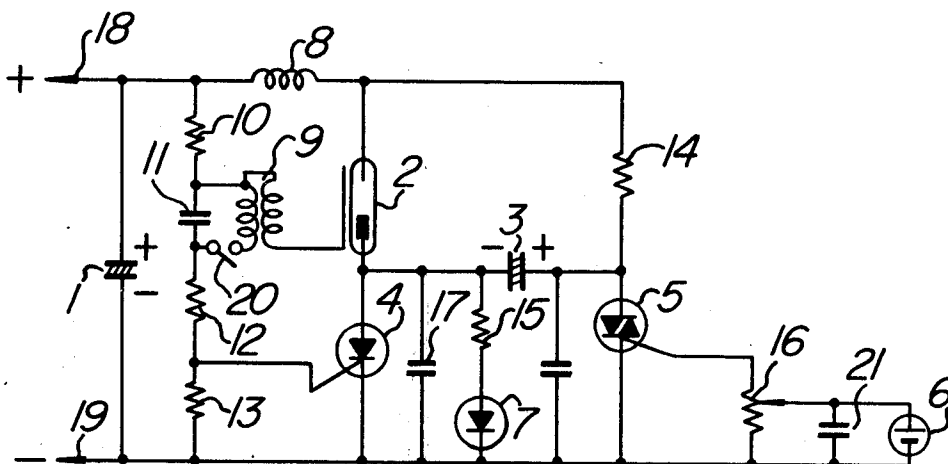
Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57]

ABSTRACT

A flashlight discharge lamp control system wherein energy stored in a main discharge capacitor is applied to a flashlight discharge tube to illuminate with the flashing light thus produced an object to be photographed to control a control element connected in series with the said flashlight discharge tube by means of the reflected light of the said flashing light such that the said control element is turned off by a voltage applied in the direction reverse to the forward voltage drop in the control element to stop the supply of energy to the said flashlight discharge tube.

5 Claims, 5 Drawing Figures



SHEET 1 OF 2

FIG. 1

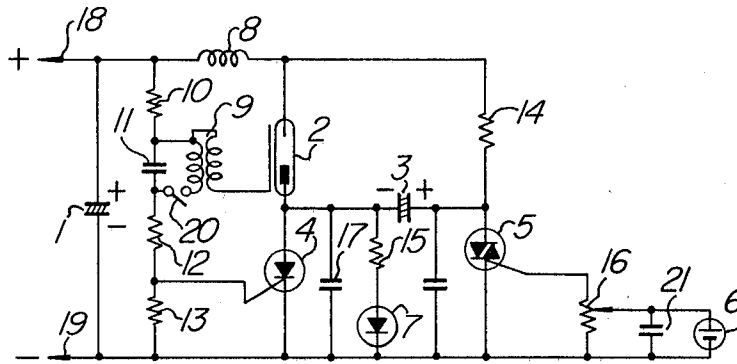


FIG. 2

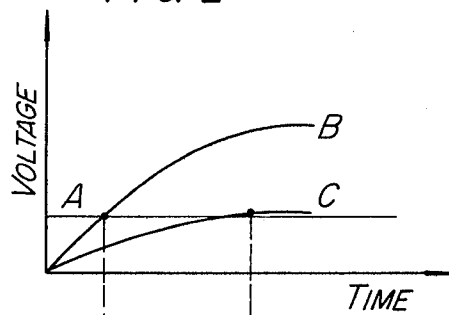
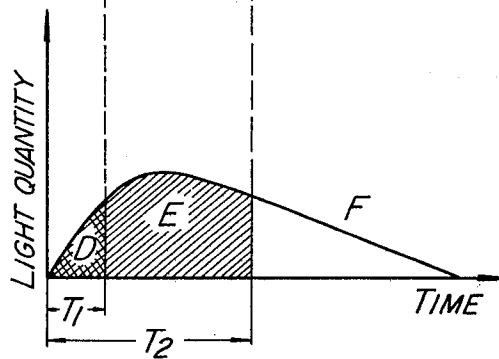


FIG. 3



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FIG 4

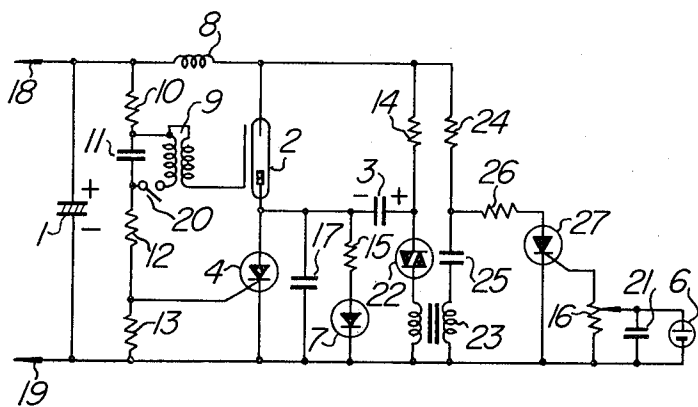
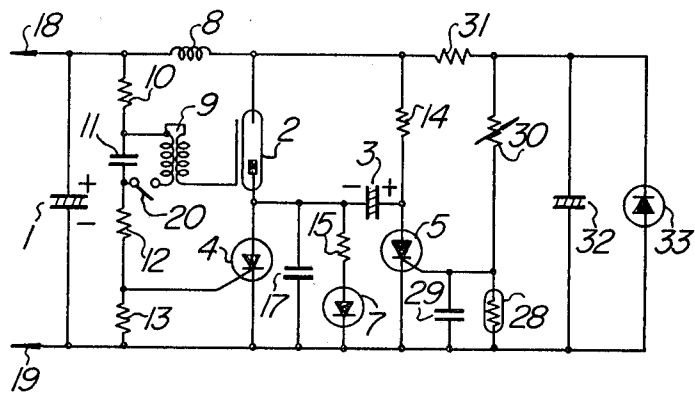


FIG 5



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ELECTRONIC FLASH DEVICE WITH AUTOMATIC LIGHT CONTROL

This is a continuation of application Ser. No. 202,559, filed Nov. 26, 1971, now abandoned.

The present invention relates to a control circuit for a flashlight discharge tube adapted to readily vary the light quantity produced and flash duration in a flash discharge circuit which supplies discharging energy to a flashlight discharge tube through a main discharge capacitor.

Methods of adjusting such factors as the flash duration and light quantity which have hitherto been used include, among others, adjusting the capacitance or charging voltage of a capacitor, the use of a turnoff discharge tube with a low internal resistance which is connected in parallel with a main discharge tube such that an ignition pulse may be applied to the turnoff discharge tube at any given time to short-circuit midway and extinguish the supply of energy to the main discharge capacitor, etc.

The disadvantage of the former method was its inability to effect a desired adjustment within a short period of time, while the latter had a drawback in that all the load of a capacitor would be always discharged even if the required light quantity were not so large with a resultant large energy loss which is undoubtedly uneconomical where a dry cell or the like is used as a power source.

The present invention contemplates eliminating these drawbacks of the conventional devices and has for its object the provision of an improved control circuit with a reduced energy loss, wherein a control element is connected in series with a discharge tube such that a reverse voltage may be applied to the control element at any given time during the discharge to turn the control element off to thereby stop the discharge.

The present invention will be explained hereinafter in conjunction with the accompanying drawings, in which:

FIG. 1 is a circuit diagram showing an embodiment of the electronic flash device with automatic light control according to the present invention;

FIG. 2 and 3 are characteristic curves showing respectively the relationships among the integrating function of reflected light receiving means, the gate level of a control element and the light radiation characteristics; and

FIGS. 4 and 5 are circuit diagrams showing further embodiments of the present invention.

Referring to FIG. 1, numeral 1 designates a main discharge capacitor, and connected in parallel with the capacitor 1 are a series circuit consisting of a resistor 10, a trigger capacitor 11 and resistors 12 and 13 and another series circuit consisting of an inductance 8, a xenon discharge tube 2 and a first control element 4 (which includes SCR, Triac, etc.). Also connected in parallel with the trigger capacitor 11 through a switch 20 is a trigger transformer 9 which serves as a trigger for the xenon discharge tube 2 and the secondary winding of this trigger transformer 9 is connected with the trigger electrode of the xenon discharge tube 2. The trigger electrode of the first control element is then connected between the resistors 12 and 13 to form a main discharging circuit as the trigger for the first control element 4; a parallel circuit of a capacitor 17 and a resistor 15 and a diode 7, and a series circuit of a con-

trol capacitor 3 and a second control element 5 (which includes Triac, SCR, Diac, etc.) are connected in parallel with the first control element 4; a control is formed including a resistor 14 connected to the main discharging circuit as the charging circuit for the control capacitor 3; and a parallel circuit of a solar battery 6, a variable resistor 16 and a capacitor 21 is connected to the gate of the second control element 5 to form a light detector circuit.

With a circuit construction as described above, the principles of operation will be explained. The energy of the main discharge capacitor 1 is charged from terminals 18 and 19 in the polarity shown in the figure, and as the switch 20 is short-circuited, the trigger energy charged in the trigger capacitor 11 through the resistors 10, 12 and 13 is discharged across the primary winding of the trigger transformer 9 to induce a high voltage across the secondary winding of the transformer, thus driving the xenon discharge tube 2 into conduction to start discharging. However, since the first control element 4 is connected in series with the xenon discharge tube 2, the first control element 4 must be gated simultaneously at the time the xenon discharge tube 2 is excited. The gating of the first control element 4 is effected by a divided voltage of the main discharge capacitor 1 which is developed across the resistor 13 through the resistors 10 and 12 upon closing the switch 20, that is, this divided voltage is applied to the gate electrode of the first control element 4 to simultaneously conduct both the first control element 4 and the xenon discharge tube 2 thus starting the conversion of the energy of the main discharge capacitor 1 into light energy. When this happens, the reflected light from an object to be photographed starts to fall upon the reflected light receiving means which in turn produces integrated waveforms as shown at B and C in FIG. 2 and as determined by the integrating characteristics associated with the capacitor 21.

Assuming, for example, that the gate level of the second control element 5 is as shown by a line A, the second control element 5 conducts, whereupon the energy charged in the control capacitor 3, as shown by the polarity marking in the figure, by means of a series circuit consisting of the resistor 14, control capacitor 3, resistor 15 and diode 7 is discharged in the direction reverse to the forward voltage drop in the first control element 4, whereby, if this reverse current is supplied for a period necessary to turn the first control element 4 off, the first control element 4 becomes non-conducting to thereby stop the radiation of light by the xenon discharge tube 2.

These relationships are shown in FIG. 3 with a curve F indicating the waveform of an ordinary flash light which will take the waveforms such as shown by the curves B and C, if it is integrated by an integrating circuit consisting of the solar battery 6 and the capacitor 21. The curve B indicates the output waveform of this integrating circuit when the distance between the light source and an object to be photographed is short, and in this case the light waveform will be as shown at D in the figure because, with the gate level being on the straight line A, the second control element 5 operates after the time T_1 to turn the first control element 4 off to thereby stop the radiation of light. Where the distance between the light source and an object to be photographed is long, the output waveform of the integrating circuit will be as shown by the curve C, while the

light waveform will take the form shown at E in the figure since the curve C intersects the straight line A of the gate level after the time T_2 , thereby radiating a large light quantity as compared with that which is obtainable when the distance between the light source and an object to be photographed is short. In this manner, an effectively constant quantity of light may be imparted at all times.

In addition, the present invention provides a protective circuit against possible errors in operation. For instance, where a number of electronic flash devices are to be used to take pictures of the same object, there is possibility that a voltage is produced at the photoelectric receiver means 6 by any other electronic flash devices to thereby gate the second control element. According to the present invention, the diode 7 is inserted in the charging circuit for the control capacitor 3 such that the energy in the control capacitor 3 will not be discharged unless the first control element 4 conducts, and moreover the first control element 4 does not conduct except when the shutter is released or the switch 20 is short-circuited and therefore the possibility of any operation errors is completely eliminated.

It is also an important feature of the present invention that, as is apparent from FIG. 1, the charging circuit is formed by the resistor 14, control capacitor 3, resistor 15 and diode 7 so that the reverse polarity power supply which provides the input to the control capacitor 3, the essential element for embodying the present invention, can be quite readily obtained from the main discharging circuit.

FIG. 4 shows another embodiment of the present invention wherein the second control element of FIG. 1 is replaced by a bidirectional switching element 22 (for example, Diac), a pulse transformer 23 is inserted to gate the bidirectional switching element 22, a control element 27 is gated by means of a gate circuit composed of the photoelectric receiver 6, capacitor 21 and resistor 16, and the energy of a capacitor 25 is discharged across the primary winding of the pulse transformer 23 to control the bidirectional switching element 22.

FIG. 5 shows another embodiment of the present invention wherein a photoconductive cell 28 is employed for the photosensitive circuit of FIG. 1. This photoconductive cell requires a power supply and thus a constant voltage is provided by means of a resistor 31, a Zener diode 33 and a smoothing capacitor 32. This voltage is then applied to the photoconductive cell 28 through a resistor 30 and further integrated by means of a capacitor 29 to control the second control element 5.

As will be evident from the foregoing, the present invention provides the electronic flash device with an automatic light control which is particularly useful where a power is supplied, for example, from a storage battery having a limited life, because the control system for controlling the light quantity to be radiated is primarily based on switching the control element 4 from its conduction state to a non-conduction state and therefore the energy in the main discharge capacitor 1 will not be consumed any more than is needed for producing the desired quantity of light, thereby attaining a reduction of energy and a longer life for the power source battery. In addition, the advantages of the device according to the present invention include the elimination of the possibility of any operation errors, etc.

What is claimed is:

1. A flashlight discharge lamp control system comprising: a DC power source; a main discharge capacitor; a first series circuit comprising a plurality of charging resistors and a trigger capacitor; a second series circuit comprising a flashlight discharge tube and a first control element; said main discharge capacitor and said first and second series circuits being connected in parallel with said DC power source; means applying a trigger pulse to a trigger electrode of said flashlight discharge tube from said trigger capacitor through a switch, including a trigger transformer connected in parallel with said trigger capacitor; means connecting a gate electrode of said first control element to the junction point of said charging resistors, wherein a voltage developed at said junction point is applied to said gate electrode concurrent with the application of said trigger pulse to said trigger electrode; a third series circuit comprising a control capacitor and second control element, said third series circuit being connected in parallel with said first control element; a charging circuit comprising a resistor and a diode for charging said control capacitor from said DC power source, said resistor being connected between one terminal of said DC power source and the junction of said control capacitor and said second control element, and said diode being connected between the electrode of said control capacitor opposite to that connected to said second control element and the other terminal of said power source to hold a charge on said control capacitor when said first control element is non-conductive and said second control element is conductive; and a light receiving circuit for sensing the light reflected from an object and for providing a control voltage corresponding to an integrated value of the amount of reflected light, said light receiving circuit connected to said second control element to apply to the gate electrode thereof the output control voltage and comprising a light sensitive element, a capacitor and a resistor, connected in parallel with each other, wherein when the control voltage reaches a predetermined level and hence said second control element is rendered conductive, said control capacitor discharges through the second control element to thereby allow a current flow through said first control element in the reverse direction.
2. A flashlight discharge lamp control system according to claim 1, wherein the resistor in said light receiving circuit comprises a variable resistor to adjust the gating time of said second control element.
3. A flashlight discharge lamp control system comprising: a DC power source; a main discharge capacitor; a first series circuit comprising a plurality of charging resistors and a trigger capacitor; a second series circuit comprising a flashlight discharge tube and a first control element; said main discharge capacitor and said first and second series circuits being connected in parallel with said DC power source; means applying a trigger pulse to a trigger electrode of said flashlight discharge tube from said trigger capacitor through a switch, including a trigger transformer connected in parallel with said trigger capacitor; means connecting a gate electrode of said first control element to the junction point of said charging resistors, wherein a voltage developed at said junction point is applied to said gate electrode concurrent with the application of said trigger pulse to said trigger electrode; a third series circuit

cuit comprising a control capacitor, second control element and a secondary winding of a pulse transformer, said third series circuit being connected in parallel with said first control element; a charging circuit comprising a resistor and a diode for charging said control capacitor from said DC power source, said resistor being connected between one terminal of said DC power source and the junction of said control capacitor and said second control element, and said diode being connected between the electrode of said control capacitor opposite to that connected to said second control element and the other terminal of said power source; a fourth series circuit comprising a primary winding of said pulse transformer, a further capacitor and a resistor, said fourth series circuit being connected across said DC power source; a third control element connected across the series circuit of said primary winding of said pulse transformer and said further capacitor; and a light receiving circuit for sensing the light reflected from an object and for providing a control voltage corresponding to an integrated value of the amount of reflected light, and light receiving circuit connect to said third control element to apply to the gate electrode thereof the output control voltage and comprising a light sensitive element, a capacitor and a resistor, connected in parallel with each other, wherein when the control voltage reaches a predetermined level and hence said third control element is rendered conductive, said control capacitor discharges through the second control element to thereby allow a current to flow through said first control element in the reverse direction.

4. A flashlight discharge control system comprising: a DC power source; a main discharge capacitor; a first series circuit comprising a plurality of charging resistors and a trigger capacitor; a second series circuit comprising a flashlight discharge tube and a first control element; said main discharge capacitor and said first and second series circuits being connected in parallel with said DC power source; means applying a trigger pulse to a trigger electrode of said flashlight discharge tube from said trigger capacitor through a switch, including a trigger transformer connected in parallel with said trigger capacitor; means connecting a gate electrode of said first control element to the junction point of said charging resistors, wherein a voltage developed at said junction point is applied to said gate electrode concurrent with the application of said trigger pulse to said trigger electrode; a third series circuit comprising a control capacitor and second control element, said third series circuit being connected in parallel with said first control element; a charging circuit comprising a resistor and a diode for charging said control capacitor from said DC power source, said resistor being connected between one terminal of said DC power source and the junction of said control capacitor and said second control element; and said diode being connected between the electrode of said control capacitor opposite to that connected to said second control element and the other terminal of said power

source to hold a charge on said control capacitor when said first control element is non-conductive and said second control element is conductive; and a light receiving circuit connected between the gate electrode and another electrode of said second control element; wherein said light receiving circuit comprises a further capacitor and a photoconductive element connected in parallel with each other between the gate and the cathode electrodes of said second control element, said photoconductive element is further connected to the DC power source through a further resistor, and a still further capacitor and a voltage regulator diode are connected in parallel with the series circuit comprising said photoconductive element and said further resistor, and wherein when said second control element is rendered conductive, said control capacitor discharges through the second control element to thereby allow a current to flow through said first control element in the reverse direction.

5. A flashlight discharge lamp control system comprising: a DC power source; a main discharge capacitor connected across said DC power source; a discharge circuit comprising a serially connected flashlight discharge lamp and a first control element, said discharge circuit being connected across said power source; means for simultaneously triggering said flashlight discharge lamp and said first control element, said simultaneous trigger means comprising a series circuit of a trigger means comprising a series circuit of a trigger capacitor and voltage dividing resistors connected across said main discharge capacitor and further comprising a trigger transformer having a primary winding connected across said trigger capacitor through a switch, the output terminal of said voltage dividing resistors being connected to the gate of said first control element, thereby upon contacting the switch the trigger capacitor discharges through the primary winding to produce a high trigger voltage in the secondary winding of the trigger transformer and at the same time a divided voltage of said main discharge capacitor is developed in the voltage dividing resistors to render said first control element conductive; light receiving circuit means for sensing the light reflected from an object and for providing a control voltage signal corresponding to an integrated value of the amount of reflected light; a control circuit comprising a serially connected second control element and a control capacitor connected for charging from said power source; means applying said control voltage signal from said light receiving circuit means to control conduction of said second control element, said second control element being rendered conductive upon said control voltage signal reaching a predetermined value; means to discharge said control capacitor upon conduction of said second control element, wherein discharge current from said discharge circuit flows through said first control element in a reverse direction with respect to its normal conduction thereby resulting in termination of the discharge of said discharge lamp.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,878,429
DATED : April 15, 1975
INVENTOR(S) : HIROSHI IWATA

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Item [73] Assignee: has been deleted.
Item [73] Assignee should read as follows:

Item [73] Assignee: West Electric Co., LTD.
Osaka, Japan

Signed and Sealed this

second Day of December 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks