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(54) ELECTRONIC FLASH APPARATUS WITH EXPOSURE-MEASURING AND FLASH LIMITING DEVICE

(71) We, FRANKE & HEIDECKE G.m.b.H., a German Body Corporate, trading as ROLLEI-WERKE FRANKE & HEIDECKE, of 196 Salzdhumerstrasse, Braunschweig, Germany, 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:—

10 The present invention relates to an electronic flash apparatus having an electronic flash tube, means for initiating a flash in said tube, means for terminating a flash in progress in said tube, and exposure-measuring and flash-terminating circuitry for operating said flash terminating means, said circuitry including a light-sensitive element and an integrating capacitor having terminals connected together so said light-sensitive element and said integrating capacitor are in series with each other, a voltage source for said exposure-measuring and flash-terminating circuitry, said voltage source including means for supplying a higher voltage point and a lower voltage point for energizing said exposure-measuring and flash-terminating circuitry, and a thyristor having an anode, a cathode, and a control electrode, said thyristor being effective when conductive to cause said terminating means to terminate a flash.

30 In a known electronic flash apparatus of this kind the series-connection of a photo-transistor and an integrating capacitor is connected between the positive and negative poles of the voltage source for the exposure-measuring and flash-limiting device. The control electrode of the thyristor is connected with the connection point between the emitter of the photo-transistor and the integrating capacitor, and the cathode of the thyristor is connected with the adjustable resistor of a voltage divider. When a specific capacitor voltage is reached the thyristor is ignited and the flash discharge is broken off in known manner. The ignition threshold of the thyristor can be adjusted by the variable resistor connected to the cathode.

50 In the case of this circuit arrangement

it has proved that the electronic flash apparatus switches off with considerable time delay in the close-up range, that is in the case of a short distance between the flash apparatus and the subject, so that the photographic images are always over-exposed. Therefore it has already been proposed to connect the cathode of the thyristor on the one hand to the centre tapping of a voltage divider circuit which is energised only during the flash tube discharge, and on the other hand through a capacitor with the lower potential side of this voltage divider circuit. In this way the cathode potential of the thyristor increases in time-dependence in a predeterminable manner in the short-time range after ignition of the flash tube, whereby the threshold voltage of the capacitor necessary for the ignition of the thyristor is reduced in this range. The ignition pulse for the interruption of the flash light thus takes place slightly earlier than is required by the quantity of light measured by the photo-transistor, whereby the over-exposure of the photographic image is compensated.

The setting of the voltage threshold value at which the thyristor ignites, at two different points, namely on the control electrode and on the cathode of the thyristor, has the effect of making the adjustment of the exposure-measuring and flash-limiting device more difficult. Moreover the apparatus becomes more trouble-prone, so that careful attention must be given to a mutually screened spatial arrangement of pulse-generating circuits within the apparatus.

Therefore the present invention provides an electronic flash apparatus of the initially stated kind which is more easily adjustable and less delicate.

According to the present invention there is provided an electronic flash apparatus having an electronic flash tube, means for initiating a flash in said tube, means for terminating a flash in progress in said tube, and exposure-measuring and flash-terminating circuitry for operating said flash terminating means, said circuitry including a light-sensitive element and an integrating

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capacitor having terminals connected together so said light-sensitive element and said integrating capacitor are in series with each other, a voltage source for said exposure-measuring and flash-terminating circuitry, said voltage source including means for supplying a higher voltage point and a lower voltage point for energizing said exposure-measuring and flash-terminating circuitry, and a thyristor having an anode, a cathode, and a control electrode, said thyristor being effective when conductive to cause said terminating means to terminate a flash, said flash apparatus being characterized by the facts that:

- a. a terminal of said integrating capacitor opposite from said terminal connected to said light-sensitive element is connected directly to said higher voltage point;
- b. a terminal of said light-sensitive element opposite from said terminal connected to said integrating capacitor is connected directly to said lower voltage point;
- c. the control electrode to cathode path of said thyristor is connected in parallel with said integrating capacitor, and
- d. a resistor is connected in parallel with said integrating capacitor and arranged for discharging said integrating capacitor after each flash.
- e. means connected between said higher and lower voltage points for maintaining the constancy of the voltage between said points.

To improve the response sensitivity of the exposure-measuring and flash-terminating circuitry in the close-up range, the apparatus may further comprise means for actuating said voltage source at the beginning of a flash in said tube to provide said higher voltage point and said lower voltage point, and another capacitor connected in parallel with said light-sensitive element to co-operate with said integrating capacitor in forming a capacitive voltage divider. In this way the object is achieved that in the case of very short times between the switching on of the exposure-measuring circuit and the response of the flash-limiting circuit, such as occur in the case of a short distance between flash unit and subject, the flash-limiting circuit responds with a certain time lead before the reaching of the threshold value of the measured light quantity set for optimum exposure, and thus the over-exposure error ordinarily occurring in the close-up range is largely suppressed.

According to a preferred feature of the invention the apparatus further comprises a voltage divider connected directly in parallel with said integrating capacitor, and the cathode of said thyristor being con-

nected directly to a center tap of said voltage divider.

The circuitry of the apparatus of the invention is illustrated in two examples of embodiment in the accompanying drawing, wherein:—

Figure 1 shows the circuit diagram of the electronic flash apparatus according to the invention, and

Figure 2 shows the circuit diagram of the apparatus according to Figure 1 in which additional measures have been taken to facilitate the dimensioning of the individual circuit elements.

In Figure 1, 1 designates the storage capacitor of the electronic flash apparatus, which is charged up to working voltage, for example 360 volts direct-current voltage, through a voltage transformer or voltage converter 2. Parallel with the storage capacitor there are arranged an electronic flash tube 3 and an electronic switch in the form of a thyatron 4. The flash tube 3 is ignited by a universally known ignition device 5 which is operable together with the camera release. The thyatron 4 is ignited through an ignition electrode which is connected with the secondary winding of a pulse transformer 6 the primary winding of which lies in the discharge circuit of an extinguishing capacitor 7.

The pulse transformer 6 and extinguishing capacitor 7 are components of the exposure-measuring and flash-limiting device and connected in series with an extinguishing thyristor 8. The capacitor 7 can be charged up to working voltage through a resistor 9. The exposure-measuring device consists of an integrating capacitor 10 and a photo-transistor 11 which are connected in series and connected to the voltage supply of the exposure-measuring and flash-limiting device. The voltage supply is formed from a capacitor 12 which in series with a resistor 13 and a Zener diode 14 is connected in parallel with the storage capacitor 1 and the flash tube 3. When the flash tube is conductive the capacitor 12 discharges through the resistor 13, the flash tube 3 and the Zener diode 14, and a constant voltage is present on the Zener diode 14 for the duration of the capacitor discharge and for the duration of the flash radiation by the flash tube 3. The integrating capacitor 10 is here connected to the upper potential and the photo-transistor to the lower potential of the potential difference present on the Zener diode. The cathode of the thyristor 8 is connected to the connection point between the integrating capacitor 10 and photo-transistor 11 and the control electrode of the thyristor 8 is connected to the other plate of the integrating capacitor 10, so that the integrating capacitor 10 is connected in parallel with

the control electrode-cathode path of the thyristor 8. A resistor 15 is connected in parallel with the integrating capacitor 10 and a capacitor 16 is connected in parallel with the photo-transistor 11. The manner of operation of this circuit arrangement is as follows:—

When the electronic flash apparatus is ready to flash, the storage capacitor 1 is charged up directly, the extinguishing capacitor 7 is charged up through the resistors 9 and 15 and the capacitor 12 is charged up through the resistor 13 and the Zener diode 14, in each case to working voltage, for example 360 volts direct-current voltage. On release of the camera the ignition device 5 is actuated which applies an ignition pulse to the ignition electrode of the electronic flash tube 3, so that the latter ignites through. The storage capacitor 1 discharges through the flash tube 3, whereby the latter radiates a light flash. At the same time the capacitor 12 also discharges in the manner as described, and a constant voltage is present on the series connection of integrating capacitor 10 and photo-transistor 11.

The light flash radiated by the flash tube strikes upon the subject, is reflected there and arrives at the photo-transistor 11. According to the intensity of the arriving light, the integrating capacitor 10 charges itself up more or less quickly, whereby the cathode potential of the thyristor 8 is reduced in relation to its control electrode potential. When the potential difference reaches the magnitude of the ignition voltage of the thyristor, the latter switches through and the extinguishing capacitor 7 discharges itself through the thyristor 8 and the primary winding of the pulse transformer 6. As a result of the current flux through the primary winding of the pulse transformer a pulse is generated in its secondary winding which arrives at the ignition electrode of the thyatron 4 and ignites the latter. Since the thyatron has a substantially lower burning voltage than the flash tube, the thyatron takes over the discharge current of the capacitor 1 and consequently the flash tube 3 is extinguished.

The capacitor 16 improves the response sensitivity of the exposure-measuring and flash-limiting device in the close-up range. At the beginning of the flash discharge the capacitors 10 and 16 charge up very rapidly, the cathode potential of the extinguishing thyristor 8 being reduced in relation to its control grid potential. The capacitors 10 and 16, acting as capacitive voltage dividers during the charging, are here so dimensioned that the voltage difference on the capacitor 10, that is between the control electrode and the cathode of the thyris-

tor 8, remains less than the ignition voltage of the thyristor.

When the light reflected from the subject strikes upon the photo-transistor 11 the capacitor 10 charges up until the potential difference on its plates exceeds the ignition voltage of the thyristor. Since the capacitor 10 already has a voltage difference between its plates at the moment when the light flux reflected by the subject strikes upon the photo-transistor 11, a lower charging of the integrating capacitor 10, which takes place by the current caused in the photo-transistor as a result of the light flux, is necessary for the ignition of the thyristor 8. Thus the capacitor is charged up to the ignition voltage of the thyristor 8 in a substantially shorter time, so that as a whole the exposure-measuring and flash-limiting device can already respond at very short times such as occur in the case of a short distance between the flash unit or camera and the subject. The resistor 15 renders possible the discharge of the extinguishing capacitor 10 after the interruption of the flash discharge, so that at the next measurement the capacitor 10 is again fully discharged.

In Figure 2 the circuit arrangement of the electronic flash apparatus according to the invention as shown in Figure 1 is slightly modified in which the characteristic values of the individual circuit elements are altered. Here a voltage divider circuit consisting of the resistors 17 and 18 is connected in parallel with the integration capacitor 10 and the cathode of the extinguishing thyristor 8 is connected to the divider tapping of this voltage divider. The remainder of the formation is identical with the circuit arrangement according to Figure 1. The operation of this circuit arrangement corresponds to that as described with reference to Figure 1.

WHAT WE CLAIM IS:—

1. An electronic flash apparatus having an electronic flash tube, means for initiating a flash in said tube, means for terminating a flash in progress in said tube, and exposure-measuring and flash-terminating circuitry for operating said flash terminating means, said circuitry including a light-sensitive element and an integrating capacitor having terminals connected together so said light-sensitive element and said integrating capacitor are in series with each other, a voltage source for said exposure-measuring and flash-terminating circuitry, said voltage source including means for supplying a higher voltage point and a lower voltage point for energizing said exposure-measuring and flash-terminating circuitry, and a thyristor having an anode, a cathode, and a control electrode, said thyristor being



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the control electrode-cathode path of the thyristor 8. A resistor 15 is connected in parallel with the integrating capacitor 10 and a capacitor 16 is connected in parallel with the photo-transistor 11. The manner of operation of this circuit arrangement is as follows:—

When the electronic flash apparatus is ready to flash, the storage capacitor 1 is charged up directly, the extinguishing capacitor 7 is charged up through the resistors 9 and 15 and the capacitor 12 is charged up through the resistor 13 and the Zener diode 14, in each case to working voltage, for example 360 volts direct-current voltage. On release of the camera the ignition device 5 is actuated which applies an ignition pulse to the ignition electrode of the electronic flash tube 3, so that the latter ignites through. The storage capacitor 1 discharges through the flash tube 3, whereby the latter radiates a light flash. At the same time the capacitor 12 also discharges in the manner as described, and a constant voltage is present on the series connection of integrating capacitor 10 and photo-transistor 11.

The light flash radiated by the flash tube strikes upon the subject, is reflected there and arrives at the photo-transistor 11. According to the intensity of the arriving light, the integrating capacitor 10 charges itself up more or less quickly, whereby the cathode potential of the thyristor 8 is reduced in relation to its control electrode potential. When the potential difference reaches the magnitude of the ignition voltage of the thyristor, the latter switches through and the extinguishing capacitor 7 discharges itself through the thyristor 8 and the primary winding of the pulse transformer 6. As a result of the current flux through the primary winding of the pulse transformer a pulse is generated in its secondary winding which arrives at the ignition electrode of the thyristor 4 and ignites the latter. Since the thyristor has a substantially lower burning voltage than the flash tube, the thyristor takes over the discharge current of the capacitor 1 and consequently the flash tube 3 is extinguished.

The capacitor 16 improves the response sensitivity of the exposure-measuring and flash-limiting device in the close-up range. At the beginning of the flash discharge the capacitors 10 and 16 charge up very rapidly, the cathode potential of the extinguishing thyristor 8 being reduced in relation to its control grid potential. The capacitors 10 and 16, acting as capacitive voltage dividers during the charging, are here so dimensioned that the voltage difference on the capacitor 10, that is between the control electrode and the cathode of the thyris-

tor 8, remains less than the ignition voltage of the thyristor.

When the light reflected from the subject strikes upon the photo-transistor 11 the capacitor 10 charges up until the potential difference on its plates exceeds the ignition voltage of the thyristor. Since the capacitor 10 already has a voltage difference between its plates at the moment when the light flux reflected by the subject strikes upon the photo-transistor 11, a lower charging of the integrating capacitor 10, which takes place by the current caused in the photo-transistor as a result of the light flux, is necessary for the ignition of the thyristor 8. Thus the capacitor is charged up to the ignition voltage of the thyristor 8 in a substantially shorter time, so that as a whole the exposure-measuring and flash-limiting device can already respond at very short times such as occur in the case of a short distance between the flash unit or camera and the subject. The resistor 15 renders possible the discharge of the extinguishing capacitor 10 after the interruption of the flash discharge, so that at the next measurement the capacitor 10 is again fully discharged.

In Figure 2 the circuit arrangement of the electronic flash apparatus according to the invention as shown in Figure 1 is slightly modified in which the characteristic values of the individual circuit elements are altered. Here a voltage divider circuit consisting of the resistors 17 and 18 is connected in parallel with the integration capacitor 10 and the cathode of the extinguishing thyristor 8 is connected to the divider tapping of this voltage divider. The remainder of the formation is identical with the circuit arrangement according to Figure 1. The operation of this circuit arrangement corresponds to that as described with reference to Figure 1.

WHAT WE CLAIM IS:—

1. An electronic flash apparatus having an electronic flash tube, means for initiating a flash in said tube, means for terminating a flash in progress in said tube, and exposure-measuring and flash-terminating circuitry for operating said flash terminating means, said circuitry including a light-sensitive element and an integrating capacitor having terminals connected together so said light-sensitive element and said integrating capacitor are in series with each other, a voltage source for said exposure-measuring and flash-terminating circuitry, said voltage source including means for supplying a higher voltage point and a lower voltage point for energizing said exposure-measuring and flash-terminating circuitry, and a thyristor having an anode, a cathode, and a control electrode, said thyristor being

effective when conductive to cause said terminating means to terminate a flash, said flash apparatus being characterized by the facts that:

- 5 a. a terminal of said integrating capacitor opposite from said terminal connected to said light-sensitive element is connected directly to said higher voltage point;
- 10 b. a terminal of said light-sensitive element opposite from said terminal connected to said integrating capacitor is connected directly to said lower voltage point;
- 15 c. the control electrode to cathode path of said thyristor is connected in parallel with said integrating capacitor, and
- 20 d. a resistor is connected in parallel with said integrating capacitor and arranged for discharging said integrating capacitor after each flash.
- e. means connected between said higher and lower voltage points for maintaining the constancy of the voltage between said points.
- 25 2. A flash apparatus as claimed in claim 1, further comprising means for actuating said voltage source at the beginning of a

flash in said tube to provide said higher voltage point and said lower voltage point, and another capacitor connected in parallel with said light-sensitive element to co-operate with said integrating capacitor in forming a capacitive voltage divider.

3. A flash apparatus as claimed in claim 1, further comprising a voltage divider connected directly in parallel with said integrating capacitor, and the cathode of said thyristor being connected directly to a center tap of said voltage divider.

4. A flash apparatus as claimed in claim 3, further comprising means for actuating said voltage source at the beginning of a flash in said tube to provide said higher voltage point and said lower voltage point, and another capacitor connected in parallel with said light-sensitive element to co-operate with said integrating capacitor in forming a capacitive voltage divider.

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