

PATENT SPECIFICATION

(11) 1 225 917

DRAWINGS ATTACHED



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- (21) Application No. 37410/69 (22) Filed 25 July 1969
- (31) Convention Application No. 747 714 (32) Filed 25 July 1968 in
- (33) United States of America (US)
- (45) Complete Specification published 24 March 1971
- (51) International Classification G 03 b 15/03
- (52) Index at acceptance
 - G2A 1G 1H 1K1 1KY
 - G1A 205 206 247 248 269 300 302 309 325 357 358 359
 - 369 372 378 380 391 393 39X 502 504 506 524
 - 52Y 53X 53Y 543 615 773 790 798 79Y
 - H2H 14 2B7
 - H3T 1CX 2A1N 2B5 2E 2RX 2S 2T2Z 2T3J 2T3TX 2T5
 - 2V 2W2 3D
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(54) IMPROVEMENTS IN OR RELATING TO FLASH APPARATUS

(71) We, HONEYWELL INC., a Corporation organised and existing under the laws of the State of Delaware, United States of America, of 2701, Fourth Avenue South, Minneapolis, Minnesota, 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 flash apparatus for use in photography.

Electronic photographic flash apparatus is known in which the flash produced by the flash tube within the apparatus is automatically terminated after a predetermined total quantity of light has been received from the photographed scene or subject by a light responsive control circuit included in the apparatus. This is done with the intention of causing the quantity of light reaching the film of the associated camera, during each exposure, to be independent of the camera to subject distance i.e. the distance between the location of the camera and the flash apparatus and the location of the subject.

Such apparatus is described, for example, in British Patent Specifications Nos. 1,108,615, 1,117,057, 1,117,058 and 1,145,296. While such apparatus has been generally satisfactory, there still exists a need for improved apparatus which operates more accurately and reliably under varying conditions, than has been the case previously.

According to the present invention, there is provided flash apparatus for use in photography comprising circuit means operable to initiate a flash, a light responsive control circuit arranged to generate an output signal when a light sensitive device within the control circuit has been exposed to a predetermined total quantity of light, terminating

means responsive to an output signal from the control circuit either effectively to terminate the flash or to actuate means for otherwise effectively terminating the exposure of the film in an associated camera and gating means for controlling the operative condition of the light responsive control circuit, said gating means being coupled to said circuit means at points across which a significant voltage change occurs on initiation of a flash, and being arranged to operate so that the control circuit is free to operate only for a period following the occurrence of said voltage change. .

Examples of flash apparatus according to the present invention will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a circuit diagram of a first flash apparatus, and

Figures 2 and 3 are circuit diagrams of parts of modified flash apparatus.

Referring to Figure 1 of the drawings, the flash apparatus is an electronic one which includes a conventional type of electronic flash tube and firing circuit, together with a light responsive control circuit. The purpose of the control circuit is automatically to control the termination of any flash produced by the tube, when a predetermined quantity of light has been received back by the apparatus from the subject being photographed. Thus, the apparatus is one which automatically controls the duration of the flash produced by the flash tube in such manner as is necessary to cause a predetermined total quantity of light from the illuminated subject to fall on the film exposed in an associated camera (not shown).

As shown, the apparatus includes a storage capacitor 1, which is connected between conductors 2 and 3 and a flash tube 4 having

main electrodes 6 and 7 which are connected, respectively to the conductors 2 and 3, and a trigger electrode 8. Trigger electrode 8 is connected to one end of the secondary winding 10 of a trigger transformer 5, the other end of the winding being connected to the conductor 3.

A resistor 11 and a normally open firing switch 12 are connected in series between the conductors 2 and 3 and have a common junction 13. The switch 12 is intended to represent the usual camera shutter flash contacts for example or the open flash or test switch of the flash apparatus. The primary winding 9 of transformer 5 is connected in series with a trigger capacitor 14 between the junction 13 and the conductor 3, i.e. across the switch 12. The conductors 2 and 3 are connected to terminals 15 and 16 which in operation are connected to a suitable D.C. voltage source for charging the capacitor 1, conductor 2 being positive with respect to conductor 3.

In operation, the capacitor 1 is normally maintained in a charged state by the source connected to terminals 15 and 16 so that a relatively high voltage is maintained between the conductors 2 and 3. The capacitor 14 is also normally maintained charged, by virtue of its connection to the conductors 2 and 3 through the resistor 11 and winding 9.

When the flash tube 4 is to be fired to initiate a flash, the switch 12 is closed. This discharges the capacitor 14 through the winding 9, with the result that a trigger pulse is applied between the electrodes 8 and 7. This fires the tube 4 and causes it to conduct and to emit light. In the absence of the automatic control circuit to be described, the tube 4 would continue to emit light until the charge on the capacitor 1 drops sufficiently that the voltage between the conductors 2 and 3, is insufficient to maintain a discharge in the tube 4 so that it is extinguished. Thereafter, the capacitors 1 and 14 are recharged to be ready for the next firing of the tube 4.

The control circuit is one in accordance with claim 1 of our copending U.K. Patent Application No. 37412/69 (Serial No. 1,225,918) and includes a light activated silicon controlled rectifier (LASCR) 17 which is arranged on the apparatus to be exposed to light coming from the scene which is to be illuminated by the flash tube and which is to be photographed. The rectifier 17 has an anode 18, a cathode 19, and a gate 20. An energising circuit for the rectifier 17, consisting of a power switch 21 and resistors 22, 23, and 24 in series is connected between the conductors 2 and 3. A Zener diode 27 is connected in parallel with the resistor 24. The anode 18 is connected to the junction 25 between resistors 22 and 23, while the cathode 19 is connected to a slider 28 which

is adjustable along the resistor 24. A capacitor 29 is connected between the slider 28 and the conductor 3 and a diode 30 is connected between the cathode 19 and the junction 26.

An integrating capacitor 31 and an anticipation resistor 32 are connected in series between the gate 20 of rectifier 17 and the conductor 3. The inclusion of the resistor 32 is in accordance with the invention claimed in our co-opending U.K. Patent Application No. 37409/69 (Serial No. 1,225,916). A further capacitor 33 is connected directly between the gate 20 and the cathode 19.

The control circuit also includes a quench trigger transformer 34 having a primary and secondary windings 35 and 36, the trigger electrode 40 and one main electrode 39 of a quench tube 37 being connected to the control circuit by connection across the secondary winding 36. The secondary winding 35 is connected in series with a trigger capacitor 41 between the junctions 25 and 26, the capacitor 41 thus normally being charged to the potential drop across the resistor 23 so long as the rectifier 17 is non-conducting. The main electrodes 38 and 39 of the quench tube 37 are connected respectively to the conductors 2 and 3, so that the quench tube 37 is connected directly in parallel with the flash tube 4.

The quench tube 37 must, when conducting, have an impedance which is low relative to that of the flash tube 4. The latter may typically have an impedance of about 1.5 to 2 ohms and the tube 37 should for example then have an impedance of about 0.1 ohm. This can be achieved for example by low gas pressure within the tube and small electrode spacing. In addition, the tube 37 must be capable of carrying a high current for a short period and of being triggered readily whatever value the voltage across its main electrodes 38 and 39 may become whilst the flash tube 4 is discharging. By way of example, suitable tubes have been provided in which the main electrode spacing is 0.5 cms, the gas (Xenon) pressure was 100 mms of mercury and the main electrodes were of doped sintered tungsten.

In accordance with the present invention the flash apparatus further includes a gating circuit, the circuit of NPN transistor 42, which, as will be explained, operates to prevent untimely operation of the control circuit. This is accomplished by arranging that the transistor 42 normally disables the control circuit and enables it only upon the firing of the flash tube 4. To this end, the collector of the transistor 42 is connected to that side of the capacitor 31 which is connected to the gate 20, while the emitter is connected to the conductor 3, thus placing the collector-emitter path of the transistor

42 across the capacitor 31 and resistor 32. The base is connected through a resistor 43 to the junction 13, so that the base-emitter path of the transistor 42 is connected in series with the resistors 11 and 43 between the conductors 2 and 3. The base-emitter path of the transistor 42 in series with the resistor 43 is thus connected between the junction 13 and the conductor 3, i.e. across the switch 12. These constitute points across which a significant voltage change occurs upon the firing of the flash tube 4, this change being produced by the closure of the switch 12 to effect firing of the tube 4. At the same time when the tube is fired, the voltage between conductors 2 and 3 will drop due to the discharge of the capacitor 1.

In operation, with flash tube 4 not conducting, the capacitor 1 has its normal operating charge, and the apparatus is thus in condition to fire the flash tube 4 on closing the switch 12. In these circumstances, the tubes 4 and 37, and the rectifier 17, are all non-conducting and the voltage between the conductors 2 and 3 produces such a base bias on the gating transistor 42 that the latter is fully conducting, causing its collector-emitter path effectively to short-circuit the capacitor 31 and resistor 32. The gate 20 of the rectifier 17 is thus effectively clamped to the cathode 19, neglecting the voltage across the capacitor 29, and the rectifier 17 is held non-conducting thus disabling the control circuit. In this condition, the rectifier 17 and thus the quench tube 37 are prevented from being actuated or affected by extraneous causes, which might otherwise prematurely fire the quench tube 37 and prevent proper operation of the apparatus upon subsequent firing of the flash tube.

If the switch 12 is closed, thereby firing the flash tube 4, junction 13 is connected directly to the conductor 3 removing the base bias from the transistor 42 and rendering it non-conducting. The gating circuit therefore no longer disables the control circuit. The following re-opening of the switch 12, which usually occurs almost at once, does not cause the gating circuit to disable the control circuit again, however, since the discharge in the tube 4 will have by then so reduced the charge on the capacitor 1, and thus the voltage between the conductors 2 and 3, that there will then be insufficient base bias on the transistor 42 to render it conducting. This effect will be enhanced by the voltage drop across the resistor 11 which will result from the charging current for the capacitor 14 which will flow at that time.

In all normal circumstances, light will commence to fall on the rectifier 17 as a result of the operation of the flash tube 4, causing the generation of a current in the photo-electric junction of it which is proportional to the intensity of the incident

light and which charges the integrating capacitor 31, through the anticipation resistor 32. This produces an integration voltage V_i across the capacitor 31 in accordance with the equation:

$$V_i = \frac{1}{C} \int i \, dt,$$

where C is the capacitance of the capacitor 31, and i is the photo current generated in the rectifier 17.

In other words the charge and voltage on the capacitor 31 are proportional to the integral of the intensity of the light incident on the rectifier 17 from the time of the turning off of the transistor 42.

The flow of the photo current through the anticipation resistor 32 produces across the latter an anticipation voltage V_a of a magnitude which is proportional to said incident light intensity, and which can be expressed by the equation:

$$V_a = i R$$

where R is the resistance of the resistor 32. The practical importance of this anticipation voltage is discussed in the specification of our co-pending Patent Application No. 37409/69 (Serial No. 1,225,916).

The sum of the integration voltage V_i and the anticipation voltage V_a effectively appears as a control voltage between the gate 20 and the cathode 19 of the rectifier 17 but in addition to the voltage across that part of the resistor 24 which is connected across the capacitor 29. This latter voltage is an adjustable bias voltage which determines at what value of the control voltage the rectifier 17 will switch to a conducting condition.

As light continues to fall on the rectifier 17, the control voltage will increase until the gate trigger voltage of the rectifier 17 is exceeded. When this occurs, the rectifier 17 switches to a conducting state. This causes the anode-cathode path of the rectifier 17 effectively to short-circuit the resistor 23 and to discharge the capacitor 41 through the winding 35 of the quench trigger transformer 34. This in turn causes the generation of a trigger pulse constituting an output signal from the control circuit. This trigger pulse is applied across the electrodes 40 and 39 of the quench tube 37 which then fires effectively short-circuiting the flash tube 4 and so terminating the discharge in it.

The discharge of the capacitor 41 charge produces a ringing action which back-biases the rectifier 17 and positively turns it off following the generation of a trigger pulse. Thus, the rectifier 17 is returned to its normal, non-conducting state, ready for the next flash-controlling operation. It should

be noted that references to the rectifier 17 being either conducting or non-conducting are intended to refer to the anode-cathode discharge path only and not to the photo-current which charges the capacitor 31.

Subsequent to the quenching of the flash tube 4, the voltage between the conductors 2 and 3 rises sufficiently, as the capacitor 1 is recharged, to bias the transistor 42 so that it becomes fully conducting again. The transistor 42 is then turned on again, disabling the control circuit and discharging the capacitor 31 ready for the next integrating operation.

The purpose of the switch 21 is to permit the automatic action of the control circuit to be entirely suspended so that the flash tube and circuit can operate conventionally if this is desired. The purpose of the capacitor 33 which is connected directly across the gate and cathode of the rectifier 17, is to reduce the tendency of the rectifier 17 to be triggered by random incident rotation. The capacitor 33 also serves to increase the maximum value of rate of change of anode voltage which the rectifier 17 can tolerate without being turned on.

As previously noted, the voltage across that part of the resistor 24, which is connected across the capacitor 29, is an adjustable bias voltage the value of which determines the value of the control voltage which will turn on the rectifier 17. The value of this bias voltage is determined by the adjusted position of the contact 28. This voltage is held substantially constant, when once set, by the storage action of the capacitor 29, and by the action of the Zener diode 27, which maintains the voltage across the resistor 24 constant for all voltages between the conductors 2 and 3 above a predetermined minimum value.

The diode 30 is provided in order effectively to connect the anode-cathode path of the rectifier 17 directly across the resistor 23, when the rectifier 17 is conducting. The diode 30 is normally back biased but as soon as the rectifier 17 becomes conducting, the diode 30 is forward biased, and completes the circuit required to discharge the capacitor 41.

Figure 2 shows the circuit of part of a modified apparatus, the modifications affecting the circuits for firing the flash tube 4 and the gating circuit. The remaining parts of the circuit which are not shown are the same as in Figure 1 and components which are the same as those in Figure 1 have been given the same reference numerals as in Figure 1. The modifications are

- (i) the inclusion of resistors 44 and 45 in series with resistor 11 and switch 12, the resistors 44 and 45 being connected one on either side of the switch 12

- (ii) the base of transistor 42 is connected through the resistor 43 to the junction 46 between resistors 44 and 11, a capacitor 47 being connected in parallel with the resistor 43 and

- (iii) a diode 48 is connected between the base of transistor 42 and the conductor 3.

In operation, prior to the closure of the switch 12, the transistor 42 is biased into a conducting condition. When the switch 12 is closed, the capacitor 14 is discharged through the transformer winding 9, thereby firing the flash tube 4. The closure of the switch 12 also causes the voltage at the junction 46 to drop, thus turning off the transistor 42. The capacitor 47 imparts a snap action to this turning off of the transistor. The subsequent re-opening of the switch 12 does not result in the transistor 42 becoming conducting again, since, as in the apparatus of Figure 1, the voltage across conductors 2 and 3 falls due to the discharge of capacitor 1 by the tube 4. Subsequent to the quenching of the flash tube 4, the voltage between the conductors 2 and 3 rises sufficiently to increase the base bias on the transistor 42, to the point where it again becomes conducting. The diode 48 serves to protect the transistor 42.

Figure 3 shows part of the circuits of yet another modified apparatus. Here again the remainder of the circuit is as shown in Figure 1 and like components have the same references in Figure 1. However the modified gating circuit which it includes could be used with some other form of light responsive control circuit than that which is included in the flash apparatus described with reference to Figure 1.

In Figure 3, the firing circuit for the flash tube 4 is essentially the same as that of Figure 1, except that the primary winding 50 of a transformer 49 which has a secondary winding 51, is connected between the electrode 7 of the flash tube 4 and the conductor 3.

The gating circuit includes a silicon controlled rectifier (SCR) 52 having an anode 53, a cathode 54, and a gate 55. The anode 53 is connected to the junction 25, and the anode 18 of the rectifier (LASCR) 17, which was connected directly to the junction 25 in the apparatus of Figure 1, is now connected to cathode 54 of SCR 52. The gate 55 of the SCR 52 is connected through a resistor 56 and a diode 57 to one end of the transformer winding 51, the other end of which is connected to the SCR cathode 54. A filter capacitor 58 is connected across the diode 57 and the winding 51.

In operation, prior to the closure of the switch 12, the flash tube 4 is not conducting

and no current flows through the winding 50. As a result, there is no voltage produced across the winding 51, and no voltage is applied across the gate and cathode of the SCR 52. The latter does not therefore conduct and the rectifier 17 is disabled. On closure of the switch 12, the flash tube 4 fires and the large discharge current which then flows through the tube 4 also flows through the winding 50. This current induces a voltage pulse across the winding 51 which is rectified and applied across the gate-cathode junction of the SCR 52. As a result, the latter is switched on, thereby enabling the rectifier 17. The terminals of the winding 51 are points across which in operation a significant change in voltage occurs which is related to the firing of the tube 4, this change being utilised to control the light responsive control circuit constituted by the circuit associated with the rectifier 17.

The time constant of the capacitor 58 and the resistor 56 is chosen so that the SCR 52 remains conducting for the duration of the flash. Subsequent to the termination of the flash, the SCR 52 is turned off and the rectifier 17 is once again disabled. Accordingly, the SCR 52 performs a gating operation which is similar to that performed by the transistor 42 in the circuits described with reference to Figures 1 and 2.

It should be appreciated that the present invention can be used advantageously in apparatus having a light responsive control circuit other than the particular circuit described with reference to Figure 1 and further that this circuit may be employed in flash apparatus other than of the kind employing electronic flash tubes. Thus it may be employed for example in flash bulb apparatus equipped with means for terminating the radiation of flash light towards the scene being photographed and thus effectively terminating the flash by interrupting the passage of light from the bulb to the scene in response to a trigger pulse. Examples of such apparatus are described in the specification of our co-pending British Patent Application No. 2809/69 (Serial No. 1,201,236). The circuits may further be employed in flash apparatus in which a pulse-actuated terminating means terminates the exposure of the film by interrupting the passage of light to it, for example by the use of a shutter, instead of by stopping the production of light by the flash device or by interrupting the passage of the light from the flash device.

WHAT WE CLAIM IS:—

1. Flash apparatus for use in photography comprising circuit means operable to initiate a flash, a light responsive control circuit arranged to generate an output signal when a light sensitive device within the control circuit has been exposed to a predetermined

total quantity of light, terminating means responsive to an output signal from the control circuit either effectively to terminate the flash or to actuate means for otherwise effectively terminating the exposure of the film in an associated camera and gating means for controlling the operative condition of the light responsive control circuit, said gating means being coupled to said circuit means at points across which a significant voltage change occurs on initiation of a flash, and being arranged to operate so that the control circuit is free to operate only for a period following the occurrence of said voltage change.

2. Flash apparatus according to Claim 1 in which said circuit means includes a firing circuit in which a capacitor is normally charged and is discharged on operation of the circuit means to initiate a flash and the gating means is coupled across points in the circuit means the potential difference between which is dependent on the voltage across the capacitor.

3. Flash apparatus according to Claim 2 which is of the kind including an electronic flash tube, the main electrodes of which are connected in parallel with a storage capacitor across connections for charging the storage capacitor to a suitable voltage, and in which the firing circuit is connected across the same connections whereby the potential difference between said points falls when the storage capacitor is discharged so that the voltage change is maintained for an interval following initiation of a flash.

4. Flash apparatus according to any one of Claims 1 to 3 in which said gating means comprises a transistor switching circuit and means for deriving a bias signal for the transistor switching circuit by connections to said circuit means at points which are normally at a potential difference such as to bias the transistor switching circuit to a conducting condition but at which a significant change in potential occurs on initiating a flash such that the bias on the transistor switching circuit changes so that it becomes non-conducting, the transistor switching circuit being connected to the light responsive control circuit so as to clamp it in a non-operative condition while the switching circuit is conducting.

5. Flash apparatus substantially as that described in this specification with reference to either Figure 1 or Figure 2 of the drawings.

6. Flash apparatus according to Claim 1 which is of the kind including an electronic flash tube, the main electrodes of which are connected in parallel with a storage capacitor to a suitable voltage, and in which the primary circuitry of a pulse transformer is connected in series with the main discharge gap of the flash tube, the gating

and no current flows through the winding 50. As a result, there is no voltage produced across the winding 51, and no voltage is applied across the gate and cathode of the SCR 52. The latter does not therefore conduct and the rectifier 17 is disabled. On closure of the switch 12, the flash tube 4 fires and the large discharge current which then flows through the tube 4 also flows through the winding 50. This current induces a voltage pulse across the winding 51 which is rectified and applied across the gate-cathode junction of the SCR 52. As a result, the latter is switched on, thereby enabling the rectifier 17. The terminals of the winding 51 are points across which in operation a significant change in voltage occurs which is related to the firing of the tube 4, this change being utilised to control the light responsive control circuit constituted by the circuit associated with the rectifier 17.

The time constant of the capacitor 58 and the resistor 56 is chosen so that the SCR 52 remains conducting for the duration of the flash. Subsequent to the termination of the flash, the SCR 52 is turned off and the rectifier 17 is once again disabled. Accordingly, the SCR 52 performs a gating operation which is similar to that performed by the transistor 42 in the circuits described with reference to Figures 1 and 2.

It should be appreciated that the present invention can be used advantageously in apparatus having a light responsive control circuit other than the particular circuit described with reference to Figure 1 and further that this circuit may be employed in flash apparatus other than of the kind employing electronic flash tubes. Thus it may be employed for example in flash bulb apparatus equipped with means for terminating the radiation of flash light towards the scene being photographed and thus effectively terminating the flash by interrupting the passage of light from the bulb to the scene in response to a trigger pulse. Examples of such apparatus are described in the specification of our co-pending British Patent Application No. 2809/69 (Serial No. 1,201,236). The circuits may further be employed in flash apparatus in which a pulse-actuated terminating means terminates the exposure of the film by interrupting the passage of light to it, for example by the use of a shutter, instead of by stopping the production of light by the flash device or by interrupting the passage of the light from the flash device.

WHAT WE CLAIM IS:—

1. Flash apparatus for use in photography comprising circuit means operable to initiate a flash, a light responsive control circuit arranged to generate an output signal when a light sensitive device within the control circuit has been exposed to a predetermined

total quantity of light, terminating means responsive to an output signal from the control circuit either effectively to terminate the flash or to actuate means for otherwise effectively terminating the exposure of the film in an associated camera and gating means for controlling the operative condition of the light responsive control circuit, said gating means being coupled to said circuit means at points across which a significant voltage change occurs on initiation of a flash, and being arranged to operate so that the control circuit is free to operate only for a period following the occurrence of said voltage change.

2. Flash apparatus according to Claim 1 in which said circuit means includes a firing circuit in which a capacitor is normally charged and is discharged on operation of the circuit means to initiate a flash and the gating means is coupled across points in the circuit means the potential difference between which is dependent on the voltage across the capacitor.

3. Flash apparatus according to Claim 2 which is of the kind including an electronic flash tube, the main electrodes of which are connected in parallel with a storage capacitor across connections for charging the storage capacitor to a suitable voltage, and in which the firing circuit is connected across the same connections whereby the potential difference between said points falls when the storage capacitor is discharged so that the voltage change is maintained for an interval following initiation of a flash.

4. Flash apparatus according to any one of Claims 1 to 3 in which said gating means comprises a transistor switching circuit and means for deriving a bias signal for the transistor switching circuit by connections to said circuit means at points which are normally at a potential difference such as to bias the transistor switching circuit to a conducting condition but at which a significant change in potential occurs on initiating a flash such that the bias on the transistor switching circuit changes so that it becomes non-conducting, the transistor switching circuit being connected to the light responsive control circuit so as to clamp it in a non-operative condition while the switching circuit is conducting.

5. Flash apparatus substantially as that described in this specification with reference to either Figure 1 or Figure 2 of the drawings.

6. Flash apparatus according to Claim 1 which is of the kind including an electronic flash tube, the main electrodes of which are connected in parallel with a storage capacitor to a suitable voltage, and in which the primary circuitry of a pulse transformer is connected in series with the main discharge gap of the flash tube, the gating



means being coupled to the secondary winding of the pulse transformer.

7. Flash apparatus according to Claim 5 in which the gating means includes a silicon controlled rectifier the gate and cathode of which are coupled to the secondary winding of the pulse transformer so that its anode-cathode path is switched to a conducting state in response to the voltage change occurring across the secondary winding on initiation of a flash, the anode-cathode path being connected in series with an active element in the light responsive control circuit whereby the latter is operative only when the anode-cathode path is conducting.

8. Flash apparatus according to Claim 6 in which said active element is a light activated silicon controlled rectifier the anode-cathode path of which is connected in series with that of the silicon controller rectifier of the gating means.

9. Flash apparatus substantially as that described in this specification with reference to Figure 3 of the drawings.

For the Applicants,
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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1971.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.

