

PATENT SPECIFICATION

(11)

1 316 410

DRAWINGS ATTACHED

1 316 410

- (21) Application No. 54093/72 (22) Filed 27 April 1970
(62) Divided out of No. 1 309 771
(31) Convention Application Nos. 735 253 (32) Filed 27 June 1969
79321 22 Sept. 1969 in

(19)



- (33) Belgium (BE)
(44) Complete Specification published 9 May 1973
(51) International Classification G03B 15/03 H05B 41/30 41/36
(52) Index at acceptance

G1A 205 206 207 208 209 211 212 21Y 246 247 248 302
30X 322 356 357 358 376 378 380 393 39X 504
506 510 520 52Y 531 53Y 567 568 590 599 59Y
615 773

(54) CONTROL DEVICES FOR ELECTRONICALLY GENERATED LIGHT PULSES

(71) We, PONDER & BEST, INC., a corporation organized under the laws of the State of California, United States of America, of 11201 West Pico Boulevard, Los Angeles, California 90064, 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 invention concerns devices for controlling the emission of light pulses from a flash unit, including auxiliary elements for use with such devices. It is applicable to electronic flash instruments, stroboscopes, lasers, etc., which are preferably provided with an automatic flash duration control.

The present invention is related to the invention which is described and claimed in co-pending Application No. 7937/69 (Serial No. 1,267,234) according to which there is provided a control circuit for controlling the duration of the emission of visible or other light from a load element which emits that light while electric current passes through the load element from an energy-storage capacitor, the control circuit including electronic switching means which is actuable by a control signal and which is either connectable in series between the load element and the source and arranged to be opened by the control signal, or is connectable in parallel with the load element and arranged to be closed by the control signal, the control circuit also including means for generating the control signal at the time when the load element is required to cease emitting the said light, said means for generating the control signal comprising a measuring device which produces said signal in response to the receipt of a predetermined quantity of light.

The present invention was disclosed in the Specification of co-pending Application No.

10883/70 (Serial No. 1,309,771) according to which there is provided a light sensing device comprising in combination light receiving means comprising a plurality of lenses, or a lens having a plurality of parts of different focal lengths, and light sensing means comprising one or more photoelectric light sensitive elements, optically associated with the light receiving means so that the said lenses or lens parts have different angles of acceptance (as herein before defined) the bisectors of which angles coincide or extend substantially parallel to one another, for simultaneously receiving the light associated with both or all the said angles of acceptance.

The present specification has been divided out of the last-mentioned specification, as have the specifications of Applications Nos. 54091/72 (Serial No. 1,316,408) and 54092/72 (Serial No. 1,316,409).

According to the invention claimed in Application No. 54091/72 there is provided an electronic flash unit including a circuit for terminating a light pulse, generated by the discharge of a capacitor, in response to a measurement of a result produced by the light pulse, wherein the circuit includes two zener diodes for providing a supply voltage to said means and for providing a threshold voltage with which another voltage, resulting from the measurement, is compared to effect the termination of the pulse.

According to the invention claimed in Application No. 54092/72 there is provided in, or for use with, an electronic flash unit in which the duration of a pulse of light produced by the unit is determined by the light reflected by a subject on which it is incident, light-sensing means for measuring the reflected light adapted to be electrically connected to said electronic flash unit for

terminating said pulse, said light sensing means being arranged in or mounted on a body which is part of or separate from the flash unit, in a manner whereby the reflected light can be received from a selected one of a plurality of directions independently of the direction of the light produced by the flash unit and without physically repositioning said body.

According to the present invention there is provided a device for controlling the initiation and duration of a light flash produced by a light flash tube in response to a pulse produced by the discharge of a capacitor and including a light-sensitive element arranged for receiving light coming from a given direction and for triggering the production of a light flash by the said tube in response to the application of light exceeding a threshold intensity to said element, wherein the device also includes switching means for controlling, in response to a predetermined quantity of light received by said element, the duration of the light flash produced by the said tube.

The invention will be more fully described, by way of example, with reference to the accompanying drawings, in which:—

Figure 1 is a schematic circuit diagram of a basic circuit with which the improvements according to the present invention can be used;

Figure 2 is a schematic circuit diagram of another form of the circuit of Figure 1;

Figure 3 is a more detailed circuit diagram containing a more detailed showing of one embodiment of a flash duration control circuit;

Figure 4 is a view similar to that of Figure 3 of another embodiment of a flash duration control circuit;

Figure 5 is a view similar to that of Figure 3 of still another embodiment of a flash duration control circuit;

Figure 6 is a view similar to that of Figure 3 of yet another form of flash duration control circuit;

Figure 7 is a view similar to that of Figure 3 of a further form of a flash duration control circuit;

Figure 8 is a view similar to Figure 3 of yet a further embodiment, of a flash duration control circuit;

Figure 9 is a view similar to that of Figure 3 of a still further form of a flash duration control circuit;

Figure 10 is a view similar to that of Figure 3 of an additional embodiment of a flash duration control circuit;

Figure 11 is a view similar to that of Figure 3 of a further additional flash duration control circuit;

Figure 12 is a view similar to that of Figure 3 of another embodiment of a flash duration control circuit;

Figure 13 is a pictorial view of one embodiment of a dual field light receiver;

Figure 14 is a view similar to that of Figure 13 of another embodiment of the light receiver;

Figure 15 is a view similar to that of Figure 13 of a further embodiment of the light receiver;

Figure 16 is a view similar to that of Figure 13 of yet another embodiment of the light receiver;

Figure 17 is a view similar to that of Figure 13 of still another embodiment of the light receiver;

Figure 18 is a view similar to that of Figure 13 of still a further embodiment of the light receiver;

Figure 19 is a circuit diagram of a light sensor arrangement;

Figure 20 is a view similar to that of Figure 19 of another light sensor arrangement;

Figure 21 is a view similar to that of Figure 19 of still another light sensor arrangement;

Figure 22 is a view similar to that of Figure 19 of a further sensor arrangement;

Figure 23 is a view similar to that of Figure 19 of yet a further sensor arrangement;

Figure 24 is a view similar to that of Figure 19 of a still further sensor arrangement;

Figure 25 is a circuit diagram of a modified light duration control circuit;

Figure 26 is a circuit diagram of a control circuit for controlling both the initiation and termination of a light flash;

Figure 27 is a perspective view of an automatically controlled flash unit which can contain the circuit of Figure 26;

Figure 28 is a circuit diagram of a control circuit employing a low voltage activated gas-filled tube;

Figure 29 is a view similar to that of Figure 28 of another embodiment of such circuit;

Figure 30 is a view similar to that of Figure 28 of a further embodiment of such circuit;

Figure 31 is a view similar to that of Figure 28 of a further embodiment of such circuit;

Figure 32 is a view similar to that of Figure 28 of a still further embodiment of such circuit;

Figure 33 is a view similar to that of Figure 28 of yet another embodiment of such circuit;

Figure 34 is an elevational view of one embodiment of the gas-filled tube employed in the embodiments of Figures 28 to 31;

Figure 34a is a cross-sectional view of a modified form of construction of the embodiment of Figure 34.

Figure 1 shows the circuit of an electronic to-flash equipped with a control device having only one switch whose purpose is to arrest the capacitor discharge when a predetermined amount of light has been produced.

The arrangement of such a unit is as follows:

10 An energy storage capacitor 100 is charged through a voltage source 101. A flash tube 102 of the usual type is connected to the capacitor terminals through a switch 103 which is preferably a gate-turn-out thyristor or thyatron, or the like, provided, if necessary, with suitable supplementary circuitry. A light sensor 104, composed of a photodiode, phototransistor, photoresistance, or other element is connected to an integrating circuit 105 of any well-known type. A firing circuit 106 triggers the firing of the flash tube 102. This device works as follows:

25 The capacitor 100 having been charged by the source 101, the ionization of the flash tube 102 is induced by the action of the firing circuit 106. The light sensor 104 supplies an instantaneous current which is proportional to the illumination on the subject 107 to the integrating circuit 105; the latter, when the total amount of light received by the light sensor 104 reaches a predetermined value, causes the circuit to "swing" thus supplying an impulse to the switch 103, which then interrupts the discharge of the capacitor 100.

35 Thus, the light emission of the flash tube is arrested after producing the requisite amount of light, without any energy being withdrawn from the capacitor other than that used for producing the light, and possibly for commutating the circuit.

40 The arrangement of Figure 1 may be completed in the following manner:— By connecting a voltmeter 108 to the terminals of the integrator circuit 105, which is designed for such a connection, an integrating photometer, or chronometer, can be produced, which device has scales in different measuring units.

50 Another variant is illustrated in Figure 2 in which we describe a control device connected both in series and parallel with the load and combined with a compensating device, which is also capable of being used with the preceding embodiment, constituted by an induction coil.

60 The discharge capacitor 200 is charged through the voltage source 201. The flash tube 202 is connected to the terminals of the capacitor 200 through the intermediary of an induction coil 203. A thyatron 204 is connected in parallel with the flash tube 202. A light sensor 205 is coupled to the integrating circuit 206; it receives reflected light from the subject 209 and controls the

firing electrode 207 of the thyatron 204. A firing circuit 208 acts to fire the flash tube 202. Meter 210 is connected to circuit 206.

The operation of the circuit of Figure 2 differs from that of Figure 1 as follows:—

70 After reaching the predetermined signal value, the circuit of the integrator 206 triggers the firing electrode 207 of the thyatron 204 in parallel with the flash tube 202. The induction coil 203 allows for a short period during which the thyatron is practically in short-circuit. Consequently, the flash tube 202 has enough time to deionize, and hence to become extinguished.

80 A modification is illustrated in Figure 3. This control device is combined with both an electronic gate and an optical device for regulation of the sensitivity.

85 The control device consists of an electronic device 30 which is identical with the device 50 of Figure 5, the photo-flash unit 31 and an electronic switch 32.

90 In this device, a light sensor 301 generates a current proportional to the reflected light from the subject. This current is integrated by a capacitor 302 to give a voltage proportional to the amount of the reflected light. This voltage is applied to a unijunction transistor 304 or to a four-layer diode or to some other element or device which would serve as suitable substitute, which develops a positive impulse in the resistance 305 as soon as the threshold "swing" or switching level, of this component 304 has been reached.

100 This impulse is conducted by the capacitor 306 to open a semi-conductor switch, or other element, 308 by means of its firing circuit which controls the electronic switch 32 so as to terminate the capacitor discharge and thereby extinguish the flash tube of the photoflash 31.

110 As soon as the cycle is ended, the voltage across a resistance 303 sets the system back to its initial condition. A resistance 307 prevents a premature opening of the semiconductor switch 308. The unit 31 contains the elements of the photo-flash, which are not individually referenced. The electronic device 30 contains as its principal element a semiconductor switch, such as a thyristor (SCR), or else a gas-filled switching tube, preferably one of the arc arrester type or a special arc arrester, or another suitable component.

115 An improvement of the flash control device consists in equipping this device with an electronic gate which acts upon the reflected light sensor circuit.

120 Figure 3 also illustrates the electronic gate arrangement. When the flash tube is fired, the voltage at the flash tube terminals decreases sharply. This results in a current in the circuit of the capacitor 309, the re-

sistance 310 and the zener diode 311. A voltage equal to that across the zener diode will appear at the terminals of the light sensor circuit so as to place it in operation. The current intensity depends on the resistance value of resistor 310. The opening duration of the electronic gate of the light sensor circuit depends on the value of the capacitor 309.

- 10 The regulation of the sensitivity of the control device is effected by the user with the help of an adjustable optical device 315 which comprises a diaphragm and a set of filters, or the like, placed in front of the light sensor 301 of the control device.

- 15 A further explanation will now be given with reference to Figure 4, which shows a light control device for the flash of an electronic photoflash, consisting of an electronic device 40, which is similar to the device 30 of Figure 3 and the device 50 of Figure 5 and which is therefore only partially shown, of the photoflash 41, which is similar to the device 31, and of an electronic switch 42, which is similar to the device 32, connected in series with the flash tube circuit.

This device and its operation are essentially the same as those described and illustrated previously, namely:—

- 30 The thyristor 421, which is fired upon closing of the camera synchronization contacts, applies the voltage of the discharge capacitor 411 across the flash tube 412, the latter having received previously a fraction of this voltage, the value of which fraction is determined by the resistances 404 and 423, and to the tube firing circuit which consists of a capacitor 413 and a transformer 414, thus firing the flash. When the thyristor 401 becomes conductive, due to the subject having been sufficiently illuminated, it discharges the capacitor 402, which was previously charged, into the thyristor 421, which results in reversing the anode voltage of the thyristor for a short period so as to cause it to block and thus arrest the discharge of the capacitor 411. The capacitance value of the capacitor 402 is selected so as to obtain an impulse of sufficient duration to allow the extinction, or blocking, of the thyristor 421. The capacitance value of the capacitor 422 is selected so as to obtain the shortest possible impulse so that the extinction of the thyristor 421 may occur as rapidly as possible. The resistances 424 and 425 are used to polarize the capacitor 422. The value of the resistance 403 must be selected in order to give a current lower than the maintenance current of the thyristor 401, so as to prevent the capacitor 411 from continuing to discharge itself through the thyristor 401. A compensation device 415, such as an induction coil, modifies the discharge impulse in the flash

tube. Among other things, it lengthens the discharge duration.

Figure 5 shows a control device combined with an electronic gate and with an optical device for the regulation of sensitivity. This control device consists of an electronic device 50 and the photoflash 51.

The components and operation of this device are the same as those described with reference to Figure 3, with the difference that an impulse transmitted by the capacitor 506 opens a semi-conductor switch, or a special arc arrester or the like, 508, via its firing circuit, and thereby extinguishes the flash tube 512 of the photoflash while discharging the capacitor 513 of the latter.

In Figure 6, there is shown another embodiment which is equipped with an arc arrester combined with an electronic gate and with an electric device having several capacitors for the regulation of sensitivity. The arc arrester 611 and its firing device, which consists of a thyristor 606, resistances 607 and 608, a capacitor 609 and a transformer 610, serve as a substitute for the thyristor 508 of Figure 5. Here, use is made of an electric circuit for adjusting the sensitivity, the circuit consisting of a switch 615 which is arranged to select one of the capacitors 603 and 604 having different capacitance values.

In Figure 7 there is shown another embodiment in which the photodiode is replaced by a phototransistor 702 in order to give a higher sensitivity to the light integrator than is possible with the photodiode. In Figure 8 the photodiode 802 has an amplification circuit composed essentially of an *npn* transistor 803 which allows the selection of a very high sensitivity, as a function of the gain of the transistor.

In Figure 9 a *pnp* transistor 903 replaces the *npn* transistor.

In Figure 10 the light sensor is a photovoltaic cell, such as a solar cell, 1002, the current of which is amplified by a transistor 1003.

In Figure 11 the firing of the thyristor 1106 is effected by a threshold amplifier which consists of a transistor 1114 and resistances 1103, 1105, 1115 and 1116. The switching threshold may be adjusted or regulated internally and/or externally by means of the resistance 1103. The threshold voltage determines the control device sensitivity.

In Figure 12 the threshold amplifier contains two transistors 1214 and 1216. The switching threshold may be adjusted by selecting suitable values for the resistances 1215 and 1203.

Figures 1 to 12 are shown in our co-pending Application No. 7937/69 (Serial No. 1,267,234).

Figure 13 shows a light sensor 2201 which

is provided with two ancillary lenses, or lens systems, 2202 and 2203 which have respectively different angles of acceptance, as illustrated, for light travelling in the direction of the arrows. The light gathered by each lens is conveyed, still in the form of light, to a light-sensitive element 2201 where it is converted into electrical signals in a well-known manner.

Figure 14 shows a light-sensitive element 2301 with one ancillary lens or lens system 2302 having three different focal lengths, or angles of acceptance.

Figure 15 shows a light-sensitive element 2401 which is disposed behind two light conductors 2402 and 2403, which may be constituted by optical fibres, or a transparent material in other forms. Lenses 2406 and 2407, possibly ones having different light attenuation characteristics and in any case having different angles of acceptance 2404 and 2405 are placed in front of the light conductors.

Figure 16 shows substantially the same arrangement as Figure 15, except that only one light conductor 2502 is employed, a bifocal lens 2506 being placed in front of it; it has two portions 2507 and 2508 with respectively different radii of curvature and angles of acceptance, and possibly different optical attenuation characteristics.

Figure 17 shows a device with two light-sensitive elements 2601 and 2602 provided with lenses 2603 and 2604 having different diameters and angles of acceptance.

Figure 18 shows an arrangement similar to that of Figure 17 but with two light-sensitive elements 2701 and 2702 having the same angle of acceptance which are disposed behind an optical device consisting of two lenses 2705 and 2706 with different angles of acceptance 2703 and 2704 and two light conductors 2707 and 2708.

Figure 19 shows one embodiment of a computing circuit 2803 which algebraically adds the two partial currents from the two parallel-connected light-sensitive elements 2801 and 2802, here shown as two photodiodes. The circuit 2804 contains the remaining circuit elements. The two photodiodes are arranged so that each receives light from a respective one of the two lenses of Figures 13, 15, 17 or 18, or from a respective portion of the composite lenses of Figures 14 and 16.

Figure 20 shows substantially the same arrangement as Figure 19, but the two light-sensitive elements 2901 and 2902 are photoresistors which, in the embodiment of an electronic flash unit also themselves perform the light integration operation and are followed by a light duration control circuit 2903.

The resistance of each photoresistor corresponds, during the duration of a flash, to

the amount of light received at each instant.

Figure 21 corresponds essentially to Figure 20 except that the two photoresistors 3001 and 3002 are connected in series with a control circuit 3003.

Figure 22 is similar to Figure 21, except that the signal of one of the two photoresistors 3101 is additionally fed to a separate input of the computing circuit 3103. The circuit 3104 contains the other elements.

Figure 23 corresponds substantially to Figure 19, except that the computing circuit contains a voltage divider which consists of potentiometers 3203 and 3204 and fixed resistors 3205 and 3206, having their common junction connected to a control circuit 3207. Thus, the effective sensitivity of the two light-sensitive elements 3201 and 3202 can be separately regulated.

Figure 24 shows an automatic light duration control device which is provided with two light-sensitive elements 3301 and 3302. Each light-sensitive element has its own integration circuit which consists of a respective one of the capacitors 3303 and 3304. The capacitor voltages are applied to respective ones of the two voltage dividers, which are formed of the variable resistors 3305 and 3306, and a fixed resistor 3307. The two voltage dividers have a common output terminal connected to a control circuit 3308.

The voltage of the fixed resistor 3307 is applied to a threshold value amplifier which is disposed in the circuit 3308, together with the other elements of the light duration control device.

The arrangements illustrated in Figures 19 to 24 can be substituted for the light-sensitive element assemblies of the circuits of Figures 1 to 12. For example, the elements 2801, 2802 and 2803 of Figure 19 or the elements 3001 and 3002 of Figure 21 could simply be "plugged in" in place of the light sensor of any of the circuits of Figures 1 to 12.

The embodiment of Figure 23 could be connected in the circuit of Figure 11 by removing the light sensor of the latter figure, connecting terminal 3210 of Figure 23 to the upper power supply conductor of Figure 11, connecting the Figure 23 terminal 3211 to the capacitor shown in Figure 11 so as to be connected in series with the light sensor, and connecting the Figure 23 terminal 3212 to the emitter of the amplifier transistor 1114 of Figure 11.

The embodiment of Figure 24 could be connected in the circuit of Figure 11 in a similar manner, but in this case both the light sensor and its series integrating capacitor of Figure 11 would be removed.

The embodiments of Figures 23 and 24 could similarly be incorporated in the circuits of Figures 1 to 10 and 12.

Figure 25 illustrates one embodiment of a circuit possessing other advantageous features. In this case two zener diodes 3401 and 3402 are employed in a series connection so that the total voltage across them determines the supply voltage of the light-sensing phototransistor 3403. The voltage across the zener diode 3402 alone determines the value which the voltage across the integration capacitor 3404 must reach in order to fire the thyristor 3405.

The circuit includes a resistor 3406 across which is produced a voltage proportional to the nonlinearity error of the control device, which error is caused by voltage fluctuations of the zener diodes 3401 and 3402, by the switching delays of the thyristor 3405 and by the arc arrester 3407. The resistor 3406 is connected in such a way as to compensate these errors.

When thyristor 3405 fires, i.e., becomes conductive, it causes capacitor 3412 to discharge through the primary winding of a transformer 3413 whose secondary winding is connected to an arrester 3407. The voltage to which the capacitor 3412 is charged prior to the firing of the thyristor 3405 is determined in part by the value of resistors 3409, 3410 and 3411.

A switch 3408 is connected across resistor 3409 and when this switch is opened resistors 3409, 3410 and 3411 determine the voltage of the firing capacitor 3412, corresponding to the full power output of the flash.

When switch 3408 is closed, only the resistors 3410 and 3411 determine the voltage of the firing capacitor corresponding to a partial power output from the flash.

The light control device of an electronic flash unit can be supplemented to give it the capability of initially functioning as a light responsive flash trigger device, or slave unit, and then automatically switching to function as a light duration control unit. This combined device is so constructed that it performs the automatic switching between the two modes of operation. This device preferably employs a single light-sensitive element to initiate the two functions, and possibly further common components. This means that during its periods of use as a remote triggering device, the light-sensitive element is not conducting an electric current and thus operates as a simple photovoltaic element or the like, whereas during the period when it operates as a flash control device, the light-sensitive element is connected to an electric current supply and thus operates as a photodiode or the like.

Figure 26 illustrates one example of such a device in which the circuit substantially illustrated in Figure 6 is supplemented with the following components, i.e., a switch 3501 for connecting or disconnecting the re-

mote triggering device and a capacitor 3502 connected in series between the light-sensitive element 3508 and the gate electrode of a thyristor 3503, as well as other components present in a conventional electronic flash assembly, such as the firing transformer 3504, the firing capacitor 3505, the resistor 3506 and the flash tube 3507, the thyristor 3503 being connected across the series arrangement of the capacitor 3505 and transformer 3504.

The device operates as follows:—

When switch 3501 of the light duration control device of the flash unit is closed, the photoelectric remote triggering device is also rendered operative. The light-sensitive element operates in this case principally as a photoelement without any steady-state electric current.

In this mode of operation, when the light from an external main flash instrument reaches the photoelement 3508 of the slave flash unit, it produces a voltage pulse which triggers the thyristor 3503 via the switch 3501 and capacitor 3502, and thus the flash tube 3507 of the flash unit.

Thereafter, the light duration control device operates in the same manner as was described in connection with Figure 6, i.e. the light receiver 3508, which now operates as a photodiode, is supplied with an operating voltage and can no longer operate as a remote triggering device as long as the current supply thereto is not interrupted, which does not occur until the end of the flash, since it is produced by its flash unit.

On the other hand, when the switch 3501 is open, only the light duration control function will be performed.

In case it is desired to produce an "indirect" flash, i.e. the flash unit is directed toward the ceiling or the wall, the light-sensitive element of a known light duration control device would receive reflected light from the ceiling or the wall, but not from the subject being photographed, so that the control device would not be responsive to the illumination of the subject being photographed.

To avoid these difficulties there is provided the use of one or a plurality of light-sensitive elements whose position may be adjustable and which may be provided with light conductors, when themselves may also be adjustable. The setting of these elements may be made manually or automatically.

Figure 27 shows an electronic flash unit incorporating such an arrangement. The unit is capable of being oriented to produce a direct flash or a bounce flash. The light beam of the flash is directed and shaped in the usual manner by a lens 3604. The reflected light to be measured is received by an optical fibre element 3602 whose front

face is directed towards the source of reflected light to be measured and whose rear face is directed towards the light sensitive element 3601 in the control circuit. The front face of the element 3602 is aligned with a slot 3603 in the unit housing and is connected to any suitable mechanical arrangement (not shown) for allowing a pivotal movement to direct its front face towards the light to be measured. For direct flash, the element 3602 has the position indicated in solid lines and receives light coming in the direction of the solid arrow; for bounce flash, when the unit radiates light at right angles to the subject, the unit 3602 has the position shown in broken lines and senses light coming from the subject, in the direction indicated by the broken-line arrow. For intermediate bounce flash directions, the unit 3602 can be placed in any intermediate position between the two extremes illustrated.

In the case where the device contains a plurality of light-sensitive elements which are oriented in different directions, the selection of the light-sensitive element or elements employed can be made by electric, electronic, optical, or mechanical means, etc. The selection may be manual and/or automatic.

Figure 28 shows a control circuit which is similar to those previously described and employs a gas-filled switching tube 3701 which is provided with an internal low voltage control or triggering electrode 3702.

The capacitor 3703 is connected so as to be charged by resistors 3704 and 3705 to the voltage which is applied to the terminals of the gas-filled switching tube 3701. When the thyristor 3706 is fired, the voltage to which the capacitor 3704 has been charged is applied to the internal low voltage control electrode 3702 of the gas-filled switching tube 3701, so that it is also fired. The thyristor 3706 is connected in a circuit identical with that shown in Figure 7.

Figure 29 shows a circuit employing gas-filled switching tube 3808 provided with an internal low voltage control electrode 3807, which is controlled by a low voltage pulse transformer 3809 which is in turn directly controlled by a unijunction transistor 3606. Capacitor 3801, resistor 3802 and zener diode 3803 form an electronic current gate which functions in the same manner as the elements 309, 310 and 311 of Figure 3.

The phototransistor 3804, the capacitor 3805 and the unijunction transistor 3806 form the integrator and threshold value detector, which operate in the same manner as the corresponding elements shown in Figure 7. The pulse generated by unijunction transistor 3806 is transmitted by the pulse transformer 3809 to the internal low voltage con-

trol electrode 3807 of the gas-filled switching tube 3808.

Figure 30 shows a highly simplified control circuit including a gas-filled switching tube 3902 provided with an internal low voltage control electrode 3903 directly controlled by the integration capacitor 3901. The terminal voltage of the integration capacitor 3901 controls the firing of the gas-filled switching tube 3902 directly through the internal low voltage control electrode 3903, when a sufficient quantity of light has reached photo-transistor 3904.

The circuit of Figure 31 is substantially the same as that of Figure 30 except that the internal low voltage control electrode of the gas-filled switching tube 4002 is controlled directly by a photoresistor 4001 which simultaneously serves as the light integrator. The control voltage of the internal electrode of the gas-filled switching tube 4002 is obtained at the terminals of a variable resistor 4003.

Figure 32 shows a circuit employing a gas-filled switching tube 4104 provided with two internal low voltage control electrodes 4101 and 4102 one of which is polarized by a voltage divider at a fixed voltage whereas the other is controlled in the same manner as the control electrode of the circuit of Figure 28. In the quiescent state, the voltages at the two internal control electrodes 4101 and 4102 are identical.

When the thyristor 4103 fires, there results an inequality between these two voltages. This inequality has the same firing effect as that of the gas-filled switching tube 4104. Otherwise this circuit is the same as that of Figure 28.

The circuit of Figure 33 employs a gas-filled tube 4203 without any internal or external control electrode. The firing of the tube is controlled by an electrically responsive light generating element, e.g. by a gallium arsenide diode. This apparatus operates in principle in the same manner as the circuit shown in Figure 29, except that the pulse of the unijunction transistor 4201 controls a light emitting diode 4202 whose light pulse, directed toward the gas-filled switching tube 4203, initiates its firing.

In Figure 34 there is shown one embodiment of the above-mentioned special gas-filled tube of the arc arrester type. This consists of an electrically isolating enclosure 2103, which can be transparent, translucent or opaque, whose interior 2105 is filled with a gas, preferably argon, and contains two preferably identical and unpolarized electrodes 2101 and 2102. A third firing electrode 2106 protrudes into the interior 2105 of the enclosure 2103 and is extended by the connecting wire 2107. The electrodes 2101 and 2102 are located and formed in such a way, and the filling and the pressure

of the gas are so chosen that this tube will function to perform an arc operation.

As can be seen from Figure 34a, which shows a modified embodiment of the device of Figure 34, the enclosure here shown at 2103 can be formed in the shape of a tube, being delimited by two electrodes 2101 and 2102 of the "socket" type and of large surface area. The length of this tube is about the same as its diameter.

WHAT WE CLAIM IS:—

1. A device for controlling the initiation and duration of a light flash produced by a light flash tube in response to a pulse produced by the discharge of a capacitor and including a light-sensitive element arranged for receiving light coming from a given direction and for triggering the production of a light flash by the said tube in response to the application of light exceeding a threshold intensity to said element, wherein the device also includes switching means for controlling, in response to a predetermined quantity of light received by said element, the duration of the light flash produced by the said tube.

2. A device as claimed in claim 1, wherein the said automatic switching means connects the light sensitive element so as to cause the light received by this element to provide a signal which controls the duration of the flash.

3. A device as claimed in claim 2 which further comprises a switch for preventing the automatic light triggering operation of the device.

4. A device as claimed in any of claims 1—3 wherein, for terminating the pulse generated by the discharge of the capacitor, the device comprises a gas-filled switching tube which includes means for triggering conduction through the switching tube and is connected so as to be triggered in order to terminate the pulse.

5. A device as claimed in claim 4 wherein the switching tube has an internal low voltage control electrode which renders the switching tube conductive when a voltage of between 50 and 1000 volts is applied to it.

6. A device as claimed in claim 5 wherein the switching tube is constructed substantially as herein described with reference to Figure 34 or Figure 34a of the accompanying drawings.

7. A device as claimed in claim 5, wherein the switching tube includes a plurality of internal low voltage control electrodes.

8. A device as claimed in claim 7 which includes an integration circuit directly connected to one control electrode of the switching tube.

9. A device as claimed in any of claims 1—3 wherein, for terminating the pulse generated by the discharge of the capacitor, the device comprises a light-responsive, gas-filled switching tube and an electrically responsive light emitting element which is optically linked with the switching tube for producing a light output which triggers conduction through the switching tube.

10. A device as claimed in claim 9 wherein the said light emitting element is constituted by a gallium arsenide diode.

11. A device as claimed in claim 1 and substantially as herein described with reference to the accompanying drawings.

12. An electronic flash unit including a device according to any preceding claim for controlling the operation of the flash unit.

Agents for the Applicants,
STANLEY, POPPLEWELL, FRANCIS
& ROSS,
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of the gas are so chosen that this tube will function to perform an arc operation.

As can be seen from Figure 34a, which shows a modified embodiment of the device of Figure 34, the enclosure here shown at 2103 can be formed in the shape of a tube, being delimited by two electrodes 2101 and 2102 of the "socket" type and of large surface area. The length of this tube is about the same as its diameter.

WHAT WE CLAIM IS:—

1. A device for controlling the initiation and duration of a light flash produced by a light flash tube in response to a pulse produced by the discharge of a capacitor and including a light-sensitive element arranged for receiving light coming from a given direction and for triggering the production of a light flash by the said tube in response to the application of light exceeding a threshold intensity to said element, wherein the device also includes switching means for controlling, in response to a predetermined quantity of light received by said element, the duration of the light flash produced by the said tube.

2. A device as claimed in claim 1, wherein the said automatic switching means connects the light sensitive element so as to cause the light received by this element to provide a signal which controls the duration of the flash.

3. A device as claimed in claim 2 which further comprises a switch for preventing the automatic light triggering operation of the device.

4. A device as claimed in any of claims 1—3 wherein, for terminating the pulse generated by the discharge of the capacitor, the device comprises a gas-filled switching tube which includes means for triggering conduction through the switching tube and is connected so as to be triggered in order to terminate the pulse.

5. A device as claimed in claim 4 wherein the switching tube has an internal low voltage control electrode which renders the switching tube conductive when a voltage of between 50 and 1000 volts is applied to it.

6. A device as claimed in claim 5 wherein the switching tube is constructed substantially as herein described with reference to Figure 34 or Figure 34a of the accompanying drawings.

7. A device as claimed in claim 5, wherein the switching tube includes a plurality of internal low voltage control electrodes.

8. A device as claimed in claim 7 which includes an integration circuit directly connected to one control electrode of the switching tube.

9. A device as claimed in any of claims 1—3 wherein, for terminating the pulse generated by the discharge of the capacitor, the device comprises a light-responsive, gas-filled switching tube and an electrically responsive light emitting element which is optically linked with the switching tube for producing a light output which triggers conduction through the switching tube.

10. A device as claimed in claim 9 wherein the said light emitting element is constituted by a gallium arsenide diode.

11. A device as claimed in claim 1 and substantially as herein described with reference to the accompanying drawings.

12. An electronic flash unit including a device according to any preceding claim for controlling the operation of the flash unit.

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