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DRAWINGS ATTACHED

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(54) LIGHT SENSING DEVICES

(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:—

This invention relates to light sensing devices which can be used for controlling the emission of light pulses from a flash unit.

Light sensing devices embodying this invention can be used as measuring devices in control circuits of the invention which is described and claimed in our co-pending Application No. 7937/69 (Serial No. 1,267,234). Reference should also be had to three divisionals of the present application, numbered 54091/72, 54092/72 and 54093/72.

In known devices of the type here under consideration, reflected light is measured by a single light sensitive element optically associated with light receiving means having only one angle of acceptance. By the term "angle of acceptance" there is meant the angle of the field of view within which light, which is transmitted to and falls on the light sensitive element, is received by the light receiving means.

One drawback of such devices is that, when a high contrast scene, or subject, is to be photographed, the reflected light will not be measured with sufficient accuracy. Moreover, when a reflected light measuring and duration control device is used in a camera, and the subject to be photographed is moving and/or the illumination intensity is fluctuating, accurate measurement of the light reflected to the camera with known light measuring devices becomes difficult, and sometimes requires a number of complex

measurements, computations and evaluations.

It is an object of the present invention to provide an improved light sensing device enabling better measurement, computation and control of the light produced by a flash unit with which it is associated.

One specific object of the present invention is to provide a device for simultaneously measuring reflected light with at least two different angles of acceptance which device may be provided with one or a plurality of light-sensitive elements. This device is suited for electronic flash instruments, stroboscopes, lasers, etc., which are preferably provided with an automatic flash duration control, as well as for still cameras, movie cameras, photographic enlargers, light meters, etc. This method tends to produce a better evaluation, computation and control of the reflected light.

According to the present invention 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 lenses or lens parts preferably have different sensitivities. The device may further comprise light conductor means optically linking the light receiving means and the light sensing means. The latter means may be constituted by photodiodes, phototransistors, photoresistors, sun batteries, or the like.

When such a device is used in a photo-

graphic electronic flash instrument, a stroboscope, laser, or the like, each measurement made during the flash duration is transferred, before or after integration, to a computing circuit, which may perform, for example, addition, subtraction, division, or multiplication operations, or combinations thereof, which produces the control signal to be transmitted to the flash duration control device.

When such a device is employed in a still camera, a movie camera, etc., the control signal is instead transferred to these devices.

An embodiment of the present invention includes a control arrangement for pulses which are produced by the discharge from a capacitor, and which are delivered, for example, to the flash tube of an electronic flash unit. The control arrangement employs two zener diodes as threshold value detectors and it is also provided with a circuit which compensates for the time delay of certain components and for the fluctuations in the zener voltage of the zener diodes, thereby permitting the flash unit to be controlled at different light intensity settings. This arrangement is supplemented by a photoelectronic remote triggering device provided with a system which permits its use even with indirect flashes from the flash unit. Means are provided to permit automatic switching between the devices.

Any of the light control devices described in our co-pending Application No. 7937/69 may be supplemented with a threshold value detector consisting of two zener diodes, a resistor for the compensation of the delays and variations in certain components, and a switch which permits operation of the light control device with a full light intensity output or a partial light intensity output of the flash unit.

Another embodiment of the present invention includes an arrangement for controlling the pulses generated during the discharge of a capacitor and employing a gas-filled switching tube whose interior is provided with one or several triggering electrodes, which are designed to operate at relatively low voltages, preferably between 50 and 1000 volts, when compared with similar known devices, or which is provided with an electrically responsive light generating device which permits the use of a gas-filled tube having only the two main electrodes.

The invention will be more fully described 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 dia-

gram 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 embodying the invention;

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 suitable for use with the present invention;

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 suitable for use with the invention;

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

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

Figure 28 is a circuit diagram of a control circuit suitable for use with the invention 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 photo-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:—

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:

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 re-

ceived 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.

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.

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.

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.

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:—

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.

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.

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.

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.

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.

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 semi-conductor 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.

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

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 resistance 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.

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.

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:—

The thyristor 421, which is fired upon closing of the camera synchronization con-

tacts, 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 re-

placed 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 photo-voltaic 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.

There will now be described various embodiments of the present invention.

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 and 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 130

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

- 5 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.

- 10 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.

- 15 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.

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

- 25 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 of a dual field light receiver embodying the invention. 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.

- 30 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.

- 35 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.

According to another feature of the invention, the light control device of an electronic flash unit, which includes a dual field light receiver embodying the invention, 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 photo-diode 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 remote triggering device and a capacitor 3502 connected in series between the light-sensitive element 3508 of a dual field light receiver embodying the invention 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 the present invention provides the use of one or a plurality of light-sensitive elements whose position may be adjustable and which may be provided with light conductors, which 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 of a dual field light receiver embodying the invention, 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 3806. 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 from 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 control 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 phototransistor 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.

- 5 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.

- 10 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.

- 15 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.

- 20 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 light sensing device comprising in combination:
- 50 (a) light receiving means comprising a plurality of lenses or a lens having a plurality of parts of different focal lengths; and
- (b) 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 are substantially coincident or substantially parallel with each other, for simultaneously receiving the light associated with both or all the said angles of acceptance.
- 60 2. A device as claimed in Claim 1 which

further comprises optical fibre or other light conductor means optically linking the said light receiving means and light sensing means.

3. A device as claimed in Claim 1 or 2, wherein the light sensing means is connected in an electronic computing circuit which is controlled by the light sensing means.

4. A device as claimed in Claim 3, wherein the light sensing means comprises a plurality of such photoelectric elements electrically connected together in parallel.

5. A device as claimed in Claim 3, wherein the light sensing means comprises a plurality of such photoelectric elements electrically connected together in series.

6. A device as claimed in Claim 3, wherein the light sensing means comprises a plurality of such photoelectric elements electrically connected together in both series and parallel.

7. A device as claimed in Claim 3, wherein the said light sensing means is an integrating device producing an output substantially proportional to the time integral of the light which it receives.

8. A device as claimed in Claim 7, wherein the light sensing means comprises a plurality of such photoelectric elements which are photoelectric transducers each producing an electrical output proportional to the time integral of the light which it receives.

9. A device as claimed in Claim 8 which further comprises an electronic computing circuit to which the output of each of the said transducers is connected.

10. A device as claimed in Claim 9 for use with a light flash generator, wherein the said computing circuit comprises a light duration control device for controlling the duration of the flashes produced by the generator in response to the light received by the said light sensing means.

11. An arrangement for controlling the duration of the light pulses produced by a light flash tube and generated during the discharge of a capacitor, in response to a measurement of the result produced by each such pulse, wherein the arrangement includes means comprising a light sensing device as claimed in Claim 1 for measuring the light quantity reflected from a subject illuminated by the flash tube, and two zener diodes connected for providing threshold voltages for use in comparing said result.

12. An arrangement for controlling the duration of the light pulses produced by a light flash tube and generated by the discharge of a capacitor, in response to a result produced by such pulses, which includes a circuit comprising a light sensing device as claimed in claim 1 for measuring this result and a compensating element which is con-

ected so as to apply to the said measuring circuit a voltage which is proportional to errors in linearity of one or more components in the arrangement.

5 13. An arrangement as claimed in Claim 12, wherein the compensating element is constituted by a resistor.

10 14. An arrangement for controlling the duration of the light pulses produced by a light flash tube in response to electrical pulses produced by the discharge of a capacitor and including means comprising a light sensing device as claimed in Claim 1 for measuring the light quantity reflected from a subject illuminated by the flash tube.

15 15. An arrangement for controlling the initiation and duration of light flashes produced by a light flash tube in response to pulses produced by the discharge of a capacitor and including a light sensing device as claimed in claim 1 arranged for measuring the light quantity reflected from a subject illuminated by the flash tube and for triggering the production of a light flash by the said tube in response to the application of sufficient light to the sensing device, wherein the arrangement comprises an automatic switching means connected in the said circuit for causing this circuit to control the duration of the flash produced by the unit after the commencement of this flash.

20 16. An arrangement as claimed in Claim 15, wherein the said automatic switching means connects the light sensing device so as to cause the light received by this device to provide a signal which controls the duration of the flash.

25 17. An arrangement as claimed in Claim 16 which further comprises a switch for preventing the automatic light triggering operation of the arrangement.

30 18. An arrangement for controlling the light flashes generated by a flash tube in response to the pulses produced by the discharge of a capacitor, wherein the arrangement comprises a light sensing device as claimed in Claim 1 for measuring the light quantity reflected from a subject illuminated by the flash tube, and a light conductor which is optically associated with this device and can be swivelled to receive the reflected light independently of the direction of the light produced by the flash tube.

35 19. An arrangement as claimed in Claim 18, wherein the orientation of the said light conductor is adjustable.

40 20. An arrangement as claimed in Claim 18, wherein there are a plurality of light sensing devices and the arrangement further comprises means for selecting which devices are to respond to the reflected light.

21. An arrangement for controlling the duration of the light pulses produced by a light flash tube and generated by the discharge of a capacitor, wherein the arrangement includes means comprising a light sensing device as claimed in Claim 1 for measuring the light quantity reflected from a subject illuminated by the flash tube, and a gas-filled switching tube which is connected so as to be triggered in order to control such pulses in response to such measurement and which has an internal low voltage control electrode which renders the tube conductive when a voltage of between 50 and 1000 volts is applied to it.

22. An arrangement as claimed in Claim 21, wherein the said tube includes several internal low voltage control electrodes.

23. An arrangement as claimed in Claim 22 which includes an integration circuit directly connected to one control electrode of said tube.

24. An arrangement for controlling the duration of the light pulses produced by a light flash tube and generated during the discharge of a capacitor, wherein the arrangement includes a light sensing device as claimed in Claim 1 for measuring the light quantity reflected from a subject illuminated by the flash tube, a light-responsive, gas-filled switching tube connected for controlling such pulses in response to such measurement, and an electrically responsive light emitting element which is optically linked with the said tube for producing a light output which triggers conduction through the tube.

25. An arrangement as claimed in Claim 24 wherein the said light emitting element is constituted by a gallium arsenide diode.

26. A light sensing device as claimed in Claim 1 and substantially as herein described with reference to the accompanying drawings.

27. An arrangement as claimed in any of Claims 11, 12, 21 and 24 for controlling pulses generated by the discharge of a capacitor substantially as herein described with reference to the accompanying drawings.

28. An arrangement as claimed in any of Claims 14, 15 and 18 for controlling light pulses or flashes substantially as herein described with reference to the accompanying drawings.

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