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DRAWINGS ATTACHED

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(54) CONTROL CIRCUITS

(71) We, LUMINA S.P.R.L., a Belgian body corporate, of 353, Chaussee St. Job, Brussels 18, Belgium, 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 is concerned with control circuits 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.

In one aspect, the invention provides 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 connected in series between the energy-storage capacitor and the load element and connectible in series between the load element and the source, the electronic switching means being arranged to be opened by a 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.

Conveniently, the electronic switching means is a semiconductor element. The semiconductor element may have the form of a gate-turn-off switch.

In a useful arrangement, the electronic switching means is arranged to be opened by the control signal which is generated by the closure of an auxiliary electronic switching device which is connected in an auxiliary circuit.

Conveniently, the auxiliary circuit is arranged, upon the said closure of the auxiliary electronic switching device, to supply to the electronic switching means a voltage which renders that means non-conductive and thus, in use, terminates the connection of the load element to the source.

Conveniently, the said voltage derives from an auxiliary capacitor which is included within the auxiliary circuit and which, in use, tends to become charged from the said source.

Conveniently the auxiliary electronic switching device is provided with current-limiting means which, in use, tends to maintain the current passed by that device at a value less than the conduction-sustaining for that device.

The auxiliary electronic switching device may be a semiconductor element, for example a thyristor.

Alternatively, that device may be a gas-filled arrestor tube having two main electrodes and one firing electrode, all of the electrodes being cold, the tube being constructed to operate by producing an arc.

Here, the two main electrodes may be iden-

This is the replacement sheet

Date: 28/8/79

tical and unpolarised. Conveniently, the firing electrode is arranged outside of the gas-filled interior of the tube. Alternatively, the firing electrode may be arranged inside of the gas-filled interior of the tube; the gas may be argon.

The control circuit may include an electronic gate arranged so that, in use, power is passed from the load element to the circuit by way of the electronic gate which supplies that power only in response to the initiation of a current flow through the load element.

Conveniently, the electronic gate comprises a series arrangement of a capacitance and a resistance.

The present invention provides in a further aspect 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 connected in parallel with the load element and the energy-storage capacitor and which is 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, and said switching means comprising a gas-filled arrestor tube having two main electrodes disposed at and delimiting the ends of a tubular body, and a firing electrode arranged outside of the body, all of the electrodes being cold and the tube being constructed to operate by producing an arc. Said main electrodes are preferably identical and unpolarised and the gas may be argon.

Conveniently, the load element is an electronic flash tube which is connected in series with an inductance.

Conveniently, the measuring device is arranged to be responsive to the quantity of light which, in use, is emitted by the load element and therafter reflected to the measuring device from an object.

Conveniently, the output of the measuring device is supplied to an amplifying circuit.

Conveniently, the measuring device includes a photodiode or a phototransistor or a photovoltaic cell.

In one arrangement, the control circuit is intended for use with a camera and is constructed as a unit or units which are removably attachable to the camera.

The amplifying circuit may include a unijunction transistor, or a four-layer diode, arranged as an ON-OFF device, and/or may include at least one transistor amplifying stage.

Conveniently, the control circuit includes electrical means for varying the sensitivity of the measuring device to the quantity of the light incident upon it.

The electrical means may comprise means for varying the capacitance connected in series with the measuring device, or variable resistance means.

The invention also provides apparatus including the control circuit as aforesaid and the sensitivity of the measuring device to the quantity of light tending to be incident upon it.

The optical means may comprise an adjustable diaphragm, or a set of filters.

Conveniently, the optical means is adjustable with the aid of a manually settable selection device having at least two relatively movable parts provided with scale markings.

The invention also provides apparatus including a control circuit as aforesaid in which the electronic switching means emits visible or other light when electric current is passing through it, the apparatus including optical fibre means for conveying that light to a surface which is responsive to that light to emit visible light as an indication that the switching means is passing that electrical current.

The invention also includes a camera in combination with a control circuit according to the invention.

Conveniently, the control circuit is arranged to draw electrical power for its operation, from the energy-storage capacitor in response to the initiation of a current flow through the load element.

Circuits including preferred embodiments of the invention will now be described by way of example and with reference to the accompanying drawings in which:—

Figure 1 is a schematic circuit diagram of an electrical photoflash including a control circuit according to the invention;

Figure 2 is a view similar to that of Figure 1 of another form of construction of a control device, but not, per se, falling within the invention as claimed;

Figure 3 is a view similar to that of Figure 1 of a further control device according to the invention;

Figure 4 is a view similar to that of Figure 1 of still another control device according to the invention;

Figure 5 is a schematic circuit diagram of another type of control circuit but not, per se, falling within the scope of the invention as claimed;

Figure 6 is a view similar to that of Figure 5 of another control circuit according to the invention;

Figure 7 is a view similar to that of Figure 5 of a further embodiment of the modified type of control circuit according to the invention;

Figure 8 is a view similar to that of Figure 5 of a still further embodiment of the modified

This is the replacement sheet
Date: 12/12/79

type of control circuit according to the invention;

Figure 9 is a view similar to that of Figure 5 of yet a further embodiment of the modified type of control circuit according to the invention;

Figure 10 is a view similar to that of Figure 5 of yet another embodiment of the modified type of control circuit according to the invention;

Figure 11 is a view similar to that of Figure 5 of yet a further embodiment of the modified type of control circuit according to the invention;

Figure 12 is a view similar to that of Figure 5 of a further embodiment of the modified type of control circuit according to the invention;

Figure 13 is a view similar to that of Figure 5 of another embodiment of the modified type of control device according to the invention.

Figure 14 is a view similar to that of Figure 5 of a further embodiment of the modified type of control device according to the invention.

Figure 15 is a view similar to that of Figure 5 of a further embodiment of the modified type of control device according to the invention.

Figure 16 is an elevational view of a manually adjustable setting unit for use with control circuits according to the invention.

Figure 17 is an elevational view of another embodiment of the unit of Figure 16.

Figure 18 is a pictorial view of a self-regulating control device for use with a circuit according to the invention.

Figure 19 is an elevational view of one embodiment of a novel arc-operated switch.

Figure 19*a* is a cross-sectional view of a modification of the embodiment of Figure 19.

Figure 20 is a view similar to that of Figure 19 of another embodiment of the switch.

Figure 20*a* is a cross-sectional view of a modification of the embodiment of Figure 20.

The invention is especially related to electronic photoflashes, stroboscopes, lasers and the like, the reflected light of which is to be received the reflected light of which is to be device whose output signal is to be integrated. When the light sensor has received a predetermined quantity of light, a threshold amplifier consisting of, for example, a unijunction transistor, a four-layer diode or any other suitable component and placed after the integrator may generate impulses which control one or several semiconductor switches and/or one or several gas-filled tubes and/or one or several lightning arresters, preferably of the gas-filled type, and/or, most particularly, one or several gas-filled arc arresters of special construction to be described later in a detailed manner.

These components control the electrical supply to a flash tube, the impedance of which is higher than that of the switch, with or without arresting the discharge of the photoflash capacitor. Also to be described is an arc arrester component of the gas-filled type, having an impedance of about 0.01 ohm when in its conduction state, fitted with at least two electrodes, preferably unpolarized and even of identical size, and internally or externally completed with a firing electrode. This new type of gas-filled switching tube differs from other gas-filled switching tubes above all because it functions by providing an arc and not as a gas-discharge tube of the type used in the prior art. The tube has the following advantages over other gas-filled switching tubes: lower impedance; larger range of current intensities and voltages; higher resistance to overloads; easier firing, and this over a more extended range; lower light emission; possibility of utilization at faster switching rates; increased ruggedness; extended lifetime, smaller sizes; and lower cost.

Furthermore, this arrestor is suitable for use in fields where thyratrons and thyristors are presently used or where no convenient component is available.

We remark that our control circuit, when using only one electronic switch or the gas-filled, arc-operation tube may be considerably smaller than other similar devices, which is of the greatest importance in the case of portable devices.

The control circuit may be completed by one or several electronic gates. The function of the electronic gate is to conduct current from the electric supply to the control circuit only during the desired period of flash discharge. The supply of current is initiated by the discharge of a capacitor associated with the electronic gate. This capacitor was previously charged by the photoflash discharge capacitor through a resistive, inductive, semiconductor, or other element. The supply voltage is controlled by a Zener diode, a gas-filled tube, a capacitor, or a resistance.

The control device may be combined with a device that regulates its sensitivity, namely, with an adjustable optical device, such as a diaphragm, a set of filters, or others, placed in front of the light sensor of the control device, or by an adjustable electric or electronic device, such as fixed and/or variable capacitances, resistances and inductances.

These controls can be operated manually or else by coupling to a part or accessory of a camera, (the flash tube of which is to be controlled by the control circuit described) such as to the diaphragm, the film cassette, e.g. a coded Kodapak (R.T.M.) cassette, etc. Of course, in the case of a control coupled to the camera, both apparatuses should be constructed together.

The controls, being designed to be manipulated by the user, are completed with scales

This is the replacement sheet
Date: 12/12/79

graduated in film sensitivities and/or in diaphragm apertures. The selected positions could be ratcheted or locked. The components to be manipulated and the scales are preferably interchangeable and reversible. This same device could be completed by a "focal length-aperture" calculator. This same device and its scales can be lighted.

A photoflash equipped with a control device may be advantageously completed with a compensation device, e.g. an induction coil and/or a suitable circuit, connected in series with the flash tube to modify the discharge impulses to the flash tube, for instance to slow down the discharge of the capacitor, which means to reduce the rate of increase of the current density of the capacitor discharge. Figure 1 shows the circuit of an electronic photoflash 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 received by the measuring device.

The arrangement of such a unit is as follows:

An energy storage capacitor 100 is charged by 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 (or gate-turn-off) thyristor or thyratron, etc., provided, if necessary, with suitable supplementary circuitry. The equivalent expressions "gate-turn-out" and "gate turn-off" refer to a thyristor which is rendered non-conductive by the application of a control signal to its control input. A measuring device comprising a light sensor 104, composed of a photodiode, phototransistor, photoresistance, or other, 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 supplying an instantaneous current proportional to the quantity of light received by the light sensor 104 which is proportional to the illumination on 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 a 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 further energy being withdrawn from the capacitor except possibly for powering the control circuit.

The arrangement of Figure 1 may be completed in the following manner, by connecting a voltmeter 108 to the terminals of the integrating circuit 105; which is designed for such a connection, an integrating photometer, can be produced, which device may be provided with suitable scales in units of total light quantity.

In Figure 2 we describe a control circuit which does not per se fall within the scope of the invention claimed with a switch connected in parallel with the load, the control circuit including a compensating device, capable of also being used with the preceding circuit, constituted by an induction coil.

The discharge capacitor 200 is charged by the voltage source 201. The flash tube 202 is connected to the terminals of the capacitor 200 through the intermediary of the induction coil 203. A thyratron 204 is connected in parallel with the flash tube 202. A light sensor 205 is coupled to the integrating circuit 206, receives reflected light from subject 209 and controls the firing electrode 207 of the thyratron 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:

Upon receipt of the predetermined quantity of light the integrator 206 triggers the firing electrode 207 of the thyratron 204 in parallel with the flash tube 202. The thyratron 204 conducts and short circuits the flash tube 202. The induction coil 203 prevents the build up of voltage across the tube 202 for a sufficiently long time to allow the flash tube 202 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, of the photoflash unit 31 and of an electronic switch 32.

In this device, a light sensor 301 (for example, a photo diode, 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 close a semiconductor switch, or other element, (see below) 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

This is the replacement sheet
Date: 12/05/99

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 photoflash 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 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

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 is to 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 composed of a diaphragm, or a set of filters, placed in front of the light sensor 301 of the control device.

A further explanation is 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 identical to those described and illustrated previously, namely:

The thyristor 421, which may be fired upon closing of 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 consisting 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, and the receipt of a predetermined quantity of light by the measuring device, it discharges the capacitor 402, which was previously charged, into the thyristor 421, which results in reversing the anode voltage of the thyristor 421 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 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, such as an induction coil, 415 modifies the discharge impulse in the flash tube. Among other things, it lengthens the discharge duration, etc.

Figure 5 shows a control device not falling within the scope of the invention claimed 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 identical to those described with reference to Figure 3, with the difference that an impulse transmitted by the capacitor 506 closes a semiconductor switch. or an arc arrester, 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, we describe another embodiment equipped with an arc arrester combined with an electronic gate and with an electric device having several capacitors for the regulation of sensitivity. Where the arc arrestor has the form shown in Figure 19a, this circuit, and the circuits to be described with reference to Figures 7 to 15, form embodiments of the invention. An arc arrester 611 and its firing device, which consists of the thyristor 606, the resistances 607 and 608, the capacitor 609 and the transformer 610, serve as a substitute for the thyristor 508 of Figure 5. Here, we make use of an electric circuit for adjusting the sensitivity, the circuit consisting of a switch 615 connected 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 photo-

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Date: 28/05/79

voltaic cell, such as a solar cell, etc., 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 the transistor 1114 and the resistances 1103, 1105, 1115 and 1116. The switching threshold may be adjusted or regulated internally and/or externally by means of the variable resistance 1103. The threshold voltage determine 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.

In Figure 13 we use a circuit with a four-layer diode constitutitng a unilateral, bilateral switch, etc. as the level detector and at the same time as the firing impulse generator for the thyristor 1306.

In Figure 14 the control device contains a voltage divider circuit which consists of the capacitors 1401 and 1403 instead of a zener diode, a capacitor and a resistance as in the previous arrangements.

In Figure 15 the current circuit contains a phototransistor 1502 and an electric device for regulating the sensitivity. The latter device consists of a switch 1516 which permits a selection of either one of the resistances 1503 and 1504, the value of the resistance selected determining the effective sensitivity of phototransistor 1502 and, therefore, the device sensitivity.

In Figure 16 there is shown a scale device intended for permitting an external regulation of the sensitivity, i.e. related to focal distance, or range, and/or diaphragm apertures. Moreover, we have combined this device with the usual "focal distance-aperture" calculator of electronic photoflashes and with other improvements as well. This regulating device consists of a fixed interchangeable disc 1601 and a rotatable and self-locking disc 1604 coupled to the device for regulating the sensitivity of the control device.

Graduated in degrees DIN. scale 1603 on disc 1601 is provided for setting the film sensitivity, and graduated in meters, scale 1602 is provided for setting distances. In the case of a photographic camera fitted with an adjustable diaphragm, the disc 1604 is to be rotated so as to bring the desired aperture indication on scale 1607 right opposite the sensitivity figure on scale 1603 for the film being utilized. The zone 1605 of disc 1604 shows on scale 1602 the range of distances for which the control device will work accurately.

Another way of using this same device is to select the focal distance, or range, and read the aperture to be used opposite the sensitivity figure for the film being used.

For use with a photographic camera fitted with a fixed diaphragm, as for example the "Minox" camera with a 3.5 aperture, the disc 1504 is rotated so as to bring the "Minox" pointer 1609 opposite the sensitivity for the film being used on scale 1603. The zone 1605 of the disc 1604 shows on scale 1602 the range of distances for which the control device can work accurately.

If the control device is not to be used, one must rotate the disc 1604 so as to bring the "NA" pointer (= "nonautomatic") 1606 opposite the sensitivity figure of the film used on scale 1603.

The scales 1608 and 1602 are used in the same manner as those of a customary "distance-aperture" calculator. This operation results in setting the control device sensitivity to the starting, or zero point, which means that it is out of action.

This device may advantageously be combined with a light source 1610 which allows easier use and reading.

The same device may also be combined with the following luminous indicators:

for the charge of the photoflash capacitor 1611;

for the control device, to indicate whether it functions or not, (functioning 1612, not functioning 1613);

for the achievement of the functioning of the control device 1614.

Figure 17 shows essentially the same device as Figure 16, but the device of Figure 17 is in the shape of a fixed and interchangeable guide strip 1701 and a sliding and self-locking slider 1704.

In Figure 18 there is shown an optical control and indicator device useful during the operation of the control device. This optical device consists of a fiber-optic element 1902 one end of which is placed on the arc arrester 1901 which emits light when actuated. The other end of the fiber optic is covered with a fluorescent luminescent, or phosphorescent material 1903, or else the fiber optic touches a part of the photoflash which is covered with such a material, and in both cases, it is set in a plate easily viewed by the user, such as in or on the sensitivity regulation scale unit.

Possibly, a complementary optical system 1904 can be used to further increase the visibility of this indicator.

In Figure 19 there is shown one embodiment of the above-mentioned gas-filled tube of the arc arrester type. This consists of an electrically isolating enclosure 2003, which can be transparent, translucent or opaque, whose interior 2005 is filled with a gas, preferably argon and contains two preferably identical and unpolarized electrodes 2001 and 2002. A third firing electrode 2006 is arranged outside the enclosure 2003 and is extended by the connecting wire 2007. The electrodes 2001 and 2002 are located and formed in such a way, and the filling and the pressure of the gas are chosen in such a manner, that this tube

This is the replacement sheet

Date: 28/05/79

will function to perform an arc operation. The modified embodiment of Figure 20 has a firing electrode 2106 which protrudes into the gas-filled interior 2105 of the enclosure 2103.

In Figures 19*a* and 20*a*, which show modified embodiments of the devices of Figures 19 and 20 respectively, the enclosure 2003 and 2103 are formed in the shape of tubes and are delimited by two electrodes 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 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 connected in series between the energy-storage capacitor and the load element and connectible in series between the load element and the source, the electronic switching means being arranged to be opened by a 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.

2. A control circuit according to claim 1, wherein the measuring device is arranged to be responsive to the quantity of light which, in use, is emitted by the load element and thereafter reflected to the measuring device from an object.

3. A control circuit according to claim 1 or 2, wherein the output of the measuring device is supplied to an amplifying circuit.

4. A control circuit according to any of the preceding claims, wherein the measuring device includes a photodiode.

5. A control circuit according to any of claims 1 to 3, wherein the measuring device includes a phototransistor.

6. A control circuit according to any of claims 1 to 3, wherein the measuring device includes a photovoltaic cell.

7. A control circuit according to any preceding claim, wherein the electronic switching means is a semiconductor element.

8. A control circuit according to claim 7, wherein the semiconductor element is a thyristor.

9. A control circuit according to claim 7 or claim 8, wherein the semiconductor element has the form of a gate turn-off switch.

10. A control circuit according to any one of claims 1 to 8, wherein said control signal generating means includes an auxiliary electronic switching device, said control signal being generated by the closure of the auxiliary electronic switching device which is connected in an auxiliary circuit.

11. A control circuit according to claim 10 wherein the auxiliary electronic switching device is a gas-filled arrestor tube having two main electrodes and one firing electrode, all of the electrodes being cold, the tube being constructed to operate by producing an arc.

12. A control circuit according to claim 11, wherein the two main electrodes are identical and unpolarized.

13. A control circuit according to claim 11 or claim 12, wherein the firing electrode is arranged outside of the gas-filled interior of the tube.

14. A control circuit according to claim 11 or claim 12, wherein the firing electrode is arranged inside of the gas-filled interior of the tube.

15. A control circuit according to any one of claims 11 to 14, wherein the gas is argon.

16. A control circuit according to claim 1, including an electronic gate arranged so that, in use, electrical power is passed from the load element to the circuit by way of the electronic gate which supplies that power only in response to the initiation of a current flow through the load element.

17. A control circuit according to claim 16, wherein the electronic gate comprises a series arrangement of a capacitance and a resistance.

18. A control circuit according to claim 1 the circuit being intended for use with a camera and being constructed as a unit or units which are removably attachable to the camera.

19. A control circuit according to claim 3, wherein the amplifying circuit includes a unijunction transistor arranged as an ON-OFF device.

20. A control circuit according to claim 3, wherein the amplifying circuit includes a four-layer diode arranged as an ON-OFF device.

21. A control circuit according to claim 3, wherein the amplifying circuit includes at least one transistor amplifying stage.

22. A control circuit according to any preceding claim which includes electrical means for varying the sensitivity of the measuring device to the quantity of the light incident upon it.

23. A control circuit according to claim 22, wherein the electrical means comprises means for varying a capacitance connected in series with the measuring device.

24. A control circuit according to claim 22, wherein the electrical means comprises variable resistance means.

25. A control circuit according to claim 1 wherein the load element is in the form of an electronic flash, or a stroboscope, or a laser.

26. A control circuit according to claim 1 wherein the load element is in the form of an electronic flash tube in series with an inductance.

27. A control circuit according to claim 1, wherein the control circuit is arranged to draw

This is the replacement sheet

Date: 18/8/79

will function to perform an arc operation. The modified embodiment of Figure 20 has a firing electrode 2106 which protrudes into the gas-filled interior 2105 of the enclosure 2103.

In Figures 19*a* and 20*a*, which show modified embodiments of the devices of Figures 19 and 20 respectively, the enclosure 2003 and 2103 are formed in the shape of tubes and are delimited by two electrodes 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 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 connected in series between the energy-storage capacitor and the load element and connectible in series between the load element and the source, the electronic switching means being arranged to be opened by a 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.

2. A control circuit according to claim 1, wherein the measuring device is arranged to be responsive to the quantity of light which, in use, is emitted by the load element and thereafter reflected to the measuring device from an object.

3. A control circuit according to claim 1 or 2, wherein the output of the measuring device is supplied to an amplifying circuit.

4. A control circuit according to any of the preceding claims, wherein the measuring device includes a photodiode.

5. A control circuit according to any of claims 1 to 3, wherein the measuring device includes a phototransistor.

6. A control circuit according to any of claims 1 to 3, wherein the measuring device includes a photovoltaic cell.

7. A control circuit according to any preceding claim, wherein the electronic switching means is a semiconductor element.

8. A control circuit according to claim 7, wherein the semiconductor element is a thyristor.

9. A control circuit according to claim 7 or claim 8, wherein the semiconductor element has the form of a gate turn-off switch.

10. A control circuit according to any one of claims 1 to 8, wherein said control signal generating means includes an auxiliary electronic switching device, said control signal being generated by the closure of the auxiliary electronic switching device which is connected in an auxiliary circuit.

11. A control circuit according to claim 10 wherein the auxiliary electronic switching device is a gas-filled arrestor tube having two main electrodes and one firing electrode, all of the electrodes being cold, the tube being constructed to operate by producing an arc.

12. A control circuit according to claim 11, wherein the two main electrodes are identical and unpolarized.

13. A control circuit according to claim 11 or claim 12, wherein the firing electrode is arranged outside of the gas-filled interior of the tube.

14. A control circuit according to claim 11 or claim 12, wherein the firing electrode is arranged inside of the gas-filled interior of the tube.

15. A control circuit according to any one of claims 11 to 14, wherein the gas is argon.

16. A control circuit according to claim 1, including an electronic gate arranged so that, in use, electrical power is passed from the load element to the circuit by way of the electronic gate which supplies that power only in response to the initiation of a current flow through the load element.

17. A control circuit according to claim 16, wherein the electronic gate comprises a series arrangement of a capacitance and a resistance.

18. A control circuit according to claim 1 the circuit being intended for use with a camera and being constructed as a unit or units which are removably attachable to the camera.

19. A control circuit according to claim 3, wherein the amplifying circuit includes a unijunction transistor arranged as an ON-OFF device.

20. A control circuit according to claim 3, wherein the amplifying circuit includes a four-layer diode arranged as an ON-OFF device.

21. A control circuit according to claim 3, wherein the amplifying circuit includes at least one transistor amplifying stage.

22. A control circuit according to any preceding claim which includes electrical means for varying the sensitivity of the measuring device to the quantity of the light incident upon it.

23. A control circuit according to claim 22, wherein the electrical means comprises means for varying a capacitance connected in series with the measuring device.

24. A control circuit according to claim 22, wherein the electrical means comprises variable resistance means.

25. A control circuit according to claim 1 wherein the load element is in the form of an electronic flash, or a stroboscope, or a laser.

26. A control circuit according to claim 1 wherein the load element is in the form of an electronic flash tube in series with an inductance.

27. A control circuit according to claim 1, wherein the control circuit is arranged to draw

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This is the replacement sheet

Date: 18/12/79

electrical power for its operation from the energy-storage capacitor in response to the initiation of a current flow through the load element.

28. Apparatus including a control circuit according to claim 1, which includes optical means for varying the sensitivity of the measuring device to the quantity of light incident upon it.

29. Apparatus according to claim 28 wherein the optical means comprises an adjustable diaphragm.

30. Apparatus according to claim 28, wherein the optical means comprises a set of filters.

31. Apparatus according to any of claims 28 to 30 wherein the optical means is adjustable with the aid of a manually settable selection device having at least two relatively movable parts provided with scale markings.

32. Apparatus including a control circuit according to claim 1, wherein the electronic switching means emits visible or other light when electric current is passing through it, the apparatus including optical-fibre means for conveying that light to a surface which is responsive to that light to emit visible light as an indication that the switching means is passing that electrical current.

33. A camera in combination with a control circuit according to claim 1.

34. 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 connected in parallel with the load element and the energy-storage capacitor and which is 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, and said switching means comprising a gas-filled arrestor tube having two main electrodes disposed at and delimiting the ends of a tubular body, and a firing electrode arranged outside of the body, all of the electrodes being cold and the tube being constructed to operate by producing an arc.

35. A control circuit according to claim 34, wherein the two main electrodes are identical and unpolarized.

35. A control circuit according to any one of claims 34 or 35, wherein the gas is argon.

37. A control circuit according to claim 34, wherein the measuring device is arranged to be responsive to the quantity of light which, in use, is emitted by the load element and thereafter reflected to the measuring device from an object.

38. A control circuit according to any of claims 34 to 37, wherein the output of the measuring device is supplied to an amplifying circuit.

39. A control circuit according to any of claims 34 to 38 wherein the measuring device includes a photodiode.

40. A control circuit according to any of claims 34 to 38 wherein the measuring device includes a phototransistor.

41. A control circuit according to any of claims 34 to 38, wherein the measuring device includes a photovoltaic cell.

42. A control circuit according to claim 34, the circuit being intended for use with a camera and being constructed as a unit or units which are removably attachable to the camera.

43. A control circuit according to claim 38, wherein the amplifying circuit includes a unijunction transistor arranged as an ON-OFF device.

44. A control circuit according to claim 38, wherein the amplifying circuit includes a four-layer diode arranged as an ON-OFF device.

45. A control circuit according to claim 38, wherein the amplifying circuit includes at least one transistor amplifying stage.

46. A control circuit according to any of claims 34 to 45 which includes electrical means for varying the sensitivity of the measuring device to the quantity of the light incident upon it.

47. A control circuit according to claim 46, wherein the electrical means comprises means for varying a capacitance connected in series with the measuring device.

48. A control circuit according to claim 46, wherein the electrical means comprises variable resistance means.

49. A control circuit according to claim 34, wherein the load element is in the form of an electronic flash, or a stroboscope, or a laser.

50. A control circuit according to claim 49 wherein the load element is an electronic flash tube which is connected in series with an inductance.

51. A control circuit according to claim 34 wherein the control circuit is arranged to draw electrical power for its operation from the energy-storage capacitor in response to the initiation of a current flow through the load element.

52. Apparatus including a control circuit according to any of claims 34 to 48 wherein the electronic switching means emits visible or other light when electric current is passing through it, the apparatus including optical-fibre means for conveying that light to a surface which is responsive to that light to emit visible light as an indication that the switching means is passing that electrical current.

53. Apparatus including a control circuit according to any of claims 34 to 52 which includes optical means for varying the sensitivity of the measuring device to the quantity of light incident upon it.

This is the replacement sheet

Date: 18/08/79

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54. Apparatus according to claim 53 wherein the optical means comprises an adjustable diaphragm.

55. Apparatus according to claim 53 wherein the optical means comprises a set of filters.

56. Apparatus according to any of claims 53 to 55 wherein the optical means is adjustable with the air of a manually settable selection device having at least two relatively movable parts provided with scale markings.

57. A camera in combination with a control circuit according to claim 34.

58. A control circuit according to claim 34 including electronic switching means substantially as described with reference to Figure 19a of the accompanying drawings.

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