

[54] **COMPUTER FLASH WITH REMOTE
SENSOR AND TWO-WIRE CONTROL
OF FLASH FIRING AND QUENCH**

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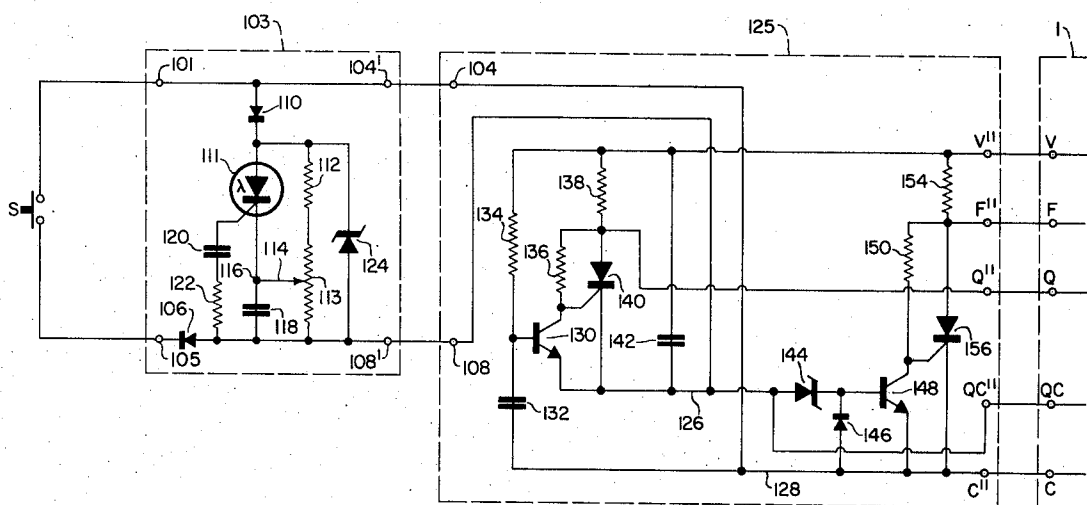
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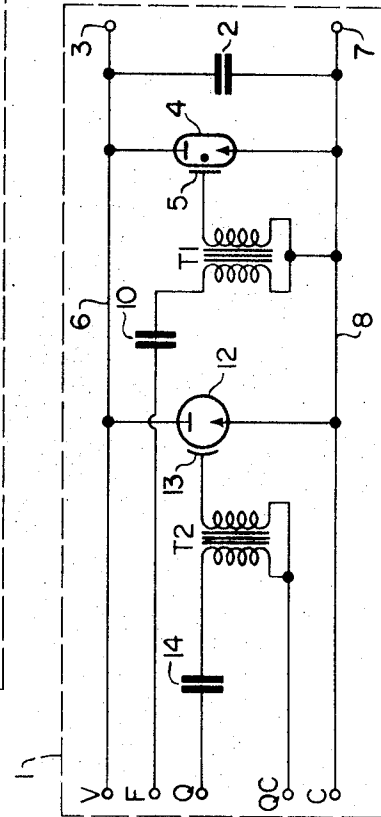
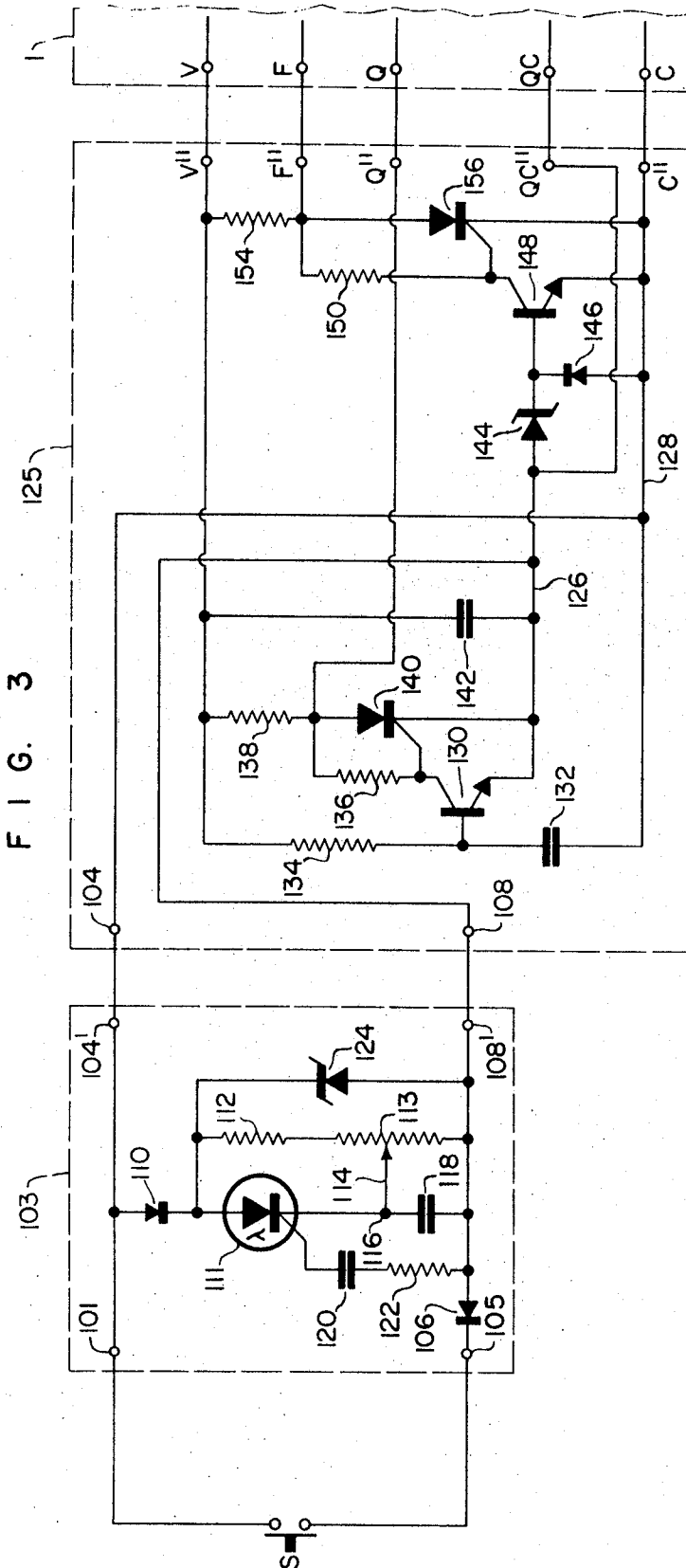
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[57] **ABSTRACT**

A light control system includes a switching means, a light sensing means, a signal conditioning means and a light producing means inter-connected with the light sensing means connected to the signal conditioning means by only two wires. The switching means is selectively operable for generating a flash signal to effect the apparent production of a source light from the light producing means for the illumination of a scene. Gating means activates the normally insensitive light sensing means to respond to light from the scene when a flash signal is generated. A signal to effect the apparent termination of the source light is generated by the light sensing means when sufficient light is received from the scene. Dynamic anticipation means provide a time varying compensation corresponding to the light intensity-time variation characteristic of flash-type light producing means.

38 Claims, 3 Drawing Figures



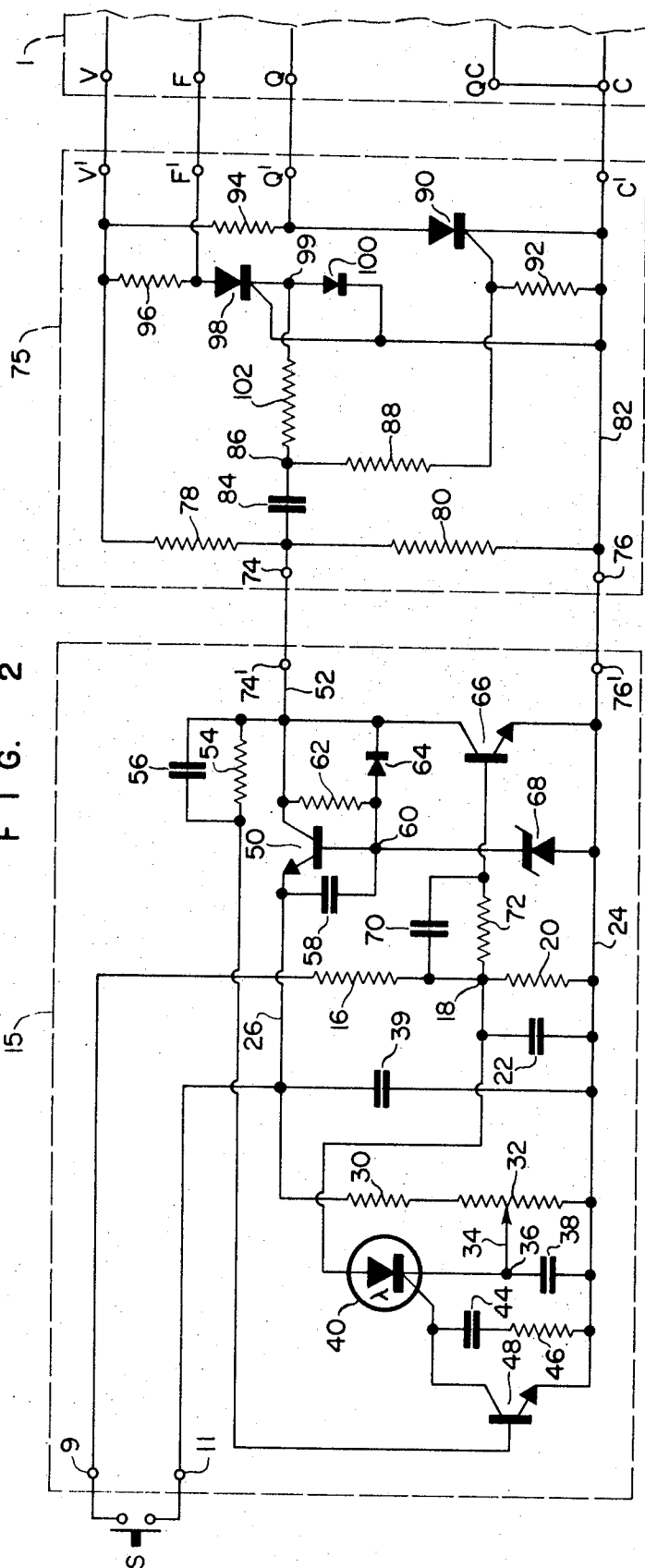


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FIG. 2



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COMPUTER FLASH WITH REMOTE SENSOR AND TWO-WIRE CONTROL OF FLASH FIRING AND QUENCH

The subject matter disclosed but not claimed herein is disclosed and claimed in the copending application of Francis T. Ogawa, Ser. No. 108,876, and the copending application of Roger D. Erickson, Ser. No. 108,877, both filed on even date herewith.

The present invention relates generally to light controlling systems and more particularly to an improved photographic light controlling system and method using computer flash techniques.

Electronic photographic flash devices are known in the art in which the flash of light produced by the flash tube of the device is automatically terminated after a predetermined total quantity of light has been received from the scene being photographed, by a light responsive control portion of the device.

While such devices have been generally satisfactory, there has still existed a need for improved apparatus wherein the actuation of the light terminating means is effected even more accurately and more reliably under varying conditions than has been realized through the use of prior art devices.

Specifically, there has existed a need for improved automatic flash apparatus having greater accuracy, that is, apparatus wherein precisely the same total quantity of light from a subject is caused to reach a light sensitive film in a camera regardless of the camera to subject distance. It has been the tendency of previously known devices to provide excessive amounts of light when the camera to subject distances are small.

In prior art photographic systems, light sensing means have been mounted on or made a part of a light producing means which, in turn, has been connected to a camera means with a standard two conductor connection therebetween. When, however, a light sensing means is mounted on or made a part of the camera means, a minimum of three conductors has been required to connect the combination camera-light sensing means with an associated light producing means. Additionally, distinct advantages may be obtained by a photographer when the light sensing means of a computer-flash system is used as an independent member of the system mechanically detached from both the camera means and the light producing means. That arrangement is similar to the first mentioned arrangement in that at least a three wire connection has been required between the light sensor and the light producing means. Since two wire cables and connections are of standard manufacture, there is a need for a light controlling system requiring only a two wire connection between the light sensing means and the light producing means when the light sensing means is either mounted on or made a part of a camera means, or is mechanically detached from both the camera means and the light sensing means.

There has also existed a need for an improved automatic flash apparatus having greater reliability, specifically, apparatus in which the light terminating means is prevented from being actuated by extraneous conditions or events, and is enabled only when it properly should be, that is, when the flash tube of the apparatus itself has been fired. Some previously known devices have often exhibited deficiencies in this respect.

It is accordingly an object of the present invention to provide an improved light controlling system which obviates the disadvantages of the prior art systems.

It is another object of the present invention to provide an improved photographic system which dynamically compensates for various subject to camera distances automatically.

It is a further object of the present invention to provide an improved computer-flash system in which the reliability of operation is increased by preventing the untimely operation of the light producing means, that is, by preventing the light producing function from being initiated by noise, the flashing of other flash apparatus, and other extraneous causes.

It is still a further object of the present invention to provide an improved computer flash photographic system wherein the firing of the flash device is the condition precedent which enables the light sensing function of the system.

It is yet another object of the present invention to provide an improved computer flash photographic system which requires only a two wire connection between the light sensing means and the light producing means.

It is yet a further object of the present invention to provide an improved method of monitoring and controlling a control effect from a remote location.

In accomplishing these and other objects, there has been provided in accordance with the present invention, an improved light controlling or photographic system including a switching means, a light sensing means, a signal conditioning means, and a light producing means. The switching means may be included as part of a camera means. The above mentioned means are interconnected with the connection between the light sensing means and the signal conditioning means comprising only two signal conductors. The switching means is selectively actuated to activate the light producing means for providing a source light which illuminates a scene. When the light producing means is activated, the light sensing means is enabled and begins to sense the scene light or the light received from the illuminated scene. When the light sensing means has received a predetermined amount of light from the illuminated scene, the light quenching signal is generated. Dynamic anticipation means is included in the light sensing means whereby the nonlinear nature of the light intensity created by the light producing means is automatically compensated for, thereby minimizing the otherwise unavoidable overexposure error apparent when the distance between the object being photographed and the camera means is relatively small. The light quenching signal is received by the signal conditioning means and is effective to apparently terminate the light emitted from the light producing means.

A better understanding of the present invention may be had from the following detailed description when read in connection with the accompanying drawings in which:

FIG. 1 is a schematic diagram of a light producing means, considered to be known in the art.

FIG. 2 is a schematic diagram of a light sensing means, a signal conditioning means and the input terminals of the light producing means shown in FIG. 1 as incorporated in one embodiment of the present invention.

FIG. 3 is a schematic diagram of a light sensing means, a signal conditioning means and the input terminals of the light producing means shown in FIG. 1, as incorporated in a second embodiment of the present invention.

Referring in more detail to FIG. 1, there is shown a flash or light producing means including a capacitor 2 connected between two terminals 3 and 7. The two terminals 3 and 7 are connected to the usual capacitor charging means which are not shown in FIG. 1. Such capacitor charging means are well known in the art and it is sufficient to say that the capacitor 2 is normally maintained in the charged state by the aforementioned capacitor charging means, a relatively high voltage being maintained across the capacitor 2. The capacitor charging means and the capacitor 2 act as an energy source means since the voltage appearing across the capacitor 2 provide the sole source of energy for the system. The high voltage terminal 3 is connected to a bus 6; the common terminal 7 is connected to a bus 8. A flash tube or light producing tube 4 is shown with its anode connected to the bus 6 and its cathode connected to the bus 8. A light triggering terminal 5 of the flash tube 4 is coupled through a transformer T1 to one terminal of a capacitor 10. The other terminal of the capacitor 10 is connected to an input terminal F. The transformer T1 has a common terminal connected to the bus 8. A light terminating tube or quench tube 12 is shown connected between the bus 6 and the bus 8. A triggering terminal 13 is connected through a transformer T2 to one terminal of a capacitor 14. The other terminal of the capacitor 14 is connected to an input terminal Q. The transformer T2 has a common terminal connected to an output terminal QC. The high voltage bus 6 is brought out to an input terminal V while the common bus 8 is brought out into an input terminal C.

FIG. 2 shows a light sensing means 15, a signal conditioning means 75 and five terminals V, F, Q, QC, and C, of the light producing means 1. The light sensing means 15 has two input terminals 9 and 11. These terminals may be connected to the terminals of any switching means for example switch 5, which is selectively operable to provide a closed contact. In a photographic system, for example, the switch 5 may be the shutter switch of a camera. Input terminal 9 is connected through a resistor 16 to a common point 18. The parallel combination of a resistor 20 and a capacitor 22 connects the common point 18 to a common bus 24 of the light sensing means 15. The other input terminal 11 is connected to a bus 26. The bus 26 is connected through two serially connected resistors 30 and 32 to the common bus 24. The resistor 32 is a slidewire resistor and has a slider 34 which connects to a junction 36. A capacitor 38 connects the junction 36 to the common bus 24. A light activated silicon controlled rectifier (LASCR) provides a cathode to anode connection from the junction 36 to the common point 18. The gate electrode of the LASCR is connected through a capacitor 44 and a resistor 46 to the common bus 24. A capacitor may be connected between the gate and cathode terminals of any LASCR shown in the drawings to insure against undesirable noise triggering. The collector-emitter path of an NPN transistor 48 connects the gate terminal of the LASCR 40 to the common bus 24. The base terminal of the transistor 48 is connected through a resistor 54 to a bus 52. A capacitor 56 is con-

nected across the resistor 54. The bus 52 is connected to the bus 26 through the collector-emitter path of an NPN transistor 50. A capacitor 39 connects the bus 26 to the common bus 24. The base terminal of the NPN transistor 50 is connected to a common point 60 which is, in turn, connected through the cathode to anode path of a zener diode 68 to the common bus 24. The common point 60 is connected to the collector terminal of the transistor 50 through a resistor 62. A capacitor 58 is connected between the emitter terminal of the transistor 50 and the common point 60. The common point 60 is also connected to the anode of a diode 64, the cathode of which is connected to the bus 52. The bus 52 is connected to the bus 24 through the collector-emitter path of an NPN transistor 66. The base terminal of the transistor 66 is connected through a resistor 72 to the common point 18. A capacitor 70 is connected across the resistor 72. The bus 52 is connected to an output terminal 74' of the light sensing means 15. The common bus 24 is connected to a second output terminal 76' of the light sensing means 15.

A signal conditioning means 75 has two input terminals 74 and 76 connected, respectively, to the corresponding output terminals 74' and 76' of the light sensing means 15. The input terminal 76 is connected to a common bus 82 of the signal receiving means 75. The common bus 82 is connected to a signal conditioning means output terminal C' and also, through two serially connected resistors 80 and 78, to another output terminal V'. The common point between the resistors 78 and 80 is connected to the signal conditioning means input terminal 74 and also, through a capacitor 84 to a common point 86. The common point 86 is connected through a resistor 88 to the gate terminal of a silicon controlled rectifier (SCR) 90. The gate terminal of the SCR 90 is connected to the common bus 82 through a resistor 92. The cathode terminal of the SCR 90 is directly connected to the common bus 82 while the anode terminal is connected to an output terminal Q' of the signal conditioning means 75. The common point 86 is also connected through a resistor 102 to a common point 99 between the cathode of an SCR 98 and the anode terminal of a diode 100. The gate terminal of the SCR 98 is connected to the cathode terminal of the diode 100 which is, in turn, connected to the common bus 82. The anode terminal of the SCR 98 is connected to an output terminal F' of the signal conditioning means 75. Output terminal V' and output terminal F' are connected together through a resistor 96. The output terminal V' is connected to output terminal Q' by a resistor 94. The four output terminals V', F', Q' and C' of the signal conditioning means 75 connect to correspondingly labeled input terminals V, F, Q and C of the light producing means 1. For the proper operation of the embodiment shown in FIG. 2, the input terminals QC and C of the light producing means 1 are connected together. The signal conditioning means 75 and the light producing means 1 together comprise a signal responsive means which cooperates with the remotely located sensing means 15 in a manner as is hereinafter described.

In FIG. 2, the signal conditioning means 75 has its output terminal V' connected to the input terminal V of the light producing means 1. The voltage appearing at the terminal V is determined by the charge on the capacitor 2 (FIG. 1) as provided by the capacitor charging means as hereinbefore explained. With the SCR 98

nonconducting, the resistor 96 provides a current path from the signal conditioning means output terminal V' to the output terminal F'. The capacitor 10 of FIG. 1 will be charged to a value representative of the voltage at the terminal F'. When the SCR 98 goes into conduction it provides a low impedance discharge path for the capacitor 10. The capacitor 10 is then rapidly discharged. That action induces a triggering pulse to appear at the flash tube triggering terminal 5 and initiates conduction in the flash tube 4. Since the rapid discharge of the capacitor 10 produces a ringing action in the LC circuit of the capacitor 10 and the transformer T1, the SCR 98 will automatically turn off after a triggering pulse has been provided when the SCR 98 anode voltage is reduced to a level below its threshold voltage. Similarly, the resistor 94 provides a connection between the output terminal V' and the output terminal Q'. The capacitor 14 of FIG. 1 is charged to a steady state value through the resistor 94 from the high voltage lead V'. When the SCR 90 is made conductive, a discharge path is provided for the capacitor 14 and a rapid discharge will occur. That rapid discharge will induce a triggering pulse to appear at the triggering terminal 13 of the quench tube 12. The quench tube 12 will then begin conduction and since the quench tube 12 has a much lower conducting impedance than the flashtube 4, the capacitor 2 will be effectively short-circuited by the quench tube 12. That short-circuiting action will cause the charge on capacitor 2 to rapidly discharge thereby lowering the voltage of the bus 6 to a point insufficient to support ionization of the flashtube 4 which then turns off. The SCR 90 will automatically turn off after a triggering pulse has been provided to the quench tube. The automatic turn-off is a consequence of the ringing action through the circuit of the capacitor 14 and the transistor T2 as hereinbefore explained. A decrease in the voltage appearing at the input terminal 74 will be coupled through the capacitor 84 and the resistor 102 to the cathode terminal of the SCR 98. The gate terminal of the SCR 98 is clamped to the bus 82. The circuit biasing components associated with the SCR 98 so valued that when the negative going or "initiate" signal appears at the input terminal 74, the SCR 98 will become conductive and initiate the operation of the signal responsive means to provide an effect which in the present example is the production of light. Similarly, when a positive going or "terminate" signal appears at the input terminal 74 of the signal receiving means 75, the SCR 90 becomes conductive. When SCR 90 becomes conductive, conduction in the quench tube is initiated, resulting in the termination of the effect produced by the signal responsive means which in the present example is the termination of the light given off by the flash tube 4. Therefore, a negative going or "initiate" signal at the input terminal 74 of the signal conditioning means 75 is operative to initiate the operation of the flashtube and the production of light thereby; while a positive going or "terminate" signal at terminal 74 is operative to effect the termination of the flash tube light.

The circuit of the light sensing means 15 operates to provide the negative going and the positive going signals at the output terminal 74'. The two input terminals 9 and 11 of the light sensing means 15 may be connected to any switching means of a light controlling system but for purposes of the present example it will be assumed that the terminals 9 and 11 are connected to

the shutter switch of an associated camera as may be used in a photographic system. Generally, in the operation of computer flash devices used in photographic systems, the shutter switch of a camera is closed and a light producing means is activated thereby providing light for a scene to be photographed. A light sensing means measures the light received from the scene to be photographed and is effective to terminate the apparent light given off by the light producing means when a predetermined amount of light has been received by the light sensing means.

In FIG. 2, the voltage appearing between the output terminals V' and C' of the signal conditioning means 75 is divided by the resistors 78 and 80. The voltage at the junction of the resistors 78 and 80 is applied to the output terminal 74' of the light sensing means 15. The biasing circuitry associated with the transistor 50 effects the conduction of the transistor 50 when a steady state voltage appears at the terminal 74'. The current flowing through the transistor 50 charges the capacitor 39 to its steady state voltage. That voltage is divided by the two resistors 30 and 32. Normally there is an open contact between the input terminals 9 and 11 of the light sensing means 15, and therefore, no voltage appears at the common point 18. Since no voltage is at the common terminal 18, the transistor 66 is nonconductive and there is no power applied to the LASCR 40. The voltage at point 74' is applied to the base terminal of the transistor 48 and operates to bias the transistor 48 on which provides a discharge path for the capacitor 44. When the LASCR 40 is enabled, a current is generated through the gate terminal of the LASCR 40 and accumulates on the capacitor 44 if the transistor 48 is OFF. Since normally the transistor 48 is conductive, no charge is normally allowed to be stored on the capacitor 44, thereby eliminating the possibility that the LASCR 40 will be actuated by ambient light.

When a switching means such as the shutter switch S of the camera provides a closed contact between the input terminals 9 and 11 of the light sensing means 15, the voltage stored by the capacitor 39 causes a current to flow from the bus 26 through the shutter switch S and through the resistor 16 to the common point 18 and then through the resistor 20 to the common bus 24. The capacitors 22 and 70 accumulate a charge representative of the voltage appearing at point 18. That voltage is applied through the resistor 72 to the base terminal of the transistor 66, and is effective to turn on the transistor 66. When the transistor 66 begins to conduct the voltage appearing at the output terminal 74' of the light sensing means 15 exhibits a sudden decrease. That sudden decrease in voltage at terminal 74' represents the signal which, as previously mentioned, causes the flashtube to fire. The voltage decrease appearing at the terminal 74' is coupled through the diode 64 to the base terminal of the transistor 50. Therefore, when the transistor 66 begins to conduct the transistor 50 is turned off. The decrease in voltage at the terminal 74' is also coupled to the base terminal of the transistor 48 through the resistor 54, whereupon the transistor 48 ceases to conduct. With the voltage present at the common point 18 and the transistor 48 nonconducting, the LASCR 40 is enabled to generate a current through its gate terminal representative of the amount of light received from a scene being illuminated by the flashtube 4. That current is accumulated on the integrating capacitor 44. The resistor 46 pro-

vides a measure of anticipation as described in U.S. Pat. No. 3,519,879 by F. T. Ogawa which is assigned to the assignee of the present invention. The charge stored by the capacitor 38 as represented by the voltage at the point 36 provides a threshold voltage which predetermines the amount of light which must be received by the LASCR 40 before the LASCR 40 becomes conductive. When the voltage as represented by the charge stored on the capacitor 44 as biased by the resistor 46, and the voltage as represented by the charge stored on the capacitor 38 attain a predetermined relationship the LASCR 40 becomes conductive. When the LASCR 40 becomes conductive, a low resistance path is provided from the common point 18 to the common bus 24. The capacitors 22 and 70 will now discharge through the LASCR 40, and the voltage at the common point 18 will decrease thereby turning off the transistor 66. When the transistor 66 is turned off, the voltage at the output terminal 74' will suddenly increase since a relatively higher resistance is introduced between the terminals 74' and 76'. That increase in voltage will effect the operation of the quench tube and thereby terminate the production of light from the flash tube 4, as hereinbefore explained. The increased voltage appearing at the output terminal 74' of the light sensing means 15 will again cause the transistor 50 to conduct and the current therethrough will begin to recharge the capacitor 38. The increased voltage at the output terminal 74' is coupled through the resistor 54 to the base of the transistor 48 and causes the transistor 48 to become conductive, thereby discharging the capacitor 44. After the charges on the capacitors 22 and 70 have been released through LASCR 40, the voltage at the common point 18 drops to a level whereat the LASCR 40 is returned to its normally disabled state. After the initiation of conduction in the quench tube 12, the charge stored on the capacitor 2 will rapidly discharge through the quench tube 12. When the voltage on the anode of the quench tube drops to a value insufficient to support ionization of the tube, the quench tube 12 will again return to its normal nonconductive state.

FIG. 3 shows a light sensing means 103 with two input terminals 101 and 105 which, again may be connected to the terminals of any switching means, selectively operable to produce a closed contact. The input terminal 101 is connected directly to an output terminal 104' while the input terminal 105 is connected, through the cathode to anode path of a diode 106, to the other output terminal 108' of the light sensing means 103. The terminals 101 and 105 may be connected externally to a shutter switch of an associated camera as hereinbefore explained in connection with FIG. 2. The input terminal 101 is also connected through the anode to cathode path of a diode or gating means 110 to the anode terminal of a light activated silicon controlled rectifier (LASCR) 111. The anode terminal of the LASCR 111 is also connected, through two serially connected resistors 112 and 113, to the output terminal 108' of the light sensing means 1103. The resistor 113 is a slidewire resistor having a slider 114 connected to a junction point 116. The point 116 is connected to the cathode terminal of the LASCR 111 and also through a capacitor 118 to the output terminal 108'. The gate terminal of the LASCR 111 is connected, through the series connection of a capacitor 120 and a resistor 122, to the output terminal 108'.

The anode terminal of a zener diode 124 is connected to the output terminal 108'; its cathode terminal is connected to the anode terminal of the LASCR 111. The two output terminals 104' and 108' of the light sensing means 103 are connected to correspondingly designated input terminals 104 and 108 of a signal conditioning means 125. The input terminal 108 is connected to a bus 126. The other input terminal 104 is connected to a bus 128. The bus 126 is connected to the emitter terminal of an NPN transistor 130. The base terminal of the transistor 130 is connected, through a capacitor 132, to the common bus 128 of the signal receiving means 125. The base terminal of the transistor 130 is also connected, through a resistor 134, to an output terminal V'' of the signal conditioning means 125. The common bus 128 is connected to another output terminal C''. The collector terminal of the transistor 130 is connected, through two serially connected resistors 136 and 138, to the output terminal V''. The common point between the two resistors 136 and 138 is connected to the anode terminal of an SCR 140. The gate terminal of the SCR 140 is connected to the collector terminal of the transistor 130; the cathode terminal of the SCR 140 is connected to the bus 126.

The anode terminal of the SCR 140 is also connected to an output terminal Q'' of the signal conditioning means 125. A capacitor 142 connects the output terminal V'' with the bus 126. The bus 126 is connected to the anode of a zener diode 144 and also to an output terminal QC'' of the signal conditioning means 125. The cathode terminal of the zener diode 144 is connected to a common point between the base terminal of an NPN transistor 148 and the cathode terminal of a diode 146. The anode terminal of the diode 146 is connected to the common bus 128. The collector terminal of the transistor 148 is connected through a resistor 150 to an output terminal F''. The output terminal F'' is connected to the output terminal V'' through a resistor 154. The output terminal F'' is also connected to the anode terminal of an SCR 156. The gate terminal of the SCR 156 is connected to the collector terminal of the transistor 148 and the cathode terminal of the SCR 156 is connected to the output terminal C'' of the signal conditioning means 125. The emitter terminal of the transistor 148 is also connected to the output terminal C''. The five output terminals V'', F'', Q'', QC'', and C'' are connected to correspondingly designated input terminals V, F, Q, QC and C of the light producing means 1 shown in FIG. 1. The signal conditioning means 125 and the light producing means 1 together comprise a signal responsive means which cooperates with the remotely located sensing means in a manner as is hereinafter described.

The circuits shown in FIG. 3 perform the same general function as the circuits shown in FIG. 2, however, the light sensing means 103 of FIG. 3 is a much simpler device than the light sensing means 15 shown in FIG. 2. Additionally, the light sensing means 103 provides for a dynamic anticipation, as is hereinafter explained. The normally unpowered feature of the light sensing means 15 of FIG. 2 is retained in the light sensing means 103 of FIG. 3 as is the need for only a conductor connection between the light sensing means and the signal conditioning means. The input terminals of V, F, Q, QC and C of the light producing means 1 are shown in FIG. 3 connected to the correspondingly labeled terminals V'', F'', Q'', QC'' and C'' of a signal condition-

ing means 125. The capacitor 10 of the light producing means 1 is charged from the high voltage bus 6 through the resistor 154 of the signal conditioning means 125 shown in FIG. 3. The capacitor 14 of the light producing means is similarly charged from the high voltage bus 6 through the resistor 138 of the signal conditioning means 125 shown in FIG. 3. The transistor 130 is so biased so that it is normally conducting, in a steady state condition. The transistor 148 is similarly biased so that it is normally conducting. With the transistor 130 conducting, the gate terminal of the SCR 140 is effectively clamped to its cathode terminal and therefore non-conductive. Similarly with the transistor 148 conducting the gate terminal of the SCR 156 is effectively clamped to its cathode terminal thereby precluding conduction. When a switching means, for example a shutter switch S of an associated camera, provides a contact closure between the terminals 101 and 105 of the light sensing means 103, a current flows from the bus 126, through the diode 106, to the bus 128. At that time the LASCR 111 is still disabled since the diode 110 is reverse biased. The voltage on the bus 126 decreases since a lower resistance path (diode 106) is now present between the buses 126 and 128 than was present before the shutter switch closure (zener 144 and base-emitter path of transistor 148). The lower voltage on the bus 126 with respect to the bus 128 will cause the transistor 148 to turn off. With the transistor 148 open, the current through the resistor 150 will flow into the gate terminal of the SCR 156 and thereby render it conductive. With the SCR 156 conducting, a relatively low resistance path is presented to the output terminal F'' of the signal conditioning means 125. That low resistance path operates to rapidly discharge the capacitor 10 shown in FIG. 1 thereby initiating the light producing operation of the flash tube 4 as hereinbefore explained. As the flash tube 4 begins to conduct the voltage on the bus 6 is suddenly reduced as the charge on the capacitor 2 is dumped through the flash tube 4. That sudden voltage decrease appears at the output terminal V'' of the signal conditioning means 125 and is coupled through the capacitor 142 to the bus 126. The coupling action of the capacitor 142 causes the voltage on the bus 126 to suddenly decrease to a negative value with respect to the bus 128. The negative voltage on the bus 126 with respect to the bus 128 is coupled to the light sensing means 103 through the output terminals 104' and 108'. Normally, the voltage at the output terminal 108' of the light sensing means 103 is positive with respect to the voltage appearing at the output terminal 104' and the gating means or diode 110 will prevent conduction in the light sensing circuit since it is then reverse biased. However, as now apparent, when the flash tube 4 begins to conduct the voltage at the output terminal 104' of the signal conditioning means 125 becomes positive with respect to the voltage appearing at the output terminal 108. That positive change in voltage acts as an "enable" signal. The diode 110 is then forward biased and allows a current to flow therethrough. The diode 106 is then reverse biased thereby effectively disconnecting the switching means from the circuits. The current flowing through the diode 110 flows through the resistor 112 and resistor 113. That current establishes a voltage at the anode of the LASCR 111 which effectively powers or enables the LASCR 111 to monitor light. The time interval between the actuation of the switching means connecting

the input terminals 101 and 105 of the light sensing means 103 and the powering of the LASCR 111 is relatively short therefore only a momentary contact is required for the switching means for the proper operation of the system. A portion of the current flowing through the resistor 112 flows through the slider 114 and begins to charge the capacitor 118. When the LASCR is enabled, a current representative of the amount of light monitored thereby flows through its gate terminal to the integrating capacitor 120 and through the anticipation resistor 122. The function of the anticipation resistor 122 is fully explained in U.S. Pat. No. 3,519,879, supra. The capacitor 118 provides a unique type of dynamic anticipation in addition to the anticipation resistor 122. The cooperative action in this particular portion of the circuit will be hereinafter explained. For now, however, it is sufficient to say that when the voltage stored by the integrating capacitor 120 as biased by the anticipation resistor 122, exceeds the voltage representative of the charge stored on the dynamic anticipation capacitor 118, the LASCR 111 becomes conductive thereby providing a low resistance path and an associated voltage decrease between the output terminals 104' and 108'. Consequently, a similar decrease in voltage is developed between the bus 126 and bus 128 of the signal conditioning means 125. That voltage decrease coupled through the capacitor 132 to the base terminal of the transistor 130 thereby causing the transistor 130 to turn off. With the transistor 130 non-conducting, a current will flow into the gate terminal of the SCR 140 thereby rendering it conductive. When the SCR 140 becomes conductive a lower resistance path is presented between the output terminals A'' and QC'' which causes the capacitor 14 of the light producing means 1 to dump its charge therethrough. That action induces a triggering signal to appear at the quench tube triggering terminal 13, thereby initiating conduction in the quench tube 12. The rapid discharge of the capacitor 14 also produces a ringing action through the circuit including the capacitor 14 and the transformer T2. That ringing action is effective to turn off the SCR 140 after the quench tube triggering signal has been provided. After the quench tube 12 fires, the charge stored on the capacitor 2 in the light producing means 1 of the signal responsive means will dissipate to a point where the voltage on the bus 6 is insufficient to support ionization in either the quench tube 12 of the flashtube 4, and the operation or production of light by the signal responsive means will terminate. The charging circuit connected to the terminals 3 and 7 of the light producing means 1 will begin to re-charge the capacitor 2. The voltage appearing at the bus 6 will build up to a value sufficient to restore the biasing voltage required to turn the transistors 130 and 148 on and the system shown in FIG. 3 will be returned to its normal condition to await the initiation of another cycle.

Dynamic anticipation acts to insure proper exposure of the light sensitive film in a camera even though the camera to subject distance is relatively small. The operation of anticipation circuitry including the integrating capacitor 120 the anticipation resistor 122 of FIG. 3 is explained in detail in U.S. Pat. No. 3,519,879 as previously mentioned. That invention essentially provided means whereby a turn-on voltage representative of an amount of light received by a light sensing means would automatically reflect the steep initial rise in light intensity when a flash tube is initiated. The use of the capaci-

tor 118 and the resistor 112 and the portion of the resistor 113 above the slide wire 114 provides an improvement over the circuitry shown in the above referenced patent. In that prior art device, the turn on voltage presented on the gate terminal of the LASCR appeared when a flash tube was fired and increased portionally to the light received by the LASCR. When that turn-on voltage exceeded a fixed threshold voltage present at the cathode of the LASCR, the LASCR would become conductive, thereby effecting the apparent termination of the production of light by the flash tube. In prior art devices a light responsive or light sensing means such as an LASCR will not become conductive until the voltage representative of the amount of light received exceeded the threshold voltage present at the cathode terminal of the LASCR. The threshold voltage which had to be exceeded had been previously set at a fixed value. For example a curve may be plotted with the voltage representative of the light received as the ordinate and time as the abscissa. At a time T, the voltage representative of the light received will exceed the fixed threshold voltage on the cathode of an LASCR, and the LASCR will become conductive. With the dynamic anticipation means in the present invention, the threshold voltage is not fixed but is initially zero volts and is increased with time as determined by the RC time constant determined by the resistor 112, the portion of the resistor 113 above the slide wire 114, and the dynamic anticipation capacitor 18. Using the dynamic anticipation means, the threshold voltage appearing at point 116 will be exceeded by the turn on voltage representative of the light received by the LASCR 111 at a time T1 which occurs prior to the aforementioned time T. Therefore the LASCR 111 will be turned on sooner with the dynamic anticipation means and the over-exposure error due to additional light received after sufficient film exposure light has already been received, is reduced to a minimum. The over-exposure error, avoided through the use of the dynamic anticipation means herein disclosed, would be proportional to the light received by the camera between the two times T and T1.

Thus, there has been provided an improved light controlling or photographic system including a switching means, which may be part of the associated camera means, a light sensing means, a signal conditioning means, and a light producing means, inter connected whereby an actuation of the switching means initiates the production of a source light from the light producing means for the illumination of a scene, and the light sensing means is responsive to the scene light or the light received from the illuminated scene to generate a light terminating or quench signal effective to arrest the apparent production of light. The improved light controlling or photographic system is characterized by the use of a unique dynamic anticipation means which minimizes the over-exposure error heretofore unavoidable in situations where the object to camera distance is relatively small. The improved light controlling system is further characterized in that only two signal conductors are required to connect the light sensing means with the signal conditioning means.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of monitoring and controlling from a first location the production at a second location re-

mote from said first location of a control effect, comprising the steps of producing at said first location a control signal to initiate said control effect at said second location, transmitting said control signal to said second location over a two wire connection means, generating at said second location an enable signal upon each occurrence of said control effect to enable at said first location the operation of means responsive to a second effect related to said control effect, transmitting said enable signal to said first location over said two wire connection means, generating at said first location a terminating signal for terminating the duration of said control effect upon the attainment of a predetermined value of said second effect, and transmitting said terminating signal to said second location over said two wire connection means.

2. The method recited in claim 1 wherein said control effect is the production of light for the illumination of an external element, said second effect is the effective illumination of said external element, and all the power needed by said means responsive to the second effect is provided from said second location over said two wire connection means.

3. Control apparatus comprising:

a signal responsive means including terminal means for connection to an energy source means, a sensing means positioned remotely with respect to said signal responsive means,

a two-wire conduction means constituting the only connection between said sensing means and said signal responsive means,

means associated with said sensing means for producing an "initiate" signal transmitted over said two-wire connection to said signal responsive means to initiate the operation of said signal responsive means,

all of the energy for said sensing means being supplied to said sensing means over said two-wire connection from said signal responsive means,

said sensing means being operative to monitor an effect produced as a result of the operation of said signal responsive means, and upon the occurrence of a predetermined value of said effect, to produce a "terminate" signal transmitted from said sensing means to said signal responsive means over said two wire connection to effectively terminate the operation of said signal responsive means.

4. The invention as set forth in claim 3 wherein said sensing means includes:

means for providing a threshold signal of a varying time-magnitude relationship; and

signal generating means responsive to said value of said monitored effect and said threshold signal for generating said "terminate" upon the occurrence of a predetermined relationship between said value and said threshold signal.

5. The invention as set forth in claim 3 wherein said signal responsive means includes a signal conditioning means coupled to a light producing means, said two wire conduction means being connected to said signal conditioning means, whereby said "initiate" signal is transmitted over said two wire connection to said signal conditioning means, said signal conditioning means being responsive to said "initiate" signal to generate a further signal for application to said light producing means, whereby to initiate the production of the light

by said light producing means for the illumination of an external element,

said sensing means being operative to monitor the light received by said sensing means as a measure of the effective illumination of said external element resulting from the operation of said light producing means, and wherein said predetermined valve of said effect is a predetermined amount of light received by said sensing means.

6. Control apparatus comprising:

a signal responsive means including an energy source means,

a sensing means positioned remotely with respect to said signal responsive means,

electrical connection means interconnecting said sensing means and said signal responsive means, all of the energy for said sensing means being supplied thereto over said electrical connection means from said signal responsive means,

means associated with said sensing means for producing an "initiate" signal transmitted over said connection means to said signal responsive means to initiate operation of said signal responsive means, means including said signal responsive means for producing an "enable" signal for said sensing means whenever said signal responsive means is rendered operative, said "enable" signal being transmitted to said sensing means over said electrical connection means,

said sensing means being operative, in response to said "enable" signal to monitor an effect produced as a result of the operation of said signal responsive means and, upon the occurrence of a predetermined value of said effect, to produce a "terminate" signal transmitted from said sensing means to said signal responsive means over said electrical connection means to effectively terminate the operation of said signal responsive means.

7. The invention as set forth in claim 6 wherein said sensing means includes:

means for providing a threshold signal of a varying time-magnitude relationship; and

signal generating means actuated by said "enable" signal to respond to the occurrence of a predetermined relationship between said value of said monitored effect and said threshold signal to generate said "terminate" signal, whereby said "terminate" signal is generated at a time after said occurrence of said value of said effect which is a function of the intensity of said effect.

8. The invention as set forth in claim 6 wherein said electrical connection means is comprised of only two wires, said two wire connection constituting the only connection between said sensing means and said signal responsive means.

9. The invention as set forth in claim 6 wherein said signal responsive means includes a signal conditioning means coupled to a light producing means for illuminating an external element, said electrical connection interconnecting said sensing means and said signal conditioning means,

said light producing means including said means for producing said "enable" signal for said sensing means whenever said light producing means is rendered operative,

said sensing means being operative, in response to said "enable" signal to monitor the light received

by said sensing means as a measure of the effective illumination of said external element resulting from the operation of said light producing means, and wherein said predetermined value of said effect is a predetermined amount of light received by said sensing means.

10. The invention as set forth in claim 9 wherein said electrical connection is comprised of only two wires, said two wire connection constituting the only connection between said sensing means and said signal conditioning means.

11. In control apparatus including sensing means with first and second terminals, means associated with said sensing means for effecting an "initiate" signal to appear across said first and second terminals, the combination comprising:

a signal responsive means including an energy source means,

said signal responsive means being positioned remotely with respect to said sensing means; and

a two wire connection connecting said first and second terminals of said sensing means with said signal responsive means,

said two wire connection means constituting the only connection between said sensing means and said signal responsive means,

all of the energy for said sensing means being supplied to said sensing means over said two wire connection means from said signal responsive means, said "initiate" signal being transmitted over said two wire connection means to said signal responsive means to initiate the operation of said signal responsive means,

said sensing means being operable to monitor an effect produced as a result of the operation of said signal responsive means and, upon the occurrence of a predetermined value of said effect to produce a "terminate" signal transmitted from said sensing means to said signal responsive means over said two wire connection to effectively terminate the operation of said signal responsive means.

12. The invention as set forth in claim 11 wherein said signal responsive means includes a signal conditioning means coupled to a light producing means, said two wire connection means being connected to said signal conditioning means, whereby said "initiate" signal is transmitted over said two wire connection to said signal conditioning means, said signal conditioning means being responsive to said "initiate" signal to generate a further signal for application to said light producing means, whereby to initiate the production of light by said light producing means for the illumination of an external element, said sensing means being operative to monitor the light received by said sensing means as a measure of the effective illumination of said external element resulting from the operation of said light producing means, and wherein said predetermined value is a predetermined amount of light received by said sensing means.

13. In control apparatus including a sensing means, means associated with said sensing means for effecting an "initiate" signal, the combination comprising:

a signal responsive means including an energy source means, said signal responsive means being positioned remotely with respect to said sensing means, electrical connection means interconnecting said sensing means and said signal responsive means, all

of the energy for said sensing means being supplied thereto over said electrical connection means from said signal responsive means, said "initiate" signal being transmitted over said electrical connection means to said signal responsive means to initiate the operation of said signal responsive means, and means including said signal responsive means for producing an "enable" signal for said sensing means whenever said signal responsive means is rendered operative, said "enable" signal being transmitted to said sensing means over said electrical connection means,

said sensing means being operative, in response to said "enable" signal to monitor an effect produced as a result of the operation of said signal responsive means and, upon the occurrence of a predetermined value of said effect, to produce a "terminate" signal transmitted from said sensing means to said signal responsive means over said electrical connection means to effectively terminate the operation of said signal responsive means.

14. The invention as set forth in claim 13 wherein said electrical connection means is comprised of only two wires, said two wires constituting the only electrical connection between said sensing means and said signal responsive means.

15. In control apparatus including an effect producing means which further includes an energy source means, said control apparatus also including a sensing means, and means associated with said sensing means for providing an "initiate" signal, the combination comprising:

a signal conditioning means coupled to said effect producing means, said signal conditioning means being positioned remotely with respect to said sensing means, and

a two wire connection means constituting the only connection between said sensing means and said signal conditioning means, all of the energy for said sensing means being supplied to said sensing means over said two wire connection from said signal conditioning means,

said "initiate" signal being transmitted over said two wire connection to said signal conditioning means, said signal conditioning means being responsive to said initiate signal to generate a further signal whereby to initiate the operation of said effect producing means,

said sensing means being operative to monitor an effect produced as a result of the operation of said effect producing means and, upon the occurrence of a predetermined value of said effect, to produce a "terminate" signal transmitted from said sensing means to said signal conditioning means over said two wire connection to effectively terminate the operation of said effect producing means.

16. The invention as set forth in claim 15 wherein said effect producing means is a light producing means.

17. In control apparatus including an effect producing means, an energy source means included within said effect producing means, a sensing means, means associated with said sensing means for producing an "initiate" signal, means included in said effect producing means for producing an "enable" signal for said sensing means whenever said effect producing means is rendered operative, the combination comprising:

signal conditioning means coupled to said effect producing means, said signal conditioning means being positioned remotely with respect to said sensing means,

electrical connection means interconnecting said sensing means and said signal conditioning means, all of the energy for said sensing means being supplied thereto over said electrical connection means from said signal conditioning means, said "initiate" signal being transmitted over said connection means to said signal conditioning means, said signal conditioning means being responsive to said "initiate" signal to generate a further signal for application to said effect producing means whereby to initiate the operation of said effect producing means, said enable signal being transmitted to said sensing means over said electrical connection means, said sensing means being operative, in response to said enable signal to monitor an effect produced as a result of the operation of said effect producing means, and upon the occurrence of a predetermined value of said effect to produce a "terminate" signal transmitted from said sensing means to said signal conditioning means over said electrical connection means to effectively terminate the operation of said effect producing means.

18. The invention as set forth in claim 17 wherein said effect producing means is a light producing means,

19. The invention as set forth in claim 17 wherein said electrical connection means comprises only two wires, said two wires comprising the only connection between said sensing means and said signal conditioning means.

20. A signal conditioning means comprising:

a first set of two terminals,

a second set of four terminals, the second terminal of said first set being connected to the fourth terminal of said second set,

a voltage divider means connecting the first terminal of said second set with the said fourth terminal of said second set, said voltage divider means having a pick-off terminal thereon coupled to the first terminal of said first set, said voltage divider means being responsive to a power signal applied thereto for applying a control signal to said first terminal of said first set,

first switching means responsive to a decrease in said control signal for providing an effective contact closure between the second terminal of said second set and said fourth terminal of said second set, and a second switching means responsive to an increase in said control signal for providing an effective contact closure between the third terminal of said second set and said fourth terminal of said second set.

21. The invention as set forth in claim 20 wherein said first and second switching means are first and second silicon controlled rectifiers, respectively, each having gate, anode and cathode terminals, and said signal conditioning means further includes first impedance means connecting said anode terminal of said first silicon controlled rectifier to said first terminal of said second set and second impedance means connecting said anode terminal of said second silicon controlled rectifier to said first terminal of said second set, and coupling means connecting said first terminal of said first set jointly to said cathode terminal of said first silicon

controlled rectifier and said gate terminal of said second silicon controlled rectifier.

22. The invention as set forth in claim 21 wherein said coupling means is a capacitor, and said first impedance means and said second impedance means are resistors.

23. A signal conditioning means comprising:

a first set of two terminals,

a second set of five terminals, the second terminal of said first set being connected to the fifth terminal of said second set,

voltage divider means connecting the first terminal of said second set with said fifth terminal of said second set, said voltage divider means having a pick-off terminal thereon coupled to the first terminal of said first set, said voltage divider means being responsive to a power signal applied thereto for applying a control signal to said first terminal of said first set,

first switching means responsive to a decrease in said control signal for providing an effective contact closure between the second terminal of said second set and said fifth terminal of said second set and a second switching means responsive to an increase in said control signal for providing an effective contact closure between the third and fourth terminals of said second set.

24. The invention as set forth in claim 23 wherein said first switching means comprises:

a silicon controlled rectifier having anode, cathode and gate terminals, said anode and cathode terminals being connected respectively to said second and fifth terminals of said second set;

a first resistor connecting said anode and gate terminals;

a second resistor connecting said anode terminal with said first terminal of said second set; and

a transistor having base, collector, and emitter terminals said collector terminal being connected to said gate terminal, said emitter terminal being connected to said fifth terminal of said second set, and said base terminal being coupled to said first terminal of said first set.

25. The invention as set forth in claim 23 wherein said second switching means comprises:

a silicon controlled rectifier having anode, cathode and gate terminals said anode and cathode terminals being connected respectively to said third and said fourth terminals of said second set;

a first resistor connecting said anode and gate terminals;

a second resistor connecting said anode terminal with said first terminal of said second set; and

a transistor having base, collector and emitter terminals, said collector terminal being connected to said gate terminal, said emitter terminal being connected to said first terminal of said first set, and said base terminal being connected to said pick-off terminal.

26. The invention as set forth in claim 3 wherein said means associated with said sensing means includes a shutter switch of a photographic camera.

27. The invention as set forth in claim 6 wherein said means associated with said sensing means includes a shutter switch of a photographic camera.

28. The invention as set forth in claim 20 and further including a light producing means responsive to said

contact closure between said third and fourth terminals of said second set whereby to provide light for the illumination of an external element.

29. The invention as set forth in claim 28 and further including a quench means responsive to said contact closure between said third and fourth terminals of said second set for terminating said light provided by said light producing means.

30. The invention as set forth in claim 23 and further including a light producing means responsive to said contact closure between said second and fifth terminals of said second set whereby to provide light for the illumination of an external element.

31. The invention as set forth in claim 30 and further including a quench means responsive to said contact closure between said third and fourth terminals of said second set for terminating said light provided by said light producing means.

32. Control apparatus comprising:

a signal responsive means including an energy source means;

a sensing means positioned remotely with respect to said signal responsive means;

electrical connection means connecting said sensing means with said signal responsive means;

means associated with said sensing means for producing an "initiate" signal for transmission over said connection means to said signal responsive means to initiate an operation of said signal responsive means, all of the energy for said sensing means being supplied to said sensing means over said connection means from said signal responsive means; said sensing means being operative to monitor an effect produced as a result of the operation of said signal responsive means, and, upon an occurrence of a predetermined value of said effect, to produce a "terminate" signal for transmission from said sensing means to said signal responsive means over said connection means to effectively terminate the operation of said signal responsive means.

33. The control apparatus as set forth in claim 32 wherein said signal responsive means includes a light producing means, said sensing means including a light sensing device operative to monitor light which is influenced by the light produced as a result of the operation of said light producing means.

34. Control apparatus comprising:

a signal responsive means;

sensing means positioned remotely with respect to said signal responsive means;

a two-wire electrical connection means interconnecting said sensing means and said signal responsive means;

means associated with said sensing means for producing an "initiate" signal for transmission over said connection means to said signal responsive means to initiate an operation of said signal responsive means;

means including said signal responsive means for producing an "enable" signal for said sensing means whenever said signal responsive means is rendered operative, said "enable" signal being transmitted to said sensing means over said electrical connection means, said sensing means being operative, in response to said "enable" signal to monitor an effect produced as a result of the operation of said signal responsive means and, upon the occurrence of a

predetermined value of said effect, to produce a "terminate" signal for transmission from said sensing means to said signal responsive means over said electrical connection means to effectively terminate the operation of said signal responsive means. 5

35. The control apparatus as set forth in claim 34 wherein said electrical connection means comprises only two wires, said two wire connection constituting the only connection between said sensing means and said signal responsive means. 10

36. A control apparatus comprising:

signal responsive means including a light producing means;

light sensing means positioned remotely with respect to said signal responsive means; 15

a two-wire electrical connection means interconnecting said sensing means and said signal responsive means;

means associated with said light sensing means for providing an "initiate" signal for transmission over said connection means to said signal responsive means to initiate an operation of said light producing means; 20

means including said signal responsive means for producing an "enable" signal for said light sensing means whenever said light producing means is rendered operative, said "enable" signal being transmitted to said light sensing means over said electrical connection means, said light sensing means being operative in response to said "enable" signal to monitor light affected by an operation of said light producing means and, upon the occurrence of a predetermined value of said affected light to produce a "terminate" signal for transmission from said light sensing to said light producing means 30 over said electrical connection means to effectively

terminate the operation of said light producing means.

37. A control apparatus comprising:

a signal responsive means;

a sensing means positioned remotely with respect to said signal responsive means;

an electrical connection means connecting said sensing means and said signal responsive means;

means associated with said sensing means for producing an "initiate" signal transmitted over said electrical connection to said signal responsive means to initiate an operation of said signal responsive means, said sensing means including isolating means responsive to a signal received from said signal responsive means indicative of an operation of said signal responsive means for electrically isolating said sensing means and said signal responsive means from said means associated with said sensing means during the continuance of said signal indicative of an operation of said signal responsive means, said sensing means being operative to monitor an effect produced as a result of the operation of said signal responsive means, and upon an occurrence of a predetermined value of said effect, to produce a "terminate" signal transmitted from said sensing means to said signal responsive means over said electrical connection means to effectively terminate the operation of said signal responsive means. 35

38. The control apparatus as set forth in claim 37 wherein said signal responsive means includes a light producing means, said sensing means including a light sensing device operative to monitor light which is influenced by the light produced as a result of an operation of said light producing means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,737,721

Dated June 5, 1973

Inventor(s) Francis T. Ogawa

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 10, line 24, after "108." insert -- Thus the gate-cathode junction of the LASCR 111 acts as a comparator means for effecting the generation of an electrical signal when the light received by the light sensing means 103 exceeds a threshold value. --. Claim 6, line 2, after "including", insert -- means for connection to --. Claim 11, line 6, after "including", insert -- means for connection to --. Claim 13, line 4, after "including" insert -- means for connection to --. Claim 15, line 2, after "includes" insert -- means for connection to --. Claim 17, line 2, after "means," insert -- means for connection to --. Claim 32, line 2, after "including" insert -- means for connection to --.

Signed and sealed this 29th day of January 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

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