

[54] AUTOMATIC PHOTOFLASH DEVICES

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[63] Continuation-in-part of Ser. No. 799,554, Feb. 13, 1969, abandoned.

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Dec. 27, 1968	Belgium	68017
Jan. 20, 1969	Belgium	68982

[52] U.S. Cl. **315/159**, 315/241 P, 315/241 R

[51] Int. Cl. **H05b 37/00**, H05b 37/02

[58] Field of Search..... 315/149, 151, 159, 315/241 R, 241 P, 240; 336/82, 83

[56] **References Cited**

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Assistant Examiner—Lawrence J. Dahl

Attorney—George H. Spencer et al.

[57] **ABSTRACT**

Automatic flash limiting devices for use in electronic photoflashes and including means for more rapidly and accurately terminating a light flash and/or blocking discharge of the photoflash energy storage capacitor after termination of such a light flash.

32 Claims, 16 Drawing Figures

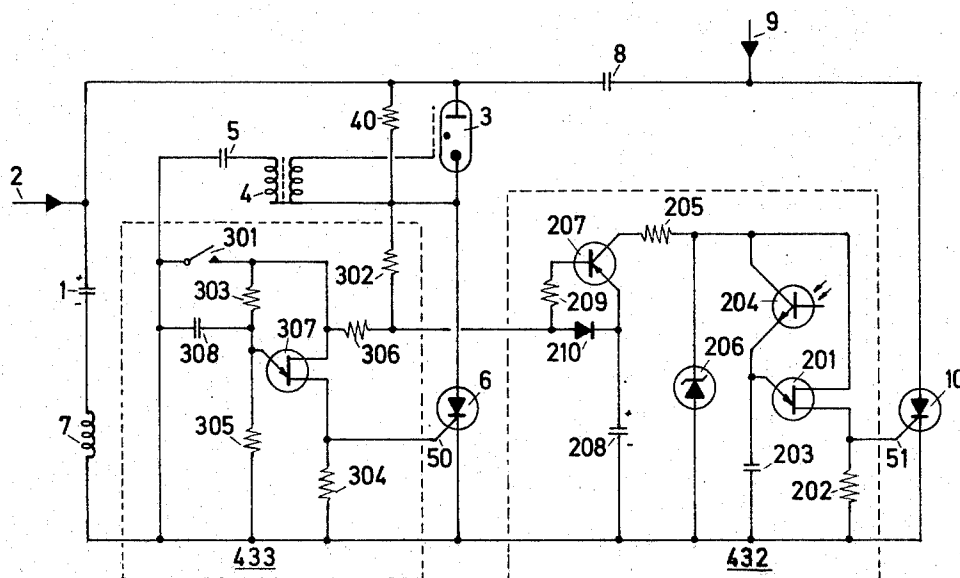


Fig. 1

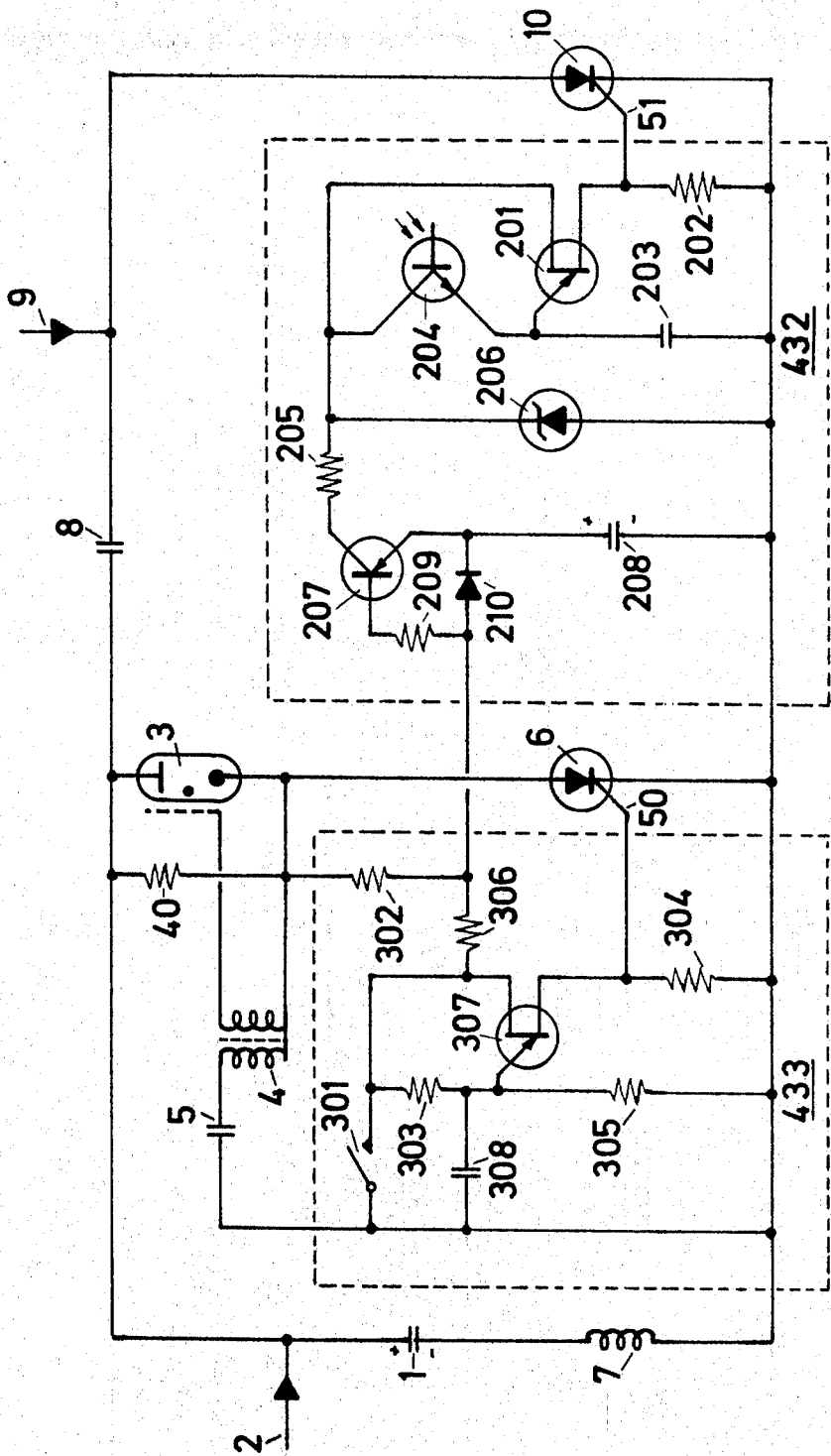


Fig. 2

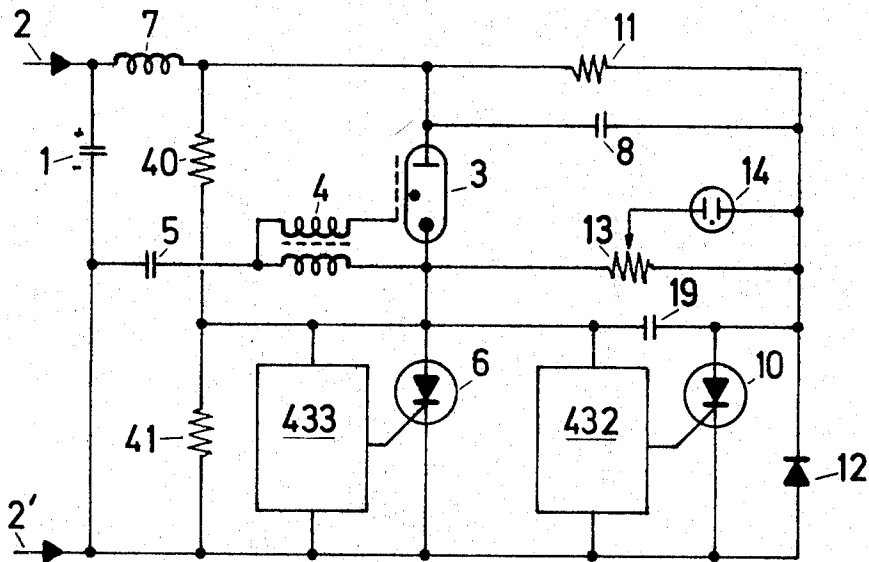


Fig. 3

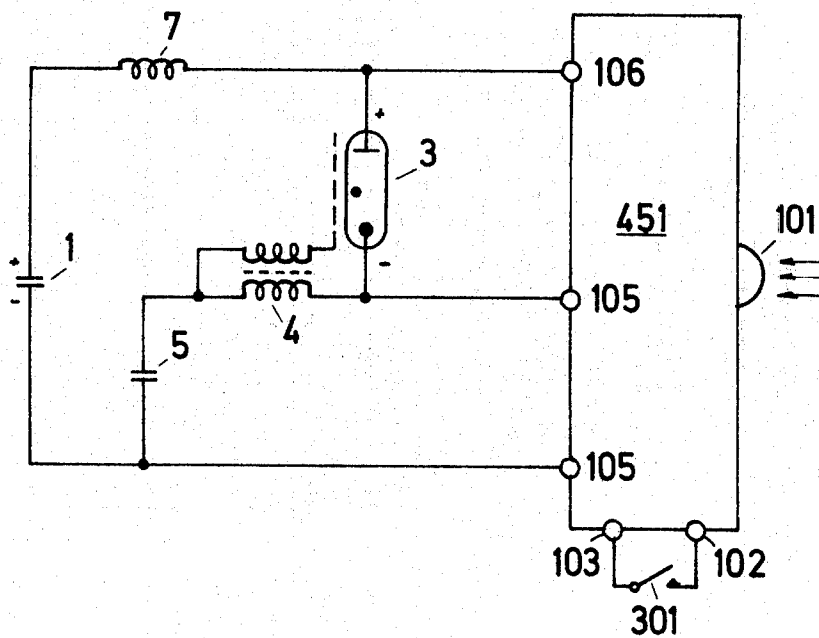


Fig. 4

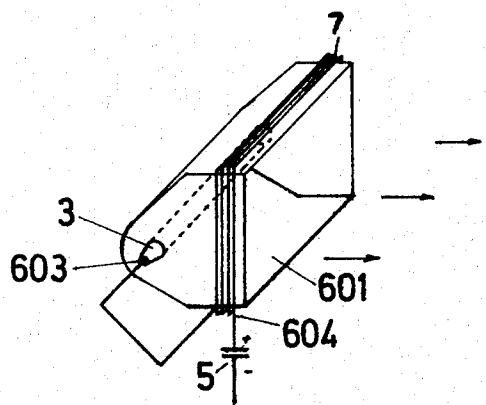


Fig. 5

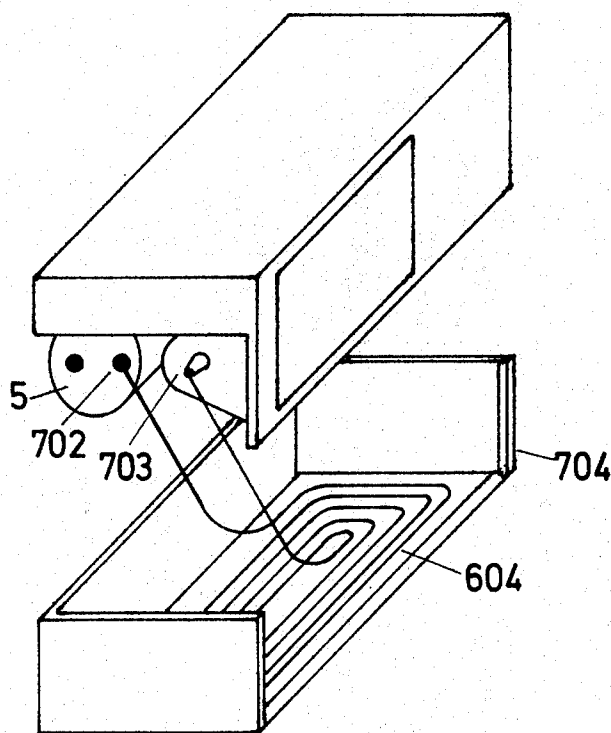


Fig. 6

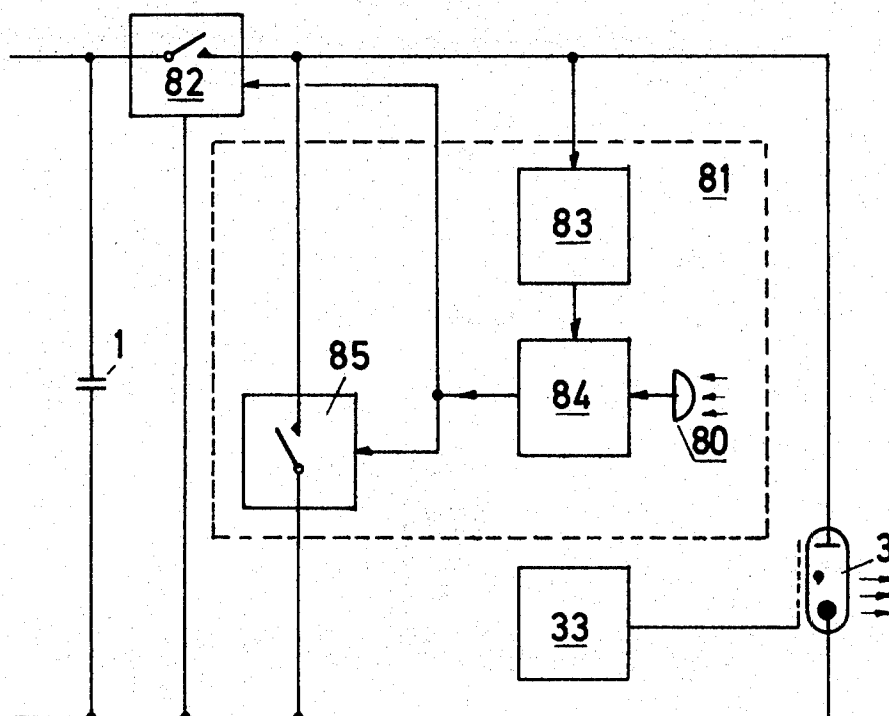
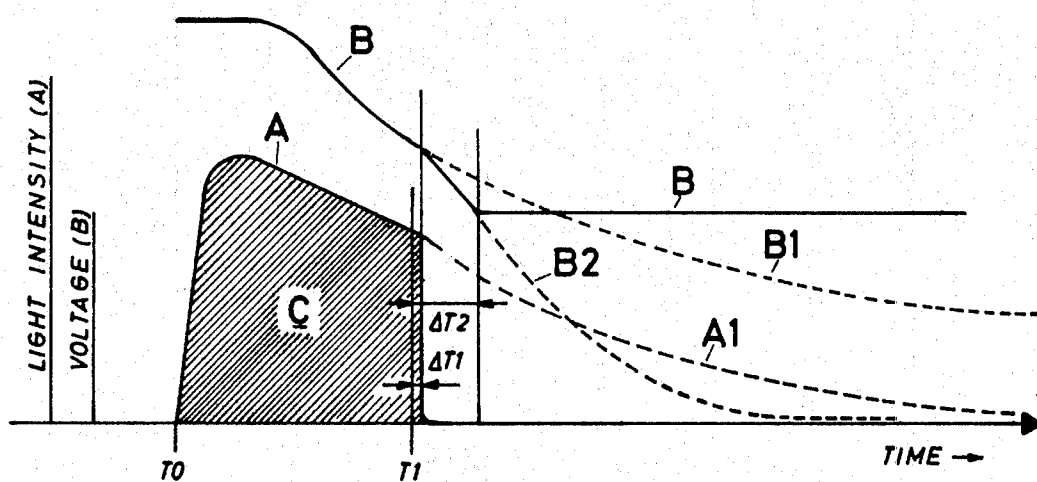


Fig. 7



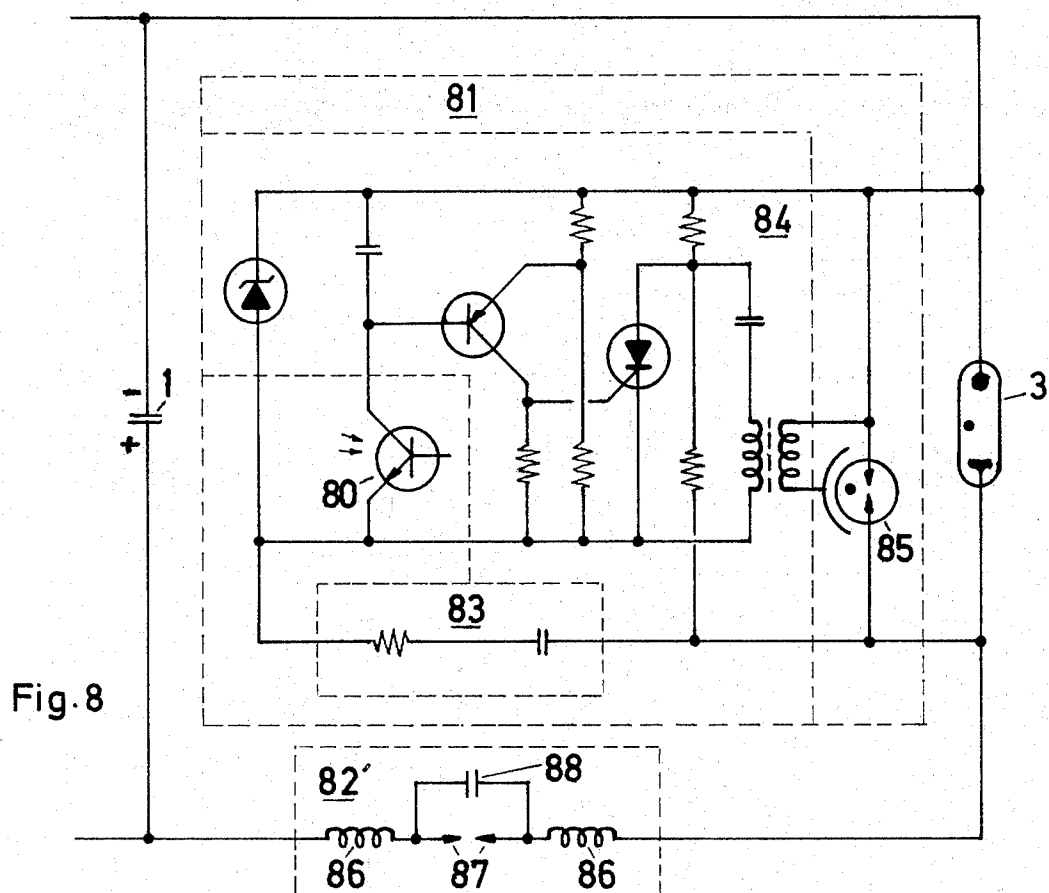


Fig. 9

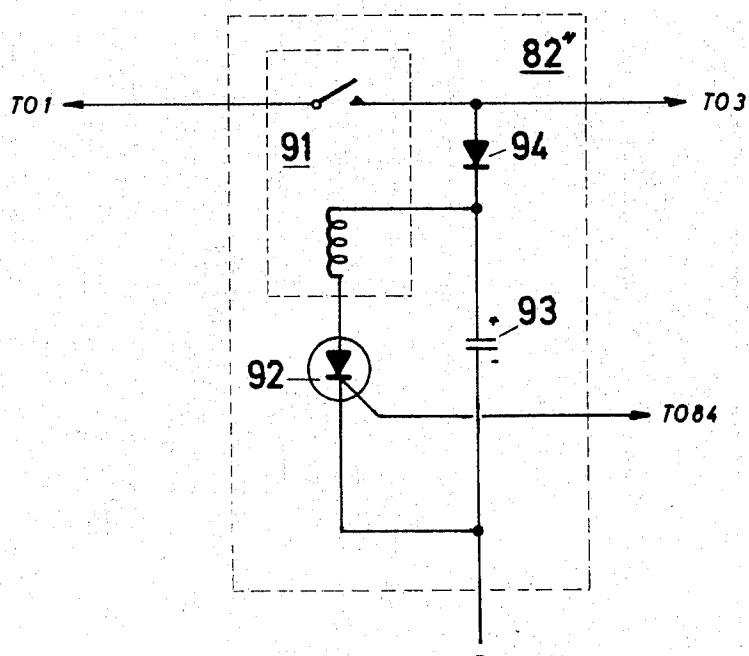


Fig. 10

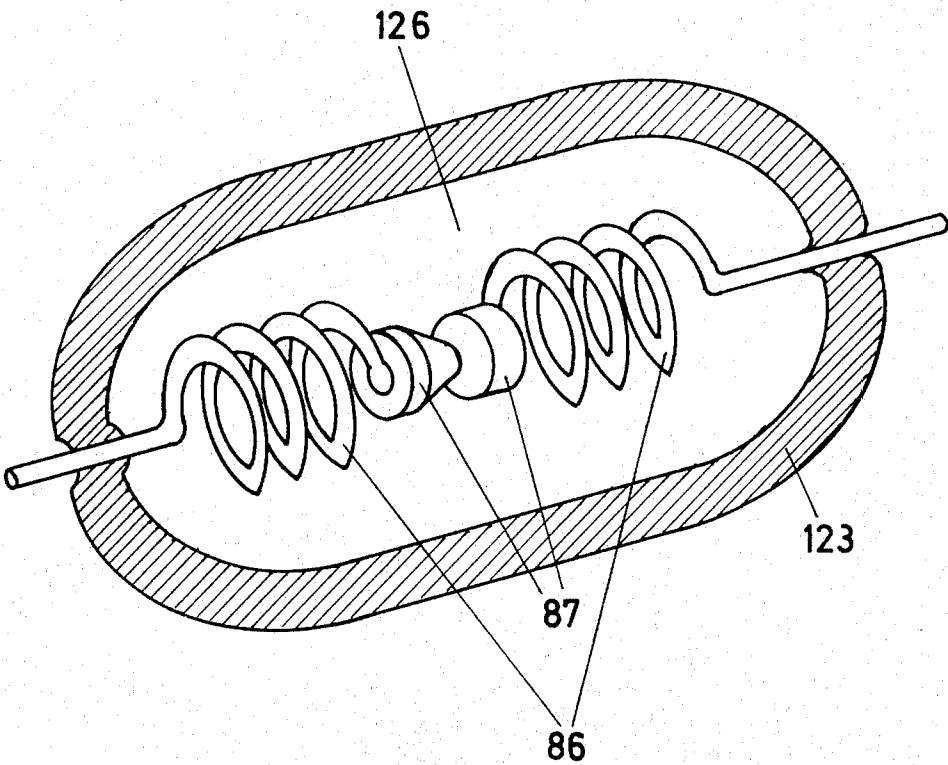


Fig. 11

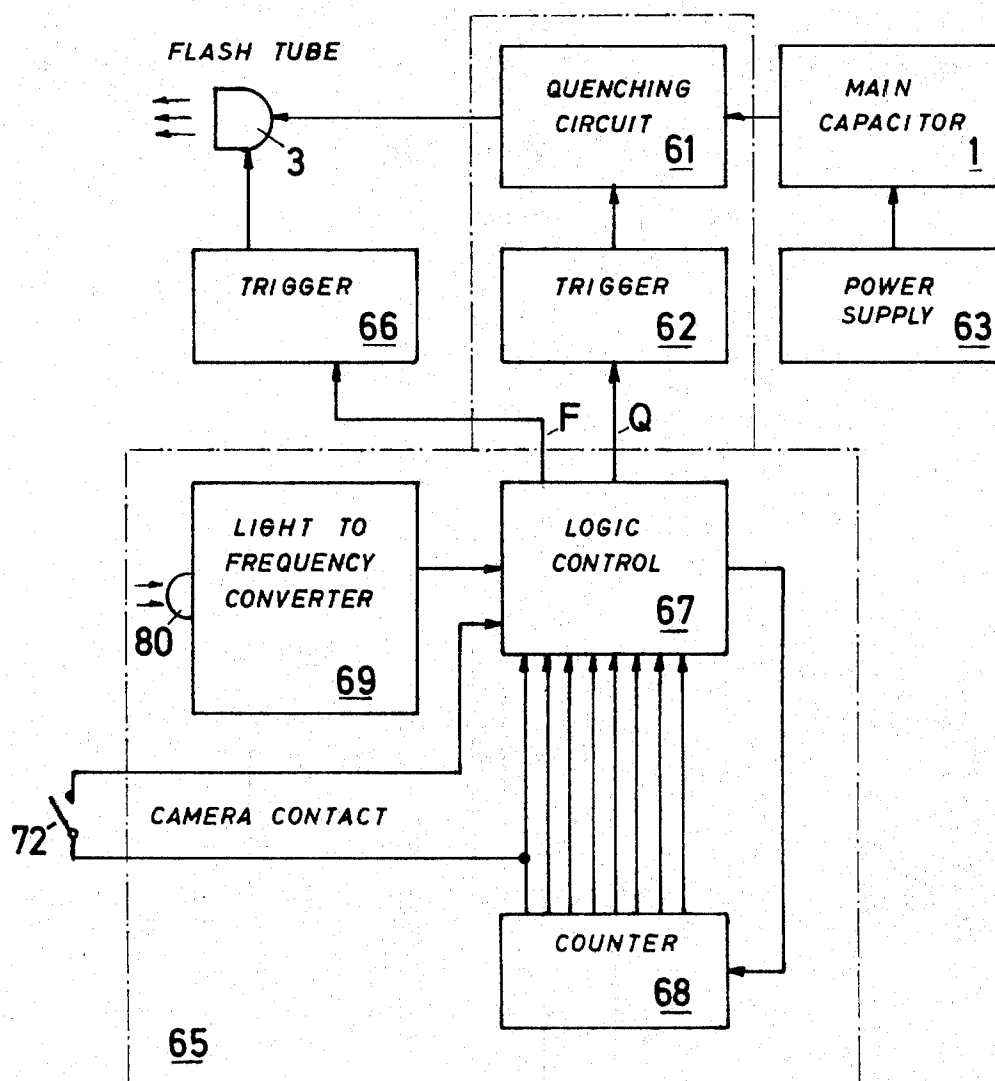


Fig. 12

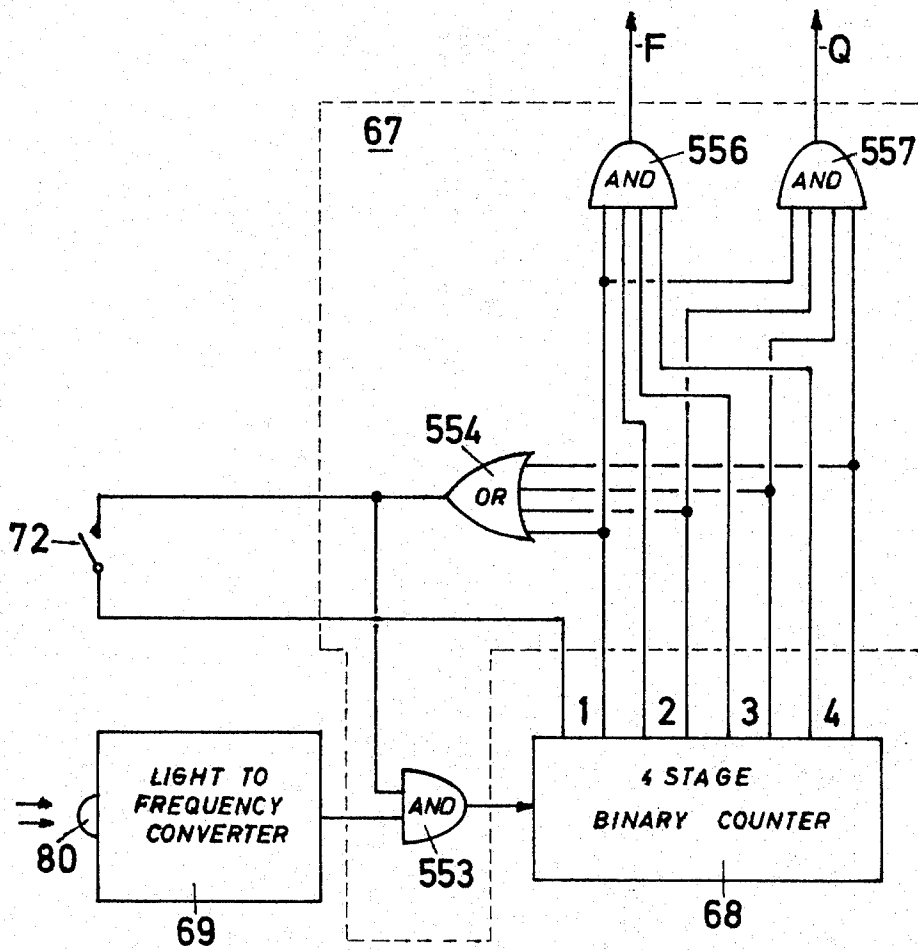


Fig. 13

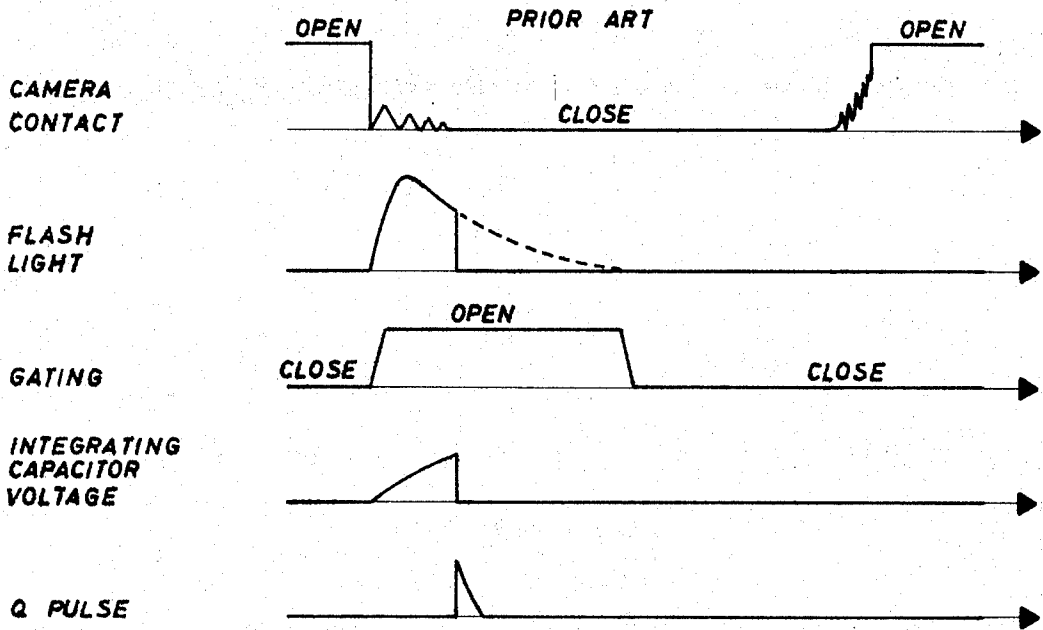
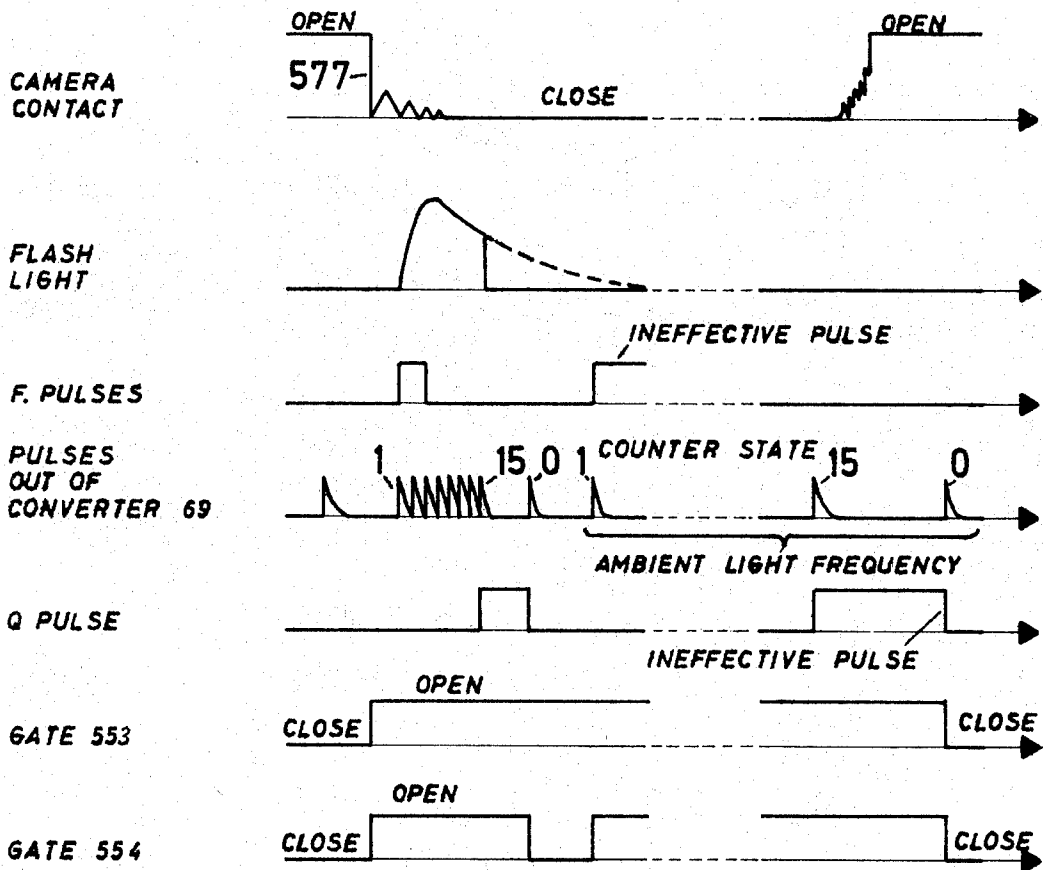


Fig. 14



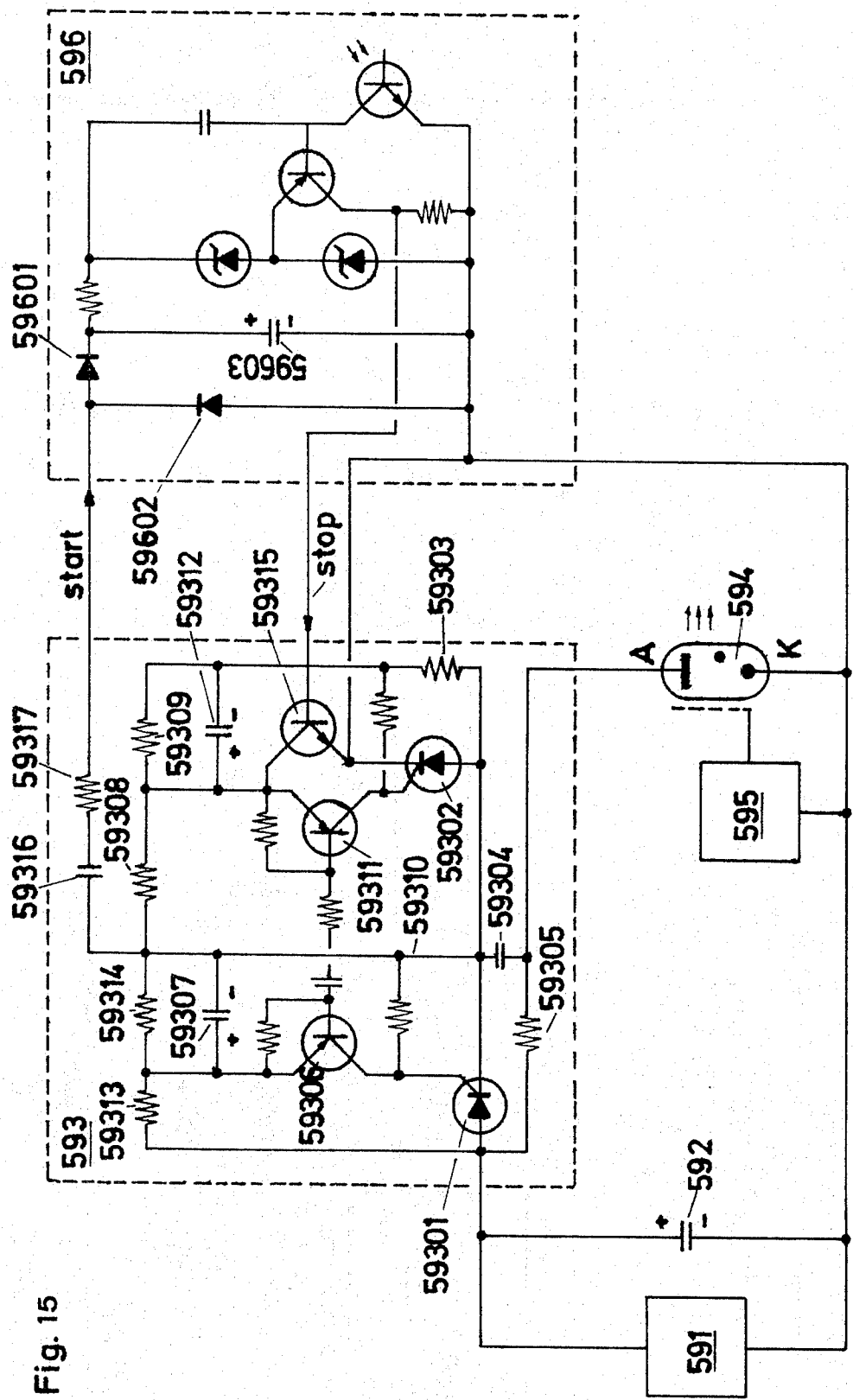
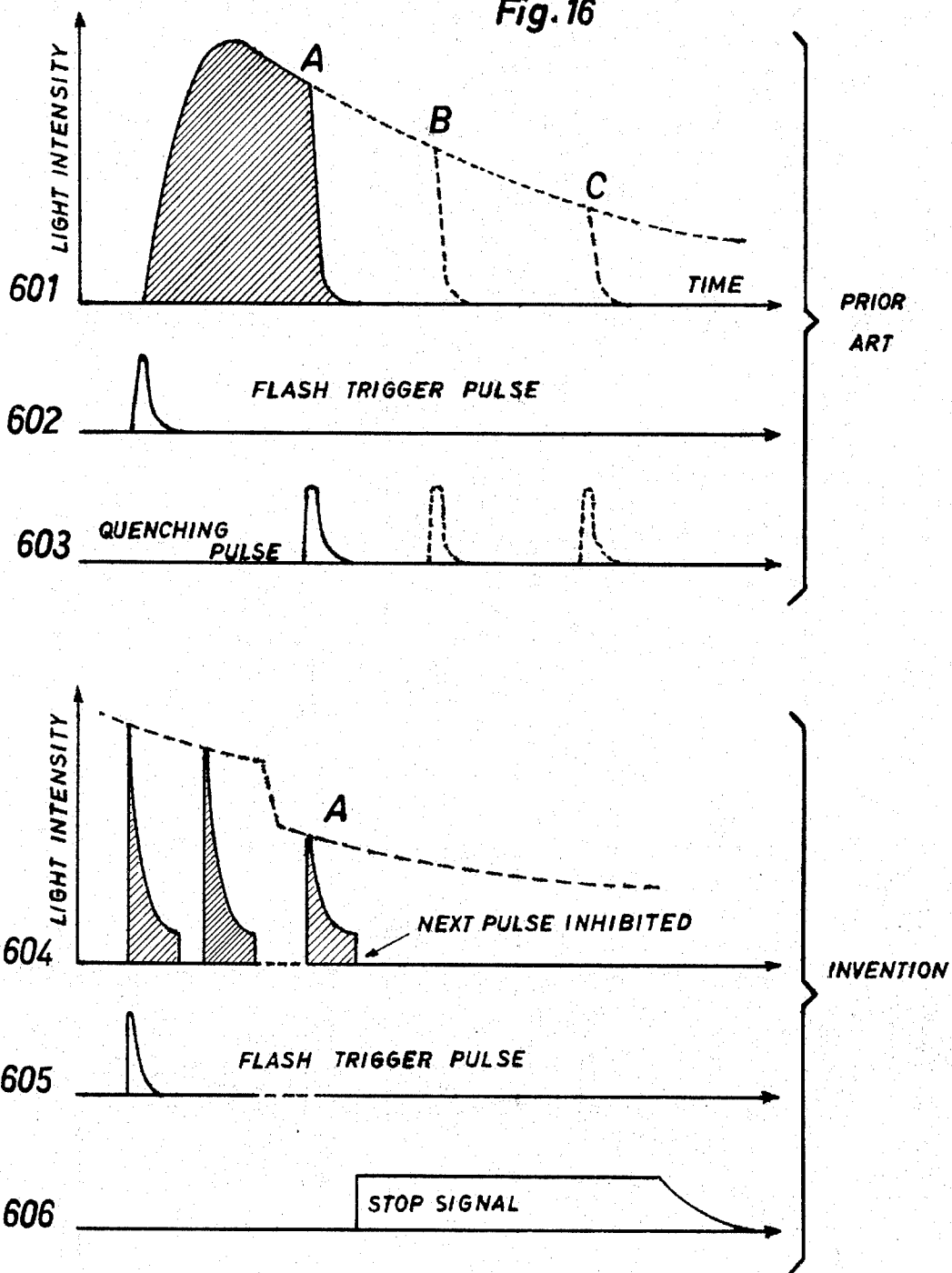


Fig. 15

Fig. 16



AUTOMATIC PHOTOFLASH DEVICES**CROSS-REFERENCE TO RELATED APPLICATION**

This is a continuation-in-part of our application Ser. No. 799,554, filed on Feb. 13, 1979 and now abandoned, and entitled **DEVICE FOR CONTROLLING IMPULSES GENERATED BY THE DISCHARGE OF A CAPACITOR**.

BACKGROUND OF THE INVENTION

The present invention relates to electronic photoflash devices, and particularly to devices for automatically terminating a light flash in response to the quantity of light reaching the subject being photographed.

In recent years, electronic photoflash devices incorporating the various types of automatic flash limiting systems have been developed on both an experimental and commercial level and have enjoyed a constantly growing commercial success. These devices represent a substantial improvement over previous nonautomatic photoflashes in which no control, or only a crude control, of the flash duration, or total light output, was possible. In the recently developed systems, the light reflected from the subject being photographed is sensed and integrated and when the total quantity of light being sensed reaches a predetermined value, a signal is produced to terminate the light flash.

In systems already proposed, this termination is effected by creating a short circuit across the photoflash tube. When this short circuit is created, this discharge current from an energy storage capacitor supplying the photoflash tube is shunted from the tube, so that the light flash is terminated. The energy storage capacitor then discharges completely through the short circuit and at some time after complete discharge of the capacitor, the short circuit is removed and the system is permitted to recycle back to its ready state.

While such systems function reasonably well and offer a generally accurate control of the light produced during a single flash as a function of the nature and range of the subject being photographed, these systems do offer certain disadvantages.

Firstly, as already noted, they cause the energy storage capacitor to be completely discharged after termination of each light flash. This results in a great waste of energy which is not employed for producing light flashes and increases the recycling time of the flash unit, since the capacitor must be recharged from a completely discharged state. It also reduces the total number of light flashes which can be provided by a power source having a given energy content.

Further, in the systems already disclosed, the actuation of the quenching, or flash terminating, circuit has the initial result of increasing the current through the tube so as to temporarily increase the light output from the tube and delay the light termination operation.

In addition, despite various efforts at miniaturization of these devices, they remain relatively large, a considerable amount of space being required within the unit housing, for example, for the induction coil normally disposed in the flash tube-energy storage capacitor circuit.

Furthermore, those known devices which provide satisfactory operation require a separate gating circuit to disable the flash limiting unit until a flash has been triggered in the tube of the associated unit. The pur-

pose of this is to prevent the flash limiting device from responding to flashes produced by other units.

Also, presently known devices are of a type which will produce a light flash even if the flash limiting circuit should become inoperative so that the photographer would not know that his automatic flash limiting system had not operated until his photos are developed.

SUMMARY OF THE INVENTION

It is a primary object of the present invention to overcome these drawbacks and difficulties.

Another object of the invention is to prevent useless discharge of the energy storage capacitor after a light flash has been terminated.

Another object of the invention is to prevent temporary increases in the light intensity due to operation of the flash limiting system.

A further object of the invention is to reduce the size of automatic photoflash units.

Still another object of the invention is to eliminate the need for a separate gating circuit in such units.

Yet a further object of the invention is to prevent a flash unit from producing a light flash if the light sensor or transducer of the automatic flash limiting system should fail.

These and other objects according to the invention are achieved by the provision of an automatic flash limiting unit which is so arranged that the short circuit current established to terminate an electronic flash flows in a direction opposite to that of current flow through the photoflash tube.

The objects according to the invention are further achieved by forming the induction coil associated with the photoflash tube around the outside of the photoflash reflector or on one inner surface of the photoflash housing.

Other objects of the invention are achieved by the provision of a flash limiting system which includes a fast-acting parallel type circuit for short-circuiting the photoflash tube when a light flash is to be terminated and a relatively slow-acting series type circuit for blocking further discharge of the energy storage capacitor after a light flash has been terminated.

The objects according to the invention are further achieved by the provision of a novel type of normally closed switch which can be used as the above-described series circuit and which inherently responds to an increase in the amplitude of the current flowing there-through above a predetermined value to create an open circuit.

The objects according to the invention are further achieved by an automatic flash limiting unit in the form of the digital logic control device which is controlled by received light to both initiate and terminate a light flash thereby eliminating the need for a separate gating circuit.

The objects of the present invention are further achieved by the provision of an automatic flash device which includes a circuit for delivering a train or relatively short electrical pulses, rather than a single pulse, to the photoflash tube and means for controlling the circuit so as to simply terminate the production and delivery of the short pulses in response to a control signal indicating that the subject being photographed has received the quantity of light necessary for producing the desired exposure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of one embodiment of an automatic flash unit according to the invention.

FIG. 2 is a circuit diagram of a modified form of construction of the unit of FIG. 1.

FIG. 3 is a partial circuit diagram of a photoflash unit according to the invention.

FIG. 4 is a perspective view of an embodiment of an induction coil arrangement according to the invention.

FIG. 5 is a perspective view of another embodiment of an induction coil unit according to the invention.

FIG. 6 is a block diagram of a further embodiment of a unit according to the invention.

FIG. 7 is a diagram illustrating the operation of the circuit of FIG. 6, in comparison with the operation of prior art circuits.

FIG. 8 is a circuit diagram of a modified form of construction of the embodiment of FIG. 6.

FIG. 9 is a circuit diagram of a modified form of construction of one component of the circuit of FIG. 6.

FIG. 10 is a perspective cross-sectional view of one embodiment of an element of the circuit of FIG. 8.

FIG. 11 is a block diagram of another embodiment of the invention.

FIG. 12 is a block diagram of one component of the circuit of FIG. 11.

FIG. 13 is a group of waveforms illustrating the operation of a prior art flash limiting circuit.

FIG. 14 is a series of waveform diagrams illustrating the operation of the circuit of FIGS. 11 and 12.

FIG. 15 is a circuit diagram of a preferred embodiment of the invention.

FIG. 16 is a series of waveform diagrams illustrating the operation of prior art automatic photoflash devices and the comparable operation of devices according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates one embodiment of an automatic electronic flash unit according to the invention. This unit basically includes a flash limiting circuit composed of a capacitor 8 and a thyristor 10, an auxiliary circuit 432 for controlling the flash limiting circuit, a flash triggering circuit 433 and a resistor 40.

The unit further includes a basic photoflash circuit composed of an energy storage capacitor 1 charged by a voltage applied via line 2, a photoflash tube 3, and a triggering circuit for the tube, the triggering circuit including a trigger transformer 4 having its secondary connected to the control electrode of the tube 3, a trigger capacitor 5, a control thyristor 6 and an induction coil 7.

The capacitor 8 of the flash limiting circuit is charged from a voltage source via a line 9. The auxiliary circuit 432 is composed of a unijunction transistor having one main electrode connected to the gate electrode of thyristor 10, a resistor 202 connected between the gate electrode 501 and the cathode of thyristor 10, a capacitor 203 connected between the gate electrode of transistor 201 and the cathode of thyristor 10, a phototransistor 204 having its emitter connected to the gate electrode of transistor 201 and its collector connected to the other main electrode of transistor 201, a resistor 205 having one end connected to the collector of transistor 204, a Zener diode 206 connected across the se-

ries arrangement of capacitor 203 and the collector-emitter path of transistor 204, a transistor 207 having its collector connected to the other side of resistor 205, an electrolytic capacitor 208 connected between the emitter of transistor 207 and the cathode of thyristor 10, a resistor 209 having one end connected to the base of transistor 207, and a diode 210 having its anode connected to the other end of resistor 209 and its cathode connected to the emitter of transistor 207.

The flash triggering circuit for the unit is composed of the camera synchronization contact 301, a resistor 303 having one end connected to one side of contact 301, a capacitor 308 connected between the other end of resistor 303 and the other side of contact 301, a resistor 305 having one end connected to the junction between elements 303 and 308, and its other end connected to the other side of capacitor 308 and also to one side of inductance 7, a unijunction transistor 307 having its gate electrode connected to the junction between resistors 303 and 305 and one main electrode connected to the one side of contact 301, a resistor 306 having one end connected to the one side of contact 301, a resistor 304 having one end connected to the other main electrode of transistor 307, and also to the gate electrode 50 of thyristor 6, and its other end connected to the other end of resistor 305, and a resistor 302 connected between the other end of resistor 306 and one main electrode of photoflash tube 3.

In addition, triggering capacitor 5 is connected between the other side of contact 301 and the primary of transformer 4, the secondary of transformer 4 is connected between the one main electrode of tube 3 and the trigger electrode of that tube, the one main electrode of tube 3 is connected to the anode of thyristor 6, and the other main electrode of tube 3 is connected to the junction between capacitors 1 and 8. In addition, inductance 7 is connected in series between capacitor 1 and the cathode of thyristor 6. A connection between inductance 7 and the cathodes of thyristors 6 and 10 constitutes the common connection for the circuit, to which other components are also connected, as illustrated.

The operation of the device is as follows: Initially, capacitors 1 and 8 are charged by voltages applied via their respective charging lines 2 and 9. In addition, capacitor 308 will become charged to a certain level by the voltage appearing across resistor 305, this resistor forming a voltage divider, together with resistors 303, 306, 302 and 40, across capacitor 1. For producing a flash, synchronization contact 301, generally located within the camera, is closed. This has the effect of provoking the discharge of capacitor 308 through transistor 307 and to gate 50 of thyristor 6 for triggering the thyristor 6 into its conductive condition. The discharge of capacitor 308 also applies a voltage pulse through capacitor 5 and this voltage pulse is converted by transformer 4 into a flash triggering pulse. Then, the charge stored in capacitor 1 is discharged through the series arrangement of tube 3, thyristor 6 and induction coil 7.

In addition, the voltage applied via line 2 serves to initially charge capacitor 208 to a predetermined value and the subsequent voltage pulse corresponding to the initiation of a light flash renders transistor 207 conductive to produce a predetermined voltage across Zener diode 206.

The light produced by tube 3 is reflected from the subject being photographed to phototransistor 204.

The voltage provided by Zener diode 206 produces a current flow through phototransistor 204 which is proportional to the intensity of the light radiation incident thereon. This current charges capacitor 203 and when the resulting voltage across that capacitor, which voltage is applied to the gate of transistor 201, reaches a predetermined value, transistor 201 is rendered conductive to produce a voltage across resistor 202 sufficient to trigger thyristor 10 into conduction. As a result, capacitor 8 discharges through thyristor 10, this discharge producing a current flow in a direction opposite to that of the current flow through tube 3 and thyristor 6. This has the result of blocking thyristor 6 and thus terminating the discharge of capacitor 1 through tube 3.

The advantage of the circuit illustrated in FIG. 1 is that, whereas in circuits disclosed in our parent application Ser. No. 799,554 the intensity of the light flash increases progressively during the period of the control pulse serving to trigger termination of the flash tube discharge, such an increase in light intensity does not occur in the circuit illustrated in FIG. 1 of the present drawings. Thus, for example, in the circuit of FIG. 4 of the above-cited parent application, the discharge current flowing from the flash terminating capacitor is in a direction opposite to the current flowing through the discharge limiting thyristor so as to provoke the turning off of the latter. However, the capacitor discharge current does flow in a direction to temporarily increase the current flowing through the electronic flash tube. As a result, rather than the light flash being terminated immediately upon the occurrence of a flash terminating signal, its intensity increases for a short period until the flash limiting thyristor has become non-conductive.

In contrast, in the circuit of FIG. 1 of the present drawings, the discharge current from capacitor 8 is in a direction which is not only opposite to the direction of conduction current flow through thyristor 6, but also opposite to the direction of current flow through tube 3. As a result, the initiation of discharge of capacitor 8 serves to immediately interrupt the flow of current through tube 3, even before thyristor 6 has been rendered non-conductive.

In a modification of the circuit of FIG. 1, thyristors 6 and 10 could be replaced by Triastor tubes of the type illustrated in our above-cited parent application, and at the same time the control circuitry for these thyristors could be replaced with comparable control circuits of the type illustrated for the Triastor tubes.

In order to reduce the reactance values and physical sizes of the various circuit components, particularly the capacitors and inductor, thyristor 6 is preferably designed to have the shortest possible turn-off time. In embodiments of the invention employing Triastors, such elements can be given the shortest possible turn-off time if they are filled with a gas having a low atomic weight, preferably hydrogen.

FIG. 2 illustrates an improved version of the circuit of FIG. 1 which eliminates the need for a second voltage supply, i.e. the voltage supplied via line 9 of FIG. 1, and which includes a control lamp for indicating when the unit is ready for use. In FIG. 2, elements identical with the circuit of FIG. 1 are given the same reference numerals.

The unit illustrated in FIG. 2 includes an auxiliary circuit 432 and a flash triggering circuit 433, both identical with the corresponding circuit of FIG. 1. In addition

to the other elements which the circuit has in common with the circuit of FIG. 1, there are provided a resistor 41 connected across circuit 433, a series arrangement of a resistor 11 and a diode 12 connected across the series arrangement of photoflash tube 3 and thyristor 6, resistor 11 being in parallel with capacitor 8, an indicating circuit composed of a potentiometer 13 connected between the junction of tube 3 and thyristor 6 and the junction of resistor 11 and diode 12 and a neon lamp 14 connected between the junction of resistor 11 and diode 12 and the movable tap of potentiometer 13, and a capacitor 19 connected in parallel with the resistor of potentiometer 13. Voltage is applied to the circuit between lines 2 and 2' connected to a suitable voltage source, which may be a battery or a.c.-d.c. rectifying supply. Similar sources may be employed for the circuit of FIG. 1.

Resistor 11 and capacitor 19 form, together with capacitor 8 and thyristor 10, the flash limiting circuit.

The operation of the circuit of FIG. 2 differs from that of the circuit of FIG. 1 in the following respects:

To place the unit in a condition for operation, a d.c. voltage is applied across lines 2 and 2' to charge capacitor 1 to the voltage between lines 2 and 2' and to charge capacitor 8 to the voltage across resistor 11 and capacitor 19 to the voltage across resistor 13, the total voltage being equal to that across resistor 40 of voltage divider 40, 41. Diode 12 serves to prevent capacitor 19 from being charged to an undesirably high voltage when thyristor 6 is in its non-conducting state.

Neon lamp 14 lights as soon as the voltage on capacitor 19 reaches a value at which the unit is ready for operation. Even after current ceases to flow through capacitor 8, capacitor 19 can continue to be charged by the current through resistor 11.

When a light flash terminating pulse is applied to the gate electrode of thyristor 10 to render that thyristor conductive, capacitor 8 discharges through the series arrangement of tube 3 and thyristor 6. At the same time, the discharge current from capacitor 19 flows only through thyristor 6 and thus accelerates the blocking of that thyristor.

Resistor 11 is given a resistance value such as to cause most of the discharge current from capacitor 8 to flow through tube 3 and thyristor 6, rather than through resistor 11.

FIG. 3 is a simplified schematic illustration of the connection between the basic components 1, 2, 2', 3-5 and 7 of the light flash unit, the auxiliary circuit, flash triggering circuit and flash limiting circuit, all contained in the sub-unit 451, the synchronizing contact 301, disposed in the camera, and the light sensor 101. As in the embodiments illustrated in FIGS. 1 and 2, capacitor 1 is preferably an electrolytic capacitor charged to have the polarity illustrated. The camera synchronizing contact is connected to the sub-unit 451 by means of connections 102 and 103. Subunit 451 also includes a connection 104 connected to the negative plate of capacitor 1, a connection 105 connected to the negative terminal of the flash tube 3, and a connection 106 connected to the positive electrode of tube 3.

FIG. 4 illustrates one embodiment of the invention wherein the inductance coil 7 is wound around the reflector 601 of the photoflash unit. This arrangement offers the advantage of reducing the current density through the flash tube, and reducing the volume required for housing the flash unit circuitry while utilizing

the otherwise wasted space around the reflector. The wire 604 connected to the positive plate of capacitor 5 is wound around reflector 601 to form coil 7 and the other end of the wire is then connected to the positive electrode 603 of tube 3.

In order to further reduce space requirements, or for other fabrication reasons, the induction coil 7 can be wound on one or more other surfaces of the photoflash housing and/or on the photoflash cover. One such arrangement is illustrated in FIG. 5 wherein the wire 604 forming the coil is wound on the inner surface of the photoflash casing component 704. One end of wire 604 is connected to the positive terminal 702 of capacitor 5, while the other end of wire 604 is connected to the positive terminal 703 of the photoflash tube.

Further embodiments of the invention represent improvements over those already described in that they utilize only the amount of electrical energy necessary to produce the desired light flash, and thus provide a substantial energy saving and substantially reduce the recycling time of the flash unit.

The above-cited parent application and the preceding portion of the present application describe essentially two different types of control circuits according to the invention. One of these is the parallel type in which a light flash is terminated by creating a conductive path in parallel with the photoflash tube. This type of circuit permits the quantity of light emitted during any one flash to be controlled with satisfactory accuracy. Moreover, the required circuits can be relatively small and inexpensive to fabricate. However, on the other hand, it causes the photoflash energy storage capacitor to discharge completely during, and after, each light flash, and this results in a substantial waste of energy. The other type of circuit is a series type which terminates a light flash by opening the circuit between the energy storage capacitor and the flash tube. This type of circuit permits a substantial energy saving but previously disclosed embodiments of the circuits of this type do not permit as accurate a control of the flash duration as parallel type circuits, due primarily to delays in the circuit opening operation. Moreover, these series type circuits are physically of large size and are relatively expensive to fabricate.

FIG. 6 illustrates a further embodiment of the invention which represents an improvement over the previously described embodiments in that it employs a combination of a parallel type circuit which determines the accuracy of the light control and a series type circuit which performs the actual function of interrupting the discharge of the photoflash energy storage capacitor.

The circuit of FIG. 6 includes, in addition to an energy storage capacitor 1 and a flash tube 3, a trigger circuit 33 controlled by the closing of the camera synchronizing contact to trigger a light flash, a parallel type light flash control circuit 81 and a series type control element 82 which functions, as is illustrated, as a normally closed electronic switch. Series type circuit 82 is connected so that the electronic switch which it represents is in series in the line between capacitor 1 and tube 3. Circuit 81 is composed essentially of a light sensor 80, an electronic gate 83 connected to activate circuit 81 upon the commencement of a light flash, an integrator-comparator circuit 84 and a circuit 85 which functions as a normally open electronic switch connected in parallel with the tube 3. Both electronic

switches 85 and 82 are connected to be operated by an output signal from circuit 84.

Circuit 81 could be constituted by any of the previously disclosed parallel circuits, e.g. the circuit 30 of FIG. 3 of the above-cited parent application, in which case element 85 would be constituted by the element 204 of FIG. 2 of the parent application. Similarly, circuit 82 could be constituted by an element such as switch 103 illustrated in FIG. 1 of the parent application, which element could be a gate turn-off thyristor or other equivalent component.

The operation of the system of FIG. 6 is as follows: The voltage due to the charge across capacitor 1 is applied across photoflash tube 3 via the normally closed electronic switch 82. When the camera synchronizing contact is closed to initiate a flash, triggering circuit 33 produces a pulse to trigger the production of a light flash by tube 3. The leading edge of the current pulse then passing through tube 3 produces a corresponding current pulse which passes through gate circuit 83 to initiate operation of integrator-comparator circuit 84. The light reflected from the subject being photographed reaches sensor 80 and is converted into a proportional electrical signal which is processed by circuit 84. When the total quantity of light received by sensor 80 reaches a predetermined value, the output signal from circuit 84 reaches a level at which it actuates switches 85 and 82. This actuation closes switch 85 so as to create an effective short circuit across the photoflash tube 3 and thus halt the production of light by that tube. At the same time, the actuation of switch 82 serves to open that switch and thus halt the discharge of capacitor 1.

The switch 82 is so designed that it will reclose only after a delay period which is longer than the period required for deionization of tube 3 and the opening of switch 85.

FIG. 7 illustrates the operation of the circuit of FIG. 6 in comparison with the operation of prior circuits. The A curves represent the intensity of the light produced by tube 3, while the B curves represent the voltage across capacitor 1. A light flash is initiated at the moment T_0 , while the moment at which the predetermined quantity of light has been received by sensor 80 is T_1 . The time required for the circuit 81 to respond by closing switch 85 is ΔT_1 and the time required for the circuit 81 to open switch 82 is ΔT_2 . The period ΔT_2 is normally longer than ΔT_1 , owing to the nature of components acting as normally closed electronic switches. However, because it is the closing of switch 85, which occurs with a delay of ΔT_1 , that determines the termination of the light flash, the longer delay involved in the closing of switch 82 will not introduce any inaccuracies into the automatic flash limiting operation. However, the utilization of series switch 82 does result in a substantial energy saving in that it conserves a large portion of the charge initially present on capacitor 1 and thus reduces the amount of energy, and the time, required to restore capacitor 1 to full charge. Curves A_1 and B_1 illustrate the operation of a conventional photoflash unit without any automatic flash limiting control. Curve B_2 illustrates the variation in the voltage across capacitor 1 in an automatic control circuit equipped only with a normally open flash limiting switch. This curve shows that with such a circuit, capacitor 1 is completely discharged after each light flash and must therefore be completely recharged be-

fore another light flash can be produced. Finally, curve B illustrates the variation in the voltage across capacitor 1 in the circuit shown in FIG. 6, wherein capacitor 1 retains a substantial portion of its initial charge after a light flash has been terminated.

The curves of FIG. 7 illustrate, in particular, that the quantity of light produced by the flash, illustrated by area C, is accurately controlled by the operation of switch 85, and that even though switch 82 does not open until after a delay at ΔT_2 , the quantity of the charge remaining on capacitor 1 after the opening of switch 82 is still relatively high. Thus, the device consumes only a small amount of energy in addition to that required for producing the desired light flash.

FIG. 8 illustrates a specific embodiment of the circuit illustrated in block form in FIG. 6. In FIG. 8, the circuit for triggering tube 3 is not illustrated for purposes of simplicity. The parallel type circuit 81 is similar to circuits of the type illustrated in our above-cited parent application and operates in a manner disclosed in that application.

The series type circuit 82' is constituted by a new type of electrodynamic switch which is connected in series between capacitor 1 and tube 3. This switch is composed of a pair of contacts 87 which are maintained normally closed by the pressure of two compression springs 86. These springs are in the form of solenoids and serve simultaneously as induction coils. Contacts 87 and springs 86 are preferably disposed on a common axis. A capacitor 88 is connected in parallel with the contacts 87.

The operation of the circuit is as follows: Circuit 81 operates in the manner disclosed above in connection with the corresponding circuit of FIG. 6. The series circuit 82' remains closed for as long as the intensity of the discharge current from capacitor 1 is equal to the current required for maintaining tube 3 conductive. As soon as the switch 85 of parallel circuit 81 closes to place a short circuit across tube 3, the discharge current from capacitor 1 increases, as indicated by the steep portion of curve B of FIG. 7, to a value which provokes sufficient electrodynamic forces in coils 86 to separate contacts 87 from one another, thus interrupting the discharge of capacitor 1. Capacitor 88 serves to absorb the arc which would normally appear between contacts 87 upon their opening and to then prolong the passage of current through the series circuit, the total result being a rapid opening of contacts 87 and a sufficiently long delay prior to their reclosing.

Each coil 86 acts as a solenoid and its connected contact 87 acts as a movable relay contact in that the current through coil 86 produces an axial magnetic field which attracts contact 87, the contact being of a magnetic material. Alternatively, the spring and solenoid could be constituted by separate elements.

The nature of circuit 82' is such as to render unnecessary the provision of a control connection between the circuit and circuit 84.

FIG. 9 illustrates a circuit 82' constituting another embodiment of a series type circuit which could be employed in the device of FIG. 6 or FIG. 8. This embodiment is constituted by an electromagnetic relay 91 of a fast acting type, for example a reed relay, having a normally closed contact. The circuit further includes a control thyristor 92 and a charging circuit composed of a capacitor 93 and a diode 94. The gate electrode of thyristor 92 is, as illustrated, connected to the output

of circuit 84 of FIGS. 6 or 8. Before operation, capacitor 93 is charged via diode 94 from capacitor 1. When a signal applied to the gate electrode of thyristor 92 renders that thyristor conductive, a current flow is produced through the coil of relay 91, this current coming from capacitor 1. This causes the normally closed contact of relay 91 to open, thus interrupting the current flow between capacitor 1 and photoflash tube 3. Even after the opening of that contact, current continues to flow through the relay coil from capacitor 93, thus assuring a sufficiently long delay before the reclosing of the contact of relay 91.

Turning now to FIG. 10, there is shown the physical structure of the switch 82' illustrated in circuit form in FIG. 8. The contacts 87 and solenoid-inductance coils 86 are preferably disposed in a hermetically sealed enclosure 123 whose interior 126 is either evacuated or filled with a gas, dielectric liquid, etc. As one alternative of this embodiment, the coil 86 could be made in the form of a printed circuit.

In further embodiments of the invention, an improved light control action is achieved through use of a logical control circuit incorporating a binary pulse counter which controls both the initiation and termination of a light flash.

Before describing one example of such an embodiment of the invention, it would be well to review briefly the general mode of operation of all prior art automatic flash limiting circuits.

In such circuits, a d.c. power supply charges an energy storage capacitor to a predetermined voltage. Thereafter, the closing of the camera synchronization contact triggers the initiation of a flash by the photoflash tube through the intermediary of an ignition circuit. Either the initiation of a light flash or the trigger pulse produced by the ignition circuit renders the automatic flash limiting circuit operative. Light reflected from the subject being photographed is received by a light sensor and converted into an electric signal which is integrated by a suitable integrating capacitor. When the voltage across this capacitor reaches a predetermined value, it causes a threshold detector and amplifying circuit to produce an output signal which triggers a flash limiting ignition circuit to render conductive a quench tube connected in parallel with the photoflash tube.

FIG. 11 illustrates one example of the above-described embodiment of the invention which, among other things, eliminates the need for any gating circuit between the photoflash device and the flash limiting circuit. The circuit of FIG. 11 includes a photoflash tube 3, an energy storage capacitor 1, a d.c. power supply 63 connected to charge capacitor 1, a quenching circuit 61 of any previously disclosed type connected in series or parallel with both capacitor 1 and tube 3, a first trigger circuit 66 for initiating the production of a light flash by tube 3, and a second trigger circuit 62 for activating quenching circuit 61 to terminate the flash being produced by tube 3. This group of elements is employed in known automatic photoflash devices. The circuit of FIG. 11 also has in common with known photoflash devices a light sensor 80 and a connection to camera synchronization contact 72.

The novel elements of the circuit of FIG. 11 are a logic control 67, a counter 68 and a light intensity-to-frequency converter 69, these elements constituting, together with light sensor 80, a logic control circuit, in

the form of a digital light computer, 65 for the device.

Circuit 69 acts to convert the electrical signal produced by sensor 80 into a train of pulses whose repetition rate is proportional to the intensity of that electrical signal. Logic control 67 is connected to receive these pulses from converter 69 and to convey them, after the closing of synchronizing contact 72, to counter 68, where they are counted. The outputs from counter 68 are connected to logic control 67 and this logic control is provided with an F output connected to apply a flash initiation signal to trigger circuit 66 and a Q output to apply light termination signal to trigger circuit 62. Since it is the circuit 65 which provides the flash initiation signal, and since this circuit does not begin counting pulses from converter 69 until camera synchronization contact 72 has been closed, the device of FIG. 11 need not be provided with a separate gating circuit for blocking the flash limiting circuitry until a light flash has been triggered.

The illustrated device can be made quite simple and compact since the entirety of circuit 65 could be formed as a single integrated circuit.

FIG. 12 illustrates a preferred specific embodiment of the circuit 65. In this embodiment counter 68 is a four-stage binary counter having a direct output and a negated output for each stage. With respect to each stage, the left-hand line represents the negated output line and the right-hand line the direct output line. The logic control circuit includes an AND gate 553 having one input connected to one side of the synchronization contact 72 and another input connected to the output of converter 69, an OR gate 554 having inputs connected to the direct output of each stage of counter 68 and an output connected to the one side of synchronization contact 72, an AND gate 556 having one input connected to the direct output of the first stage of counter 68 and further inputs each connected to the negated output of each of the remaining stages of counter 68, and a further AND gate 557 having inputs each connected to the direct output of a respective stage of counter 68. In addition, the negated output of the first stage of counter 68 is connected to the other side of contact 72. Gate 556 provides the F output pulse, while gate 557 produces the Q output pulse.

The circuit of FIG. 11, with the specific logic control circuit of FIG. 12, operates in the following manner, which is illustrated by the waveform diagrams of FIG. 14. At some time prior to the closing of contact 72, counter 68 has been placed in its zero count state, wherein a "1" signal appears at each of its negated outputs and a "0" signal appears at each of its direct outputs. Then, to initiate a light flash, synchronizing contact 72 is closed, at the point 577 illustrated in the upper curve of FIG. 14. This applies the 1 signal on the negated output of the first stage of counter 68 to one input of gate 553. At this time, 1 signals are being applied to three of the inputs of gate 556, while a 0 signal is being applied from the first stage of counter 68 to the fourth input of gate 556, with the result that this gate does not produce any output. The application of a 1 signal to one input of gate 553 enables that gate to pass pulses from converter 69 to the count input of counter 68. Therefore, the next occurring pulse from converter 69, which will normally be produced by ambient light and is indicated by the pulse 1 in the fourth curve of FIG. 14, will be transmitted to counter 68 to cause its first stage to produce a count of one, in which case a

0 value signal will appear at its negated output and a 1 signal will appear at its direct output. This will cause gate 556 to produce an F pulse, as indicated in the third curve of FIG. 14, which will result in the triggering of a light flash, as indicated by the second curve of FIG. 14. Despite the change in state at the output of stage 1 of counter 68, gate 553 will continue to be enabled by the output signal from gate 554 which is then due to the presence of a 1 value signal on the direct output of the first counter stage. Thus, the pulses from converter 69 continue to be delivered to counter 68 and to be counted therein, the result of this count being indicated by the state of the outputs of its various stages. When the count reaches a certain value, in the case of the embodiment of FIG. 12 a value corresponding to the count of 15 pulses, AND gate 557 will produce a Q pulse to terminate the light flash.

Since at the time of production of the Q pulse, gate 554 is still producing an output signal, gate 553 remains enabled. Moreover, upon receipt of the next pulse from converter 69, counter 68 is returned to its 0 count state, as illustrated in the fourth curve of FIG. 14. This will terminate the Q pulse and disable gate 554, as indicated by the bottom curve of FIG. 14. In actual operation, it will often occur that the camera synchronization contact 72 will still be closed even after production of the Q pulse, this being illustrated in the first curve of FIG. 14. In this situation, gate 553 will continue to be enabled to pass pulses from converter 69, which pulses are produced by ambient light, to counter 68 so that the counter will again count through its range. While this will result in the production of another F pulse and Q pulse, these will not be effective because the flash tube energy storage capacitor will not have had an opportunity to recharge. Once the synchronization contact 72 is permitted to open, counter 68 will continue counting until returning to its 0 count state, and will then stop since gate 553 will then become disabled.

On the other hand, even if contact 72 should open before the production of the first Q pulse, the system will continue to operate because gate 553 will remain enabled by the output signal from gate 554.

The converter 69 of FIGS. 11 and 12 could be constituted by a known, commercially available device such as that disclosed by the British firm Integrated Photomatrix Ltd., in their Bulletin No. TL 102, published in 1969.

FIG. 13 shows, by way of comparison, the operation of known automatic flash limiting devices. The upper curve illustrates the operation of the camera synchronization contact, and this is identical with the first curve of FIG. 14. In the operation of prior art systems, the closing of the contacts immediately triggers the production of a light flash, as illustrated by the second curve of FIG. 13, and the opening of a gating circuit, as illustrated by the third curve of FIG. 13, for enabling the flash limiting circuitry. Upon opening of the gating circuit, the integrating capacitor of the flash limiting circuit begins to receive the output signal from the light sensor so that the voltage across that capacitor rises progressively, as illustrated by the fourth curve of FIG. 13. When the voltage across the integrating capacitor reaches a predetermined value, a Q pulse for terminating the light flash is produced, as illustrated by the bottom curve of FIG. 13. This terminates the light flash. Sometime thereafter, the gating circuit closes and after

the synchronization contact has opened the system begins to return to its ready state.

Thus, one substantial difference between the system illustrated in FIGS. 11 and 12 and those of the prior art is that the system according to the invention does not require any gating circuit and the initiation of a light flash is controlled directly by the flash limiting control circuit. Another substantial difference is that prior art circuits utilize an analog type capacitive current integration for determining the instant of termination of the light flash, whereas the system according to the present invention utilizes a digital type pulse counting circuit for achieving this result. The digital type system of the present invention can be made more accurate than analog type capacitive integrating systems. Moreover, the system according to the present invention lends itself to an accurate variation of the sensitivity of the flash limiting circuitry because it would be a simple matter to provide a suitable switch arrangement between the outputs of counter 68 and gate 557 to vary the count value, and thus the received light quantity, which triggers the termination of a light flash. Thus, such switch could be arranged to vary the termination of the light flash as a function of the aperture setting of the camera lens.

It has been mentioned above that in the system of FIGS. 11 and 12, a flash is initiated upon receipt of a first pulse from converter 69, which pulse is produced by ambient light. In practice, there will always be sufficient ambient light to produce such pulses and the only time this will not be true is if the sensor 80 is receiving practically no light at all. If the sensor 80 and converter 69 are functioning properly, this will occur only in the case of substantially total darkness, when photographs could not be taken in any event because it would be impossible to aim or focus the camera on the desired subject. The only other situation in which a flash would not be triggered by the system according to the invention would be one in which either the sensor 80 or the converter 69 is experiencing a malfunction. In this case, the photographer would be immediately informed of the existence of a malfunction by the total absence of a light flash. This could also occur if the sensor 80 is accidentally covered by a protective cover or some other opaque object.

In contrast, when the corresponding elements of prior art system experience a malfunction, the photoflash will continue to produce a light flash and, in view of the extremely short duration of such flashes, the photographer will not be aware of a malfunction until after his film has been developed, when it will normally be too late to correct for the malfunction, either by removing the object blocking the light sensor 80 or by replacing the photoflash, while still having time to obtain the photograph. Thus, the system according to the invention offers a decided security advantage.

Turning now to FIG. 15, there is shown a circuit composed of an energy storage capacitor 592, a photoflash tube 594, a trigger circuit 595 for initiating the production of light flashes by the tube 594, a light sensing and measuring circuit 596, a pulse control switching circuit 593, and a unit 591 which contains the remaining necessary components of the photoflash, including a power supply and any necessary actuation switches.

In the operation of this circuit, capacitor 592 is initially charged by the power supply in the unit 591. The voltage across capacitor 592 is applied across the main

terminals A and K of tube 594 via circuit 593, and in particular via resistor 59305.

Capacitor 59304 of circuit 593 is connected across the main terminals of tube 594 via a resistor 59303 and as a result capacitor 59304 becomes charged to substantially the voltage across capacitor 592. Also connected across capacitor 592 is a voltage divider arrangement composed of resistors 59313, 59314, 59308 and 59309 and constituting a part of circuit 593. Due to the provision of this voltage divider arrangement, an operating capacitor 59307 connected across resistor 59314 is charged to a voltage having a value which is a predetermined fraction of the voltage across capacitor 592. Similarly, capacitor 59312 is charged to the voltage across resistor 59309, which is also a predetermined fraction of the voltage across capacitor 592.

When the flash tube 594 is triggered into its conductive state by the operation of triggering circuit 595, the positive triggering pulse is conveyed capacitatively to the anode of tube 594 and thus to the emitter of PNP transistor 59306 via the path defined by capacitor 59304, line 59310 and capacitor 59307. This renders transistor 59306 conductive to apply the voltage on capacitor 59307 to the gate electrode of thyristor 59301 to render the latter conductive. As a result, a transient current flow path is established through thyristor 59301 and capacitor 59304 from capacitor 592 to the anode of tube 594, the previously applied charge voltage across capacitor 59304 being added to that across capacitor 592. The resulting current flow through tube 594 will produce a light flash pulse. While this current flow continues, it acts to charge capacitor 59304 in the direction opposite to that of its initial charge and the current flow continues until that capacitor becomes fully charged in such opposite direction, at which time current flow through thyristor 59301 will cease and that thyristor will switch into its blocking state.

The current path defined by resistors 59308 and 59309 has the effect of urging the potential on line 59310 in a negative direction, toward the potential on the cathode K of tube 594, and this has the effect of causing a positive pulse to be applied to the emitter of PNP transistor 59311 via capacitor 59312. This causes a triggering voltage to be applied to the gate electrode of thyristor 59302, which up until this point had been non-conductive.

When thyristor 59302 becomes conductive, it establishes a current flow path via which capacitor 59304 discharges through tube 594. Since, at the time that thyristor 59302 becomes conductive, tube 594 will not yet have had an opportunity to deionize, the discharge of capacitor 59304 will cause another light pulse to be produced.

The resulting current pulse through tube 594 will continue, with the amplitude of the current diminishing progressively, until capacitor 59304 has become substantially completely discharged. At this time, since current is no longer flowing through thyristor 59302, this thyristor will switch into its blocking state.

During the discharge of the capacitor 59304, the current path constituted by resistors 59313 and 59314 will urge the potential on line 59310 in a positive direction, toward the voltage on the positive plate of capacitor 592. This has the effect of once again applying a trigger voltage to the gate of thyristor 59301 so as to render that thyristor conductive, thereby reestablishing the current path via which capacitor 592 can discharge

through capacitor 59304 and tube 594, thus causing another light flash pulse to be produced by the tube.

The cycle then repeats and, if no external influences are exerted on the circuit 593, continues until capacitor 592 becomes substantially completely discharged.

The external influence which would halt the continued repetition of the above-described cycle is the application of a positive voltage to the base of NPN transistor 59315. Such a positive voltage would act to inhibit the triggering of transistor 59302 and thus to prevent further discharge of capacitor 592 and the production of light flash pulses by tube 594.

In the circuit of FIG. 15, this positive voltage is provided by light sensing and measuring circuit 596. The energization of this circuit is effected by means of a gating arrangement composed of a series path constituted by a capacitor 59316 and a resistor 59317 connected between line 59310 of circuit 593 and a point in circuit 596. The gating arrangement further includes a portion of circuit 596 including two diodes 59601 and 59602 and an energy storage capacitor 59603.

Before tube 594 is triggered to produce a train of light flash pulses, DC blocking capacitor 59316 prevents any current flow through resistor 59317 so that no voltage will appear across capacitor 59603. Thus, sensing circuit 596 remains deactivated.

Then, when the first positive pulse appears on line 59310 as a result of the production of a triggering pulse by circuit 595, a current pulse will be delivered through resistor 59317 and diode 59601 to charge that capacitor. This starts the operation of sensing circuit 596. During the production of succeeding pulses in circuit 593, the above-described gating circuit will operate in the manner of a "pumping diode" to supply periodic charging pulses to capacitor 59603.

After circuit 596 has been placed in operation, the light reflected from the subject being photographed is received by a phototransistor forming part of circuit 596 to vary the conductance of that transistor. The instantaneous conductance variations are integrated in a known manner until a predetermined integration voltage level is reached, at which time a switching transistor connected in cascade with the phototransistor is rendered conductive to produce the positive voltage which is applied to the base of transistor 59315.

Exemplary values for the main specific components are the following: full charge voltage across capacitor 592: 360 V (between 300 and 1,000 μ F); the capacitance of capacitor 59304: 6 μ F; and the resistance of resistor 59305: 400 k Ω .

A comparison of the operation of a circuit according to the invention with that of prior art automatic flash limiting circuits is illustrated in the diagrams of FIG. 16. The upper three diagrams of that figure relate to prior art circuits, while the corresponding lower three diagrams depict the operation of the circuit according to the invention.

Diagram 601, which is identical with that shown in U.S. Pat. No. 3,303,988, illustrates the intensity of the light flash as a function of time. The cross-hatched area represents the total quantity of light emitted by the photoflash when the light flash is terminated at an instant A. The broken lines illustrate the intensity of the light flash produced when successively later quenching pulses are applied at instants B and C.

Diagram 602 illustrates the associated flash triggering pulse, while diagram 603 illustrates the quenching

pulses for terminating the light emission at the various instants A, B and C.

Diagram 604 illustrates the waveform of the light intensity with respect to time produced by the photoflash tube in a circuit according to the present invention. Here again, the total cross-hatched area illustrates the total quantity of light produced during an exposure.

Diagram 605 illustrates the flash trigger pulse which initiates the production of the light flash pulses, while diagram 606 illustrates the signal which blocks the production of further electrical energy pulses, and thus further light pulses.

It will be readily appreciated that one substantial advantage of the novel arrangement of FIG. 15 is that its light terminating operation does not involve the bypassing, and hence dissipation, of the remaining energy stored in the flash tube storage capacitor after a light flash has been terminated. Rather, in the circuit according to the invention, the light flash is terminated by simply preventing the production of further energy pulses so that the energy stored by the supply capacitor at the time of flash termination remains stored thereon and is not wasted by being simply dissipated through a short circuit. Moreover, this result is achieved by a circuit employing standard commercially available components.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

We claim:

1. An automatic electronic photoflash comprising, in combination:
 - an electronic photoflash tube having two main electrodes and a trigger electrode;
 - a trigger circuit connected to said trigger electrode for applying a flash initiation pulse thereto;
 - a first normally open electronic switch connected in series with said tube;
 - an energy storage capacitor connected in series with said tube and first switch;
 - a flash initiation circuit connected to said trigger circuit and to said first switch for causing said trigger circuit to produce a flash initiation pulse and for closing said first switch when a light flash is to be produced;
 - a flash limiting circuit for producing a signal when a light flash being produced by said tube is to be terminated;
 - a second normally open electronic switch connected to said flash limiting circuit to be closed in response to a signal therefrom;
 - a normally charged second capacitor connected in series with said second switch; and
 - means connecting said second switch and said second capacitor in parallel with the series arrangement of said tube and said first switch for enabling the closing of said second switch to convert the charge on said second capacitor into a current flow through said tube in a direction opposite to the direction of current flow from said storage capacitor to said tube and of an amplitude sufficient to open said first switch, thereby to abruptly terminate the light flash being produced by said tube.

2. An arrangement as defined in claim 1, further comprising voltage source means connected with said

second capacitor for preliminarily charging said second capacitor to a predetermined voltage.

3. An arrangement as defined in claim 1 wherein each of said switches is constituted by a thyristor, said flash initiation circuit being connected to the gate electrode of said first switch thyristor and said flash limiting trigger circuit being connected to the gate electrode of said second switch thyristor.

4. An arrangement as defined in claim 1 wherein at least one of said switches is constituted by a gas-filled discharge tube having two main electrodes and a trigger electrode.

5. An arrangement as defined in claim 4 wherein said discharge tube is filled with gas having low atomic weight.

6. An arrangement as defined in claim 5 wherein the gas is hydrogen.

7. An arrangement as defined in claim 6 wherein said discharge tube is a triastor.

8. An arrangement as defined in claim 1, further comprising: means for charging said energy storage capacitor and said second capacitor effectively in parallel to respective predetermined voltages preparatory to the initiation of a light flash.

9. An arrangement as defined in claim 8, further comprising an indicator circuit connected across said second capacitor for providing an indication that said photoflash is ready for use.

10. An arrangement as defined in claim 9 wherein said indication circuit comprises: a potentiometer having its resistance connected across said second capacitor; and an indicator lamp connected between one end of the resistance of said potentiometer and the movable tap of said potentiometer.

11. In an automatic electronic photoflash device including an electronic photoflash tube, energy supply means for supplying current to the tube when a light flash is to be produced, means connected to the tube for producing a signal which initiates the production of such a light flash, and automatic flash limiting means including a light sensor and arranged to produce a signal terminating a light flash when a predetermined quantity of light has been received by the sensor, the improvement wherein said flash limiting means comprise: first, normally open, electronic switch means connected in parallel with said tube and connected to be closed upon the appearance of a signal from said flash limiting means for short-circuiting said tube and thus terminating its light flash; and second, normally closed, electronic switch means connected in series between said energy supply means and the parallel arrangement of said tube and said first switch means and arranged to open upon the closing of said first switch means for blocking the flow of current from said energy supply means to both said tube and said first switch.

12. An arrangement as defined in claim 11 wherein said energy supply means comprise a storage capacitor connected in series with said tube and said second switch means.

13. An arrangement as defined in claim 12 wherein said second switch means is connected to be opened upon the appearance of a signal from said flash limiting means.

14. An arrangement as defined in claim 13 wherein said second switch means comprise: a fast-acting relay including a normally closed contact connected in series between said capacitor and said tube and a coil for con-

trolling the opening of said contact; and a semiconductor control element connected in series with said coil and connected to be operated by a signal from said flash limiting means for opening said relay contact.

15. An arrangement as defined in claim 12 wherein said second switch means are disposed in series between said capacitor and said first switch means and arranged to open in response to the short circuit current created by the closing of said first switch means.

16. An arrangement as defined in claim 15 wherein said second switch comprises: a pair of electrically conductive contacts, and at least one coil of a mechanically resilient, electrically conductive material connected to and supporting one of said contacts and formed as a compression spring normally urging said one of said contacts against the other one of said contacts, said coil and said contacts being connected to conduct the current flowing from said capacitor, and said coil being formed to act as a solenoid attracting said one contact with a force proportional to the current flowing there-through and to produce a mechanical spring force of a value such that it is overcome by the electromagnetic attraction force produced by the short circuit current occurring when said first switch closes, whereupon said one contact is drawn away from said other contact.

17. An arrangement as defined in claim 16 wherein there are two of said coils each connected to and supporting a respective one of said contacts and each arranged to subject its respective contact to an electromagnetic attraction force.

18. An arrangement as defined in claim 17 wherein said second switch further comprises a hermetically sealed casing enclosing said contacts and said coils.

19. An arrangement as defined in claim 16 wherein said second switch further comprises a capacitor connected between said contacts.

20. An arrangement as defined in claim 15 wherein said second switch comprises: a pair of conductive contacts; spring means normally urging said contacts together; and at least one solenoid coil connected in series with said contacts and arranged to conduct the current from said capacitor and to produce an electromagnetic force attracting its said contact, this force exceeding the force produced by said spring means upon the occurrence of the short circuit current appearing when said first switch closes.

21. A system for controlling the duration of delivery of energy to a load comprising:

sensing means for producing a signal proportional to the instantaneous response of said load to such energy;

a signal-to-frequency converter connected to receive the signal from said sensing means for producing a train of pulses whose repetition rate is proportional to the instantaneous value of such signal;

pulse counting means connected to the output of said converter for producing an output representing the number of pulses produced by said converter; and logic control means connected between said pulse counting means and said load for terminating the delivery of energy to said load after a predetermined number of pulses has been counted.

22. An arrangement as defined in claim 21, further comprising manually operable switch means connected for activating said pulse counting means.

23. An arrangement as defined in claim 22 wherein said load is an electronic photoflash tube, said sensing

means is a light sensor also responsive to ambient light, said switch means is a camera synchronization contact, and said logic control means are connected for activating said counting means upon closing of said switch means and for initiating the delivery of light flash producing energy to said tube upon response of said counting means to a pulse from said converter after closing of said switch means.

24. In an automatic photoflash device including a photoflash tube, means connected for triggering the tube into its conductive state, when operating power is applied to the tube, a power source for supplying power for the device, and a light sensing circuit arranged for sensing the light reflected from a subject illuminated by the light produced by the tube and for producing an output signal upon receipt of a predetermined quantity of light exceeding a value corresponding to a predetermined minimum quantity of light produced by the tube, the improvement comprising: pulse generating means connected in series between the power source and the tube for generating, and applying to the tube, a train of electrical pulses constituting the tube operating power upon the tube being triggered into its conductive state, each pulse produced by said means resulting in the production of less than the predetermined minimum quantity of light; and means connecting the light sensing circuit to said pulse generating means for causing the occurrence of the light sensing means output signal to prevent the generation of subsequent pulses by said generating means.

25. An arrangement as defined in claim 24 wherein successive pulses produced by said generating means are spaced from one another by a time interval no greater than the time required for the tube to deionize upon termination of the delivery of light flash producing energy thereto.

26. An arrangement as defined in claim 24 further comprising means connected between said generating means and the light sensing circuit for causing the pulses produced by said generating means to supply energizing power to the light sensing circuit.

27. An arrangement as defined in claim 24 wherein said pulse generating means are arranged to begin generating such train of pulses in response to the application of a triggering signal to the tube by the triggering means.

28. An arrangement as defined in claim 1 further comprising a current-limiting induction coil connected in series between said energy storage capacitor and one main electrode of said tube for limiting the amplitude of the current from said energy storage capacitor during the turn-on of said electronic switches.

29. An automatic electronic photoflash comprising, in combination:

- an electronic photoflash tube;
- an energy storage source;
- a first electronic switch which is closed when said photoflash tube is producing light, and means connecting said source and switch in series;
- trigger means coupled with said photoflash tube for firing said tube;
- a flash initiation circuit connected to said trigger means and to said first switch for causing firing of said tube and closing of said first switch when a light flash is to be produced by said tube;

a flash limiting circuit for producing a signal when a light flash being produced by said tube is to be terminated;

said flash limiting circuit including a light sensor arranged to produce a terminating signal when a predetermined quantity of light resulting from light from said tube has been received by said sensor;

said flash limiting circuit including a second normally open electronic switch adapted to be closed when said light flash is to be terminated, and means connecting said second electronic switch in parallel with said tube; and

means connecting said first switch and source in series with the parallel combination of said tube and second switch.

30. An automatic electronic photoflash comprising, in combination:

an electronic photoflash tube having two main electrodes and a trigger electrode;

a trigger circuit connected to said trigger electrode for applying a flash initiation pulse thereto;

a first normally open electronic switch connected in series with said tube;

an energy storage capacitor connected in series with said tube and first switch;

a flash initiation circuit connected to said trigger circuit and to said first switch for causing said trigger circuit to produce a flash initiation pulse and for closing said first switch when a light flash is to be produced;

a second normally open electronic switch;

a second capacitor;

means connecting said second switch and said second capacitor in series;

means connecting the series combination of said second switch and said second capacitor in parallel with the series arrangement of said tube and said first switch;

a flash limiting circuit responsive to a predetermined amount of light reflected from a subject illuminated by a light flash from said tube for producing a signal when the light flash being produced by said tube is to be terminated; and

means connecting said flash limiting circuit with said second switch for causing said second switch to be closed in response to the signal from said flash limiting circuit.

31. An automatic electronic photoflash comprising, in combination:

an electronic photoflash tube;

an energy storage source;

a first electronic switch which is closed when said photoflash tube is producing light, and means connecting said source and switch in series;

flash initiation means for causing firing of said tube and closing of said first switch when a light flash is to be produced by said tube, said flash initiation means including trigger means coupled with said tube for firing the tube in response to a control signal applied thereto;

a flash limiting circuit for producing a signal when a light flash being produced by said tube is to be terminated;

said flash limiting circuit including a light sensor arranged to produce a terminating signal when a predetermined quantity of light resulting from light from said tube has been received by said sensor;

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said flash limiting circuit including a second normally open electronic switch adapted to be closed when said light flash is to be terminated, and means connecting said second electronic switch in parallel with said tube; and

means connecting said first switch and source in series with the parallel combination of said tube and second switch.

32. An automatic electronic photoflash comprising, in combination:

an electronic photoflash tube having two main electrodes and a trigger electrode;

a first normally open electronic switch connected in series with said tube;

an energy storage capacitor connected in series with said tube and said first switch;

flash initiation means for causing firing of said tube and closing of said first switch when a light flash is to be produced by said tube, said flash initiation means including trigger means coupled with said tube for firing the tube in response to a control signal applied thereto and including means for closing said first switch;

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a second normally open electronic switch;

a second capacitor;

means connecting said second switch and said second capacitor in series;

means connecting the series combination of said second switch and said second capacitor in parallel with the series arrangement of said tube and said first switch;

a third capacitor, means connecting said third capacitor from the junction between said second capacitor and said second switch to the junction between said flash tube and said first switch;

a flash limiting circuit responsive to a predetermined amount of light reflected from a subject illuminated by a light flash from said tube for producing a signal when the light flash being produced by said tube is to be terminated; and

means connecting said flash limiting circuit with said second switch for causing said second switch to be closed in response to the signal from said flash limiting circuit.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,783,336 Dated January 1st, 1974

Inventor(s) Zoltan Vital and Jean Orban

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

In Figure 15 of the drawings, the conductor extending between the emitter of transistor 59315 and terminal K of element 594 should be shown connected to the conductor extending between the minus (-) side of capacitor 59312 and resistor 59303.

This connection should appear at the point of intersection of the two defined conductors.

Signed and sealed this 10th day of September 1974.

(SEAL)

Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents