United States Patent [19]

Iwata

[11] **3,831,079**

[45] **Aug. 20, 1974**

[54] **ELECTRONIC PHOTOGRAPHIC FLASH APPARATUS**

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[73] Assignee: **West Electric Co. Ltd.,** Osaka, Japan

[22] Filed: **Apr. 16, 1973**

[21] Appl. No.: **351,360**

Related U.S. Application Data

[63] Continuation of Ser. No. 152,805, June 14, 1971, abandoned.

[52] **U.S. Cl.** ..... **321/2,** 315/209 SC, 315/241 P, 320/1, 323/34

[51] **Int. Cl.** **H02m 3/22**

[58] **Field of Search** ..... 321/2, 18; 331/112, 113 R, 331/113 S; 320/1; 315/158, 183, 209, 209 CD, 194, 209 SC, 241 P; 323/34

[56] **References Cited**

UNITED STATES PATENTS

3,229,158	1/1966	Jensen	315/158
3,313,954	4/1967	Walker	331/112 SC
3,417,306	12/1968	Knak	320/1
3,474,325	10/1969	Schaefer	321/2
3,504,263	3/1970	Schaefer	321/2
3,668,505	6/1972	Dalton et al.	321/2

OTHER PUBLICATIONS

G. E. SCR Manual, 4th Ed.; Pg. 7 relied upon, (1967) TK2798C4g (Sci. Lib.).

Primary Examiner—Gerald Goldberg
Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

An electronic photographic flash apparatus with a constant voltage power supply, wherein the oscillation of a DC-DC converter is controlled by a switching element such as a thyristor to always maintain the voltage across a charged capacitor which is a load at a predetermined value thereby maintaining the light output of a discharge tube at a predetermined value, and at the same time a radiation indicating element is employed to give an indication and confirmation of said oscillation.

11 Claims, 28 Drawing Figures

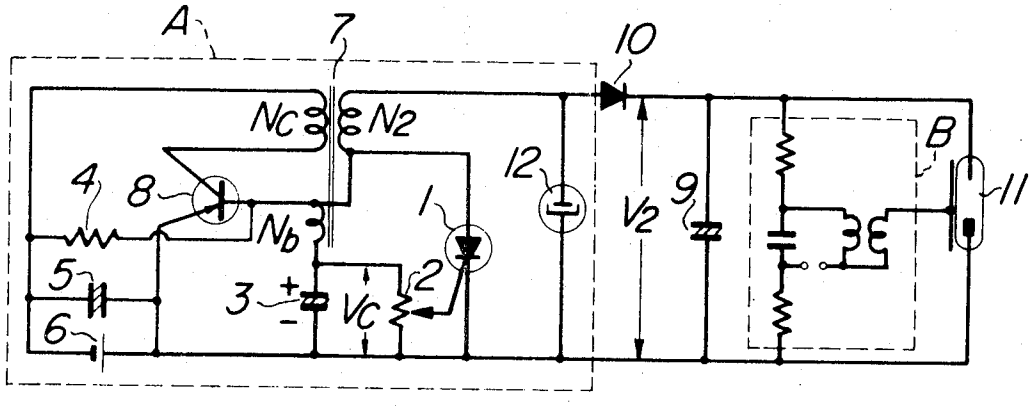


FIG. 1

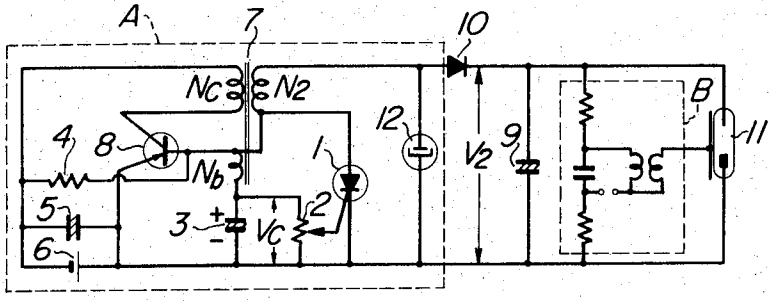


FIG. 2

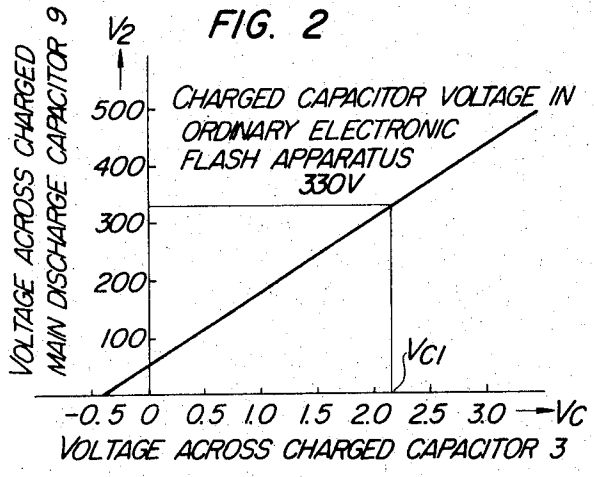


FIG. 3

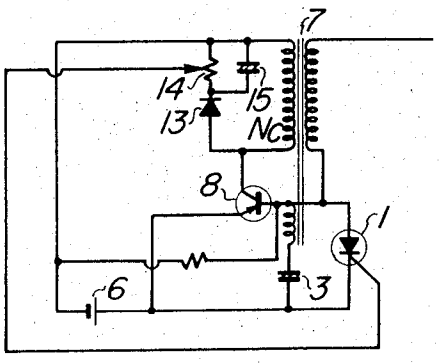
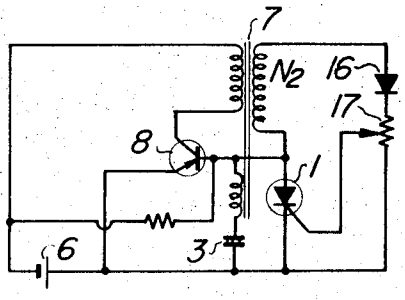


FIG. 4



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BY Stevens, Davis, Miller & Mosher
ATTORNEYS

FIG. 5

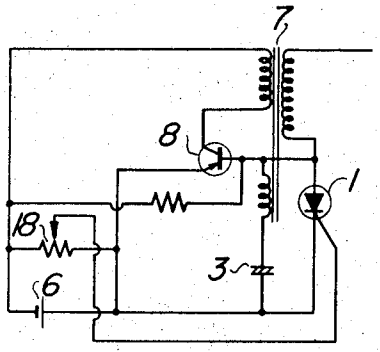


FIG. 6

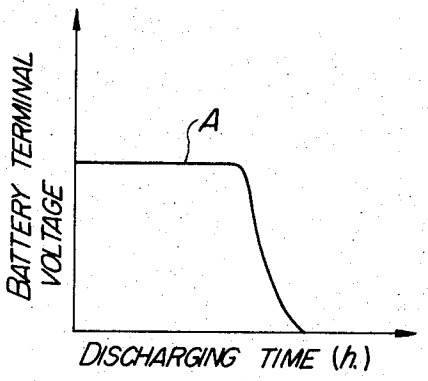


FIG. 7

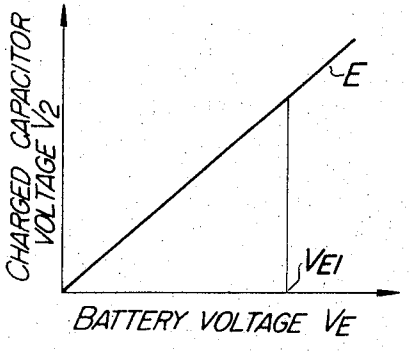


FIG. 8

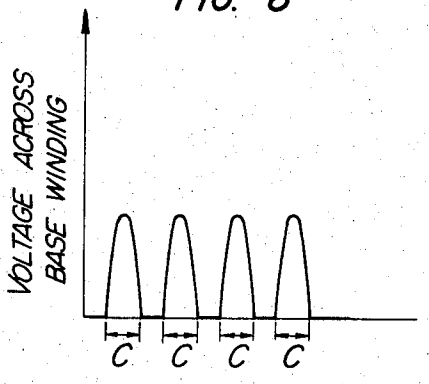


FIG. 9

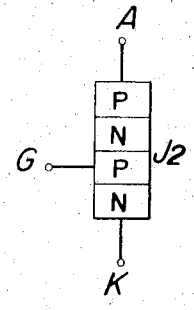


FIG. 10

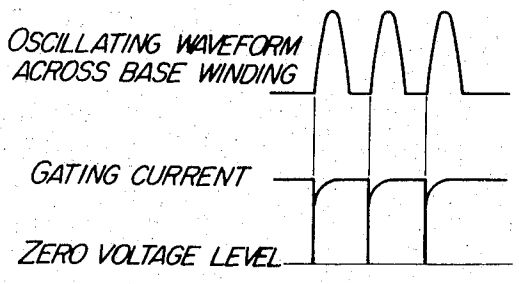


FIG. 11a

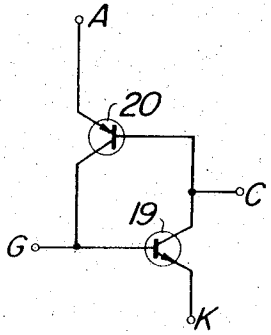


FIG. 11b

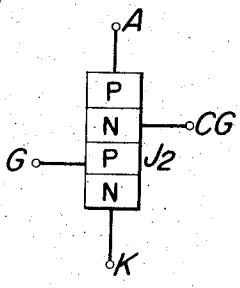


FIG. 12

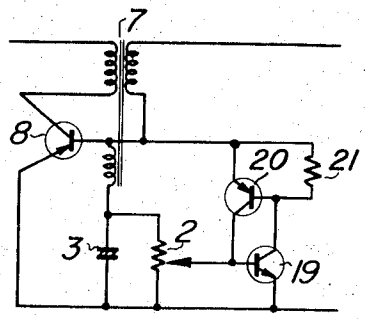


FIG. 13

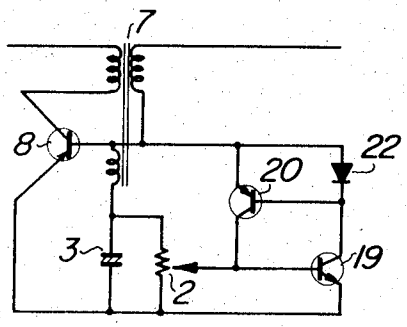


FIG. 14

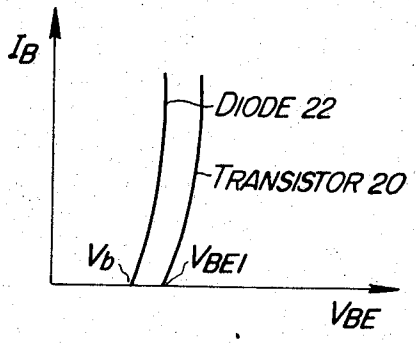


FIG. 15

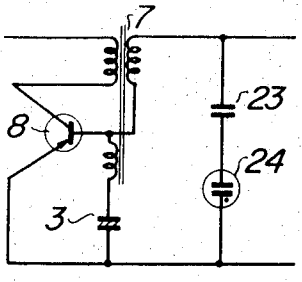


FIG. 16

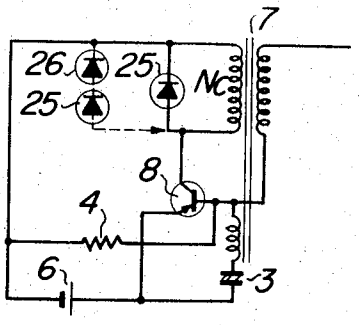


FIG. 17

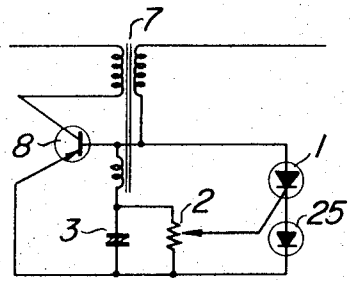


FIG. 18

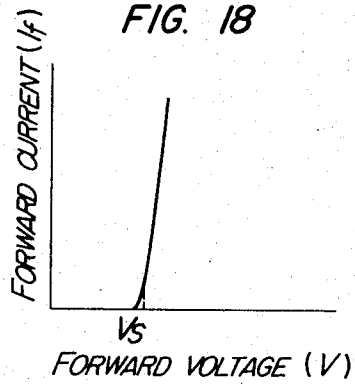


FIG. 19

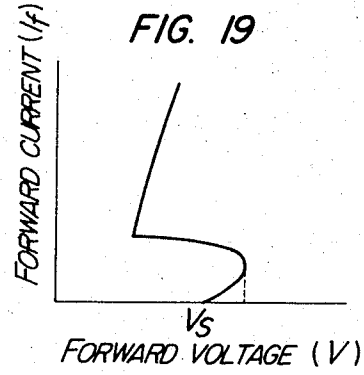


FIG. 20a

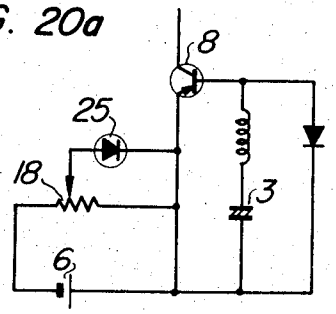


FIG. 20b

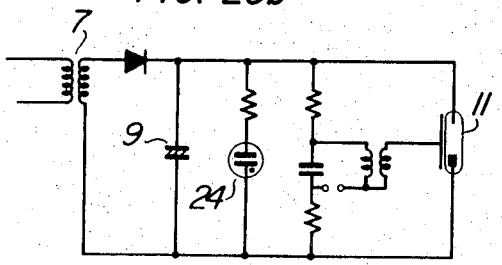


FIG. 21

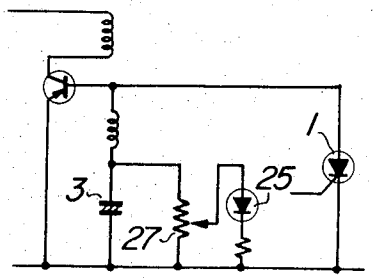


FIG. 22

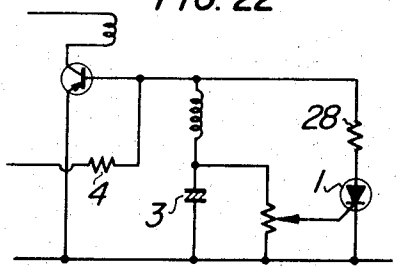


FIG. 23

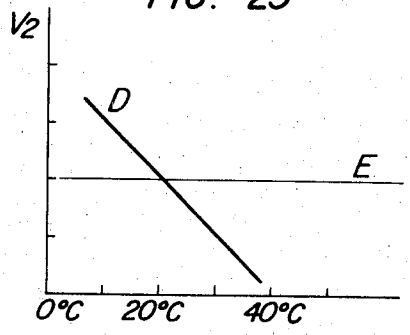


FIG. 24

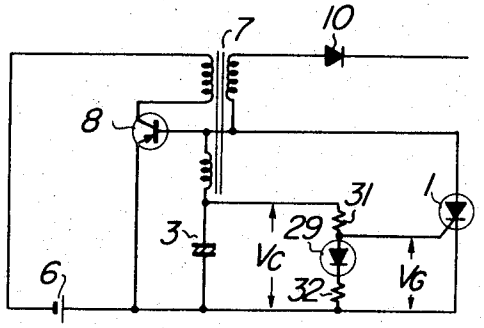


FIG. 25

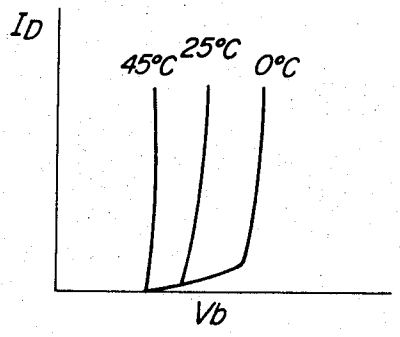
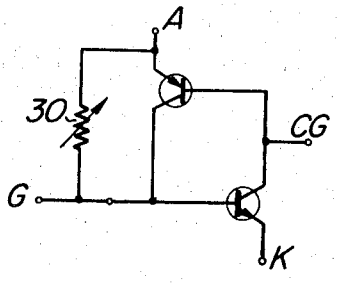


FIG. 26



ELECTRONIC PHOTOGRAPHIC FLASH APPARATUS

This is a continuation of application Ser. No. 152,805 filed June 14, 1971, now abandoned.

The present invention relates to an electronic photographic flash apparatus.

Hitherto, dry cells have been widely used as power sources for electronic photographic flash devices. However, owing to the characteristics of such dry cells, it has been inevitable that the voltage of the dry cell gradually decreases each time there is a flash discharge. Thus, with an electronic photographic flash device employing a dry cell, the voltage on the charged main discharge capacitor necessarily decreases in proportion to the decrease in the battery voltage with the result that the light output of the discharge tube also decreases, thereby affecting the exposure of the photographic film.

Therefore, it is the main object of the present invention to provide an electronic photographic flash apparatus with an improved constant voltage power supply which eliminates the above-mentioned deficiencies and in which the voltage across a charged main discharge capacitor is always maintained at a predetermined value to ensure the uniform exposure of the photographic film and at the same time a radiation indicating element is employed so that the oscillation condition of a DC-DC converter is readily confirmed.

A constant voltage power supply of this type is shown, for example, in U.S. Pat. No. 3,316,445. In this device, the oscillation is controlled by providing a feedback via a Schmitt circuit from a neon glow lamp disposed in the high voltage circuit on the load side and thus the voltage is high making it necessary to employ heavy insulation and the like, also the number of component parts tends to be large since a complicated circuit such as the Schmitt circuit is employed. On the contrary, the device of the present invention is highly reliable in operation and simple in circuit construction, since its control circuit operates with a low voltage and the biasing circuit is adapted to be fully short-circuited.

According to the present invention which is based on the principle that the voltage induced in each of the windings of a converter transformer in a DC-DC transistor converter is in proportion to the voltage across a charged main discharge capacitor which is the load, the voltage induced in any one of the converter transformer windings is detected and applied to the gate electrode of a switching element provided between the base and the emitter of said transistor so that the oscillation of said transistor is controlled to maintain the voltage across the load at a predetermined value and a radiation indicating element, such as an electroluminescence, luminescent diode or neon glow lamp is connected to a proper circuit so that the operating conditions of the converter are detected and confirmed.

A better understanding of the present invention may be had from the following detailed descriptions of the preferred embodiments when read in conjunction with the accompanying drawings, in which:

FIG. 1 is an electrical wiring diagram of an electronic photographic flash apparatus according to an embodiment of the present invention;

FIG. 2 is a diagram useful for explaining the present invention;

FIG. 3, FIG. 4 and FIG. 5 are electrical wiring diagrams showing other embodiments of the present invention;

FIG. 6 is a characteristic diagram of a nickel cadmium (NiCd) cell;

FIG. 7 is the voltage characteristic diagram of a charged capacitor when a NiCd cell is used;

FIG. 8 is a diagram showing the waveforms of the output voltages of a converter circuit;

FIG. 9 is a diagram showing the schematic symbol of a thyristor;

FIG. 10 is a diagram showing the output waveforms obtained when the thyristor of FIG. 9 is used;

FIG. 11*a* and FIG. 11*b* illustrate modified forms of the switching element;

FIG. 12 and FIG. 13 are electrical wiring diagrams showing the principal parts of further embodiments of the invention with modified switching means;

FIG. 14 is a diagram explaining the rising characteristic of the transistor;

FIG. 15, FIG. 16 and FIG. 17 are electrical wiring diagrams showing the principal parts of modified electronic photographic flash apparatus having means for indicating on and off of the oscillations of the converter circuit;

FIG. 18 and FIG. 19 are characteristic diagrams of luminescent diodes;

FIG. 20*a*, FIG. 20*b*, FIG. 21 and FIG. 22 are electrical wiring diagrams showing the principal parts of modified electronic photographic flash apparatus having indicating means employing a luminescent diode;

FIG. 23 is a diagram explaining the temperature characteristic of the electronic photographic flash apparatus;

FIG. 24 is an electrical wiring diagram showing a modified electronic photographic flash apparatus incorporating a method of temperature compensation;

FIG. 25 is a diagram illustrating the characteristic of the diode; and

FIG. 26 is an electrical wiring diagram showing a modified form of the switching means used with the electronic photographic flash apparatus of the present invention.

Referring to FIG. 1 of the drawings, there is illustrated a basic circuit diagram of the present invention in which a portion enclosed with a dotted line A designates a constant voltage circuit and a radiation indicating circuit according to the present invention.

In operation, the voltage of a power supply battery **6** is caused to oscillate and is stepped up in a DC-DC converter comprising a transistor **8,** a converter transformer **7** and so on and, after being rectified by a diode **10,** the voltage is used to charge a main discharge capacitor **9.** Numeral **12** designates a radiation indicating element, such as an electroluminescent element. Enclosed with a dotted line B is a trigger circuit of a conventional type for firing a discharge tube **11.**

A voltage V_2 across the charged main discharge capacitor **9** is in proportional relation with the voltages induced in windings N_2, N_C and N_b of the converter transformer **7** according to the following equation:

$V_2 = N_2/N_C\ K_1E$ or $N_2/N_b\ K_2E$

where E is the voltage of the power supply battery **6**, and K_1 and K_2 are constants. Thus, any one of the voltages generated across these windings can be employed as an effectively corresponding value of the voltage V_2 on the charged main discharge capacitor **9**.

With the circuit construction designated by the dotted line A in FIG. **1**, the oscillating voltage produced in the base winding N_b of the converter transformer **7** is employed so that this induced voltage is rectified by the diode characteristic between the emitter and the base of the transistor **8** and it is then applied to a capacitor **3** in the polarity shown producing a DC voltage V_C across the capacitor **3** which effectively corresponds to the voltage V_2 of the charged main discharge capacitor **9**. The graph of FIG. **2** represents the relationship between the two voltages. In the graph, the ordinate represents the voltage across the charged main discharge capacitor **9** and the abscissa represents the voltage across the charged capacitor **3** connected between the base winding N_b of the converter transformer **7** and the emitter of the transistor **8**.

Therefore, if the voltage across the main discharge capacitor **9** for providing a predetermined quantity of light is chosen to be 330 volts, for example, then the voltage across the capacitor **3** is V_{C1}. Then, if a control element **1** such as a thyristor provided between the base and the emitter of the transistor **8** is caused to conduct to stop the oscillation of the converter circuit at the value of the voltage V_{C1}, the oscillating current in the base winding N_b is shortcircuited by the control element **1** such as a thyristor so that the oscillation of the converter circuit is stopped and hence the charging of the main discharge capacitor **9** is stopped, thereby maintaining the voltage V_2 of the charged main discharge capacitor **9** at a predetermined value. However, since the main discharge capacitor **9** shows a leakage current and a circuit such as the trigger circuit B is connected in parallel with the main discharge capacitor **9**, the voltage V_2 across the capacitor **9** gradually decreases until the control element **1** such as a thyristor is rendered nonconductive again so that the converter circuit starts oscillating again to compensate for the aforesaid energy loss.

Repetitions of this process maintain the voltage V_2 across the main discharge capacitor **9** at a predetermined value. The time interval at which the oscillation of the converter circuit is to be interrupted is chosen such that the stored energy in the capacitor **3** is discharged by virtue of the control element **1** which may be a thyristor and the voltage V_C or the terminal voltage of the capacitor **3** becomes zero (the control element **1** is simultaneously turned off), whereupon the capacitor **3** is recharged through a biasing resistor **4** so that when the voltage across the capacitor **3** exceeds a base voltage V_{BE} of the transistor **8**, the converter circuit is caused to start oscillating again. In other words, the aforesaid time interval is practically determined by the time constant of the resistor **4** and the capacitor **3**.

On the other hand, there is a feature in that the connection of the radiation indicating element **12** to the high-voltage winding N_2 side of the converter transformer **7** enables the radiation indicating element **12** to flash in response to on and off of the oscillations of the converter circuit thereby giving an indication of the constant voltage across the main discharge capacitor **9**, whereas provision of an electroluminescence (EL) element or the like connected to the radiation indicating element **12** and adapted to produce light when excited by an AC current causes the EL element to start producing light upon the oscillation of the converter circuit thereby enabling observation of the oscillation of the converter circuit.

FIG. **3** illustrates another embodiment of the present invention wherein the oscillating waveform across a collector winding N_C is rectified by a diode **13** and it is then converted in a smoothing circuit comprising a resistor **14** and a capacitor **15** into a DC signal which is in turn used as a control signal for a control element **1**.

With the embodiment illustrated in FIG. **4**, the voltage generated across a secondary winding N_2 of a converter transformer is rectified by a rectifier **16**, divided by a variable resistor **17** connected in series with the rectifier **16**, and then used as a control signal for a control element **1**.

With the embodiment illustrated in FIG. **5**, the terminal voltage of a power supply battery **6** is employed as a control signal for a control element **1** through a variable resistor **18**. In this case, if a battery such as a NiCd battery whose characteristic is indicated by a curve A in FIG. **6** is employed, the battery voltage remains practically unchanged until the capacity of the battery is terminated, thus showing a characteristic indicated by a straight line E in FIG. **7** so that this battery terminal voltage can be employed as a control signal for maintaining the voltage across a charged main discharge capacitor at a predetermined value. While provision of the constant voltage circuit appears to be unnecessary since the characteristic of the NiCd battery shows practically no change in the terminal voltage as indicated by the curve A in FIG. **6**, the constant voltage circuit is advantageous in that the circuit functions to maintain the voltage across the charged main discharge capacitor **9** at a predetermined value and at the same time only the required energy is intermittently supplied from the power supply battery in response to on and off states of the converter circuit, thereby eliminating any energy loss due to the oscillations of the converter circuit. Thus, the detection of the required signal from the voltage across the power supply battery can be effective. It should be noted, however, that since the detected signal has a negative polarity because of the circuit construction, a negative gating element must be employed as a control element and, as will be explained later, this can be easily met by employing a composite transistor (the term "composite transistor" as used herein includes four-layer four-electrode construction elements as well as four-layer four-electrode four-terminal switching elements).

Next, means for controlling the oscillation of the converter circuit will be explained. As shown in FIG. **8** illustrating a typical output waveform of the converter circuit, a voltage containing very high frequency components at portions C is applied between the anode and the cathode of a control element **1**. Thus, with an ordinary thyristor available on the market such as is shown in FIG. **9**, the high frequency component indicated as C in FIG. **8** is allowed to pass from the anode side to the gate side through the junction capacitance at J_2 in the schematic symbol of FIG. **9** and therefore there is a possibility that the control element **1** is turned on with no gating signal being applied thereto or alternately a

leakage current flowing from the anode side by virtue of the oscillation component increases as the gating signal for the control element gets closer to the turn-on voltage with the result that the control signal for the control element tends to be unstable and hence the voltage V_2 across the charged main discharge capacitor also tends to be unstable.

FIG. **10** illustrates this leakage current in superimposed relation with the oscillating waveform of FIG. **8** showing the state of the leakage current flowing from the anode side to the gate side of the control element **1** or the thyristor. It is evident from the figure that the gate current flows only when the oscillating waveform across the base winding changes critically.

FIG. **12** illustrates a modified embodiment of the invention wherein, in order to prevent such leakage current, a composite transistor (FIG. **11***a*) comprising a combination of transistors **19** and **20** or a four-terminal switching element (FIG. **11***b*) is employed and a DC bias is applied externally to the third electrode CG so that almost no displacement current flows through the junction capacitance at J_2. In this case, the DC bias is applied through a resistor **21.** When a combination of transistors as shown in FIG. **11***a* is employed, these transistors themselves involve a very large degree of variation in their characteristics. More specifically, if there is a large degree of variations in V_{BE} of the transistor **20,** when considered as a control element, the control input characteristic between terminals G and K changes considerably and this constitutes a factor which indirectly causes variation in the voltage across the charged main discharge capacitor, while on the other hand it generally involves considerable problems to limit the characteristics of such transistors within the prescribed standards, in view of selection procedures and the like in the mass production of transistors.

Therefore, in order to limit variations in the V_{BE} of the transistor **20,** a diode **22** is connected in parallel with the transistor **20** as shown in FIG. **13.** The diode **22** has a rising characteristic V_b lower than V_{BE1} of the transistor **20** and it is connected so that the control circuit is stabilized by means of the combined transistors (FIG. **11***a*).

Next, the indicating methods according to the on and off oscillations of the converter circuit will be explained. If a radiation element **12** such as an EL element is connected to the secondary winding side of the converter circuit as shown in FIG. **1,** the EL element produces light as the converter circuit starts to oscillate, thereby enabling a visual confirmation of the converter circuit in operation. Then, as the voltage across the secondary winding reaches a predetermined value, the control element **1** is turned on to stop the oscillation of the converter circuit as previously explained. The instant the circuit stops oscillating, the EL element goes off. However, this voltage decreases due to the current leakage loss in the main discharge capacitor **9** and so on, the converter circuit begins oscillating again and the EL element again produces light and this process of operation is repeated.

In this way, whether the voltage across the secondary winding is maintained at a predetermined constant value can be easily observed according to the on and off states of the EL element. Similarly, the same effect can be obtained by connecting an indicator lamp **24** comprising a discharge lamp, for example, to the secondary winding side through a bypass capacitor **23** as shown in FIG. **15.**

FIG. **16** illustrates an arrangement wherein, for example, a luminescent diode **25** of gallium arsenide type which radiates with a relatively low voltage is connected across the collector winding N_c of the converter circuit. The same effect as in the previously explained arrangements can be ensured. In this arrangement, however, a diode **26** is connected in series with the luminescent diode **25** as shown by a dotted line, since the backward voltage is generally low with luminescent diodes, and this series combination of the diodes **25** and **26** is connected across the collector winding to substantially increase the withstand voltage of the diode **25** with respect to the backward voltage, thereby stabilizing the luminescent diode **25.**

Of course, the voltage generated across the base winding can be employed in similar fashion. Furthermore, instead of employing the voltage developed across the aforesaid converter transformer windings to give the required indication, the luminescent diode **25** may be provided in the series circuit including the control element **1** as shown in FIG. **17,** so that the required indication is provided by virtue of the energy supplied by the capacitor **3** on discharge.

On the other hand, according to the static characteristics of radiation elements such as the gallium arsenide luminescent diodes, one type of such element exhibits a constant voltage characteristic as shown in FIG. **18** and another type exhibits switching and radiating characteristic as shown in FIG. **19.** Either type of element may be employed to effectively indicate the voltage across the charged main discharge capacitor **9,** if, as shown in the arrangement of FIG. **20***a*, a variable resistor **18** is connected in parallel with the power supply battery **6** and if a battery voltage V_{E1} corresponding to the voltage V_2 across the charged main discharge capacitor **9** is obtained from the graph of FIG. **7** and then the variable resistor **18** is adjusted so that the battery voltage V_{E1} assumes a value corresponding to the voltage V_S of the luminescent diode **25.** According to this method, the radiation of the luminescent diode **25** can be provided with the energy from the power supply battery without turning the oscillation of the converter circuit on and off. Thus, this method can be effectively substituted for a so-called DC lighting method, such as the conventional type of indication method employing the neon tube or the like of an electronic photographic flash apparatus which is shown in FIG. **20***b* and in which the light is produced by virtue of the firing voltage of the neon tube when the voltage across the charged main discharge capacitor **9** reaches a predetermined value.

The reason is that since there is a certain proportional relationship between the power supply battery voltage and the voltage across the charged main discharge capacitor as shown in FIG. **7,** it is sufficient simply to adjust the variable resistor **18** so that a forward radiation initiating voltage V_S for the luminescent diode **25** is obtained which corresponds to a suitable voltage developed across the main discharge capacitor.

This function can be similarly performed by employing the voltages across the respective windings of the converter transformer which effectively correspond to the voltage across the charged main discharge capacitor **9** as previously explained. FIG. **20***a* illustrates a typical such arrangement.

Another form of radiation power sources utilizing the static characteristics of luminescent diodes is shown in FIG. **21**, wherein a variable resistor **27** is connected across a capacitor **3** and the voltage dividing ratio of the variable resistor **27** is adjusted so that a voltage V_S across a luminescent diode **25** effectively corresponds to a voltage V_2 across a charged main discharge capacitor **9**.

Next, the adjustment of the flashing intervals of the radiation indicating element **12** will be explained. While the flash interval can be increased simply by increasing the resistance value of the resistor **4** or the capacitance value of the capacitor **3**, that is, by increasing their time constant, this has disadvantages in that increasing the resistance value of the resistor **4** results in a decreased initial efficiency of the oscillation of the converter circuit, while an increased capacitance value of the capacitor **3** increases the bulk of the capacitor itself.

One method of easily effecting the required adjustment of the flashing intervals is shown in FIG. **22**, wherein a relatively large resistor **28** is connected in series with a control element **1** so that the capacitor **3** requires a longer time to discharge its stored energy upon the interruption of the oscillation of the converter circuit.

Next, methods of temperature compensation for the voltage V_2 across the charged main discharge capacitor **9** will be explained.

Designated as D in FIG. **23** is the temperature characteristic of the constant voltage electronic photographic flash apparatus shown in FIG. **1** and the apparatus has a so-called negative temperature coefficient with the secondary voltage of the main discharge capacitor **9** decreasing as the temperature increases.

One method of correcting this tendency is shown in FIG. **24**, wherein a diode **29** having a negative temperature coefficient is inserted in the gating circuit of a control element **1** so that a very flat characteristic as indicated by a straight line E in FIG. **23** is obtained as the temperature characteristic after correction.

The reason is that the diode **29** has a negative temperature characteristic as shown in FIG. **25** and thus the voltage dividing ratio of V_C by resistors **31** and **32** is given as

$$(R_{32} + R_{29})/R_{31}\ (R_{32} + R_{29}) \cdot V_C = V_G$$

where V_G is the gating voltage of the control element **1**. Thus, since the resistance R_{29} of the diode **29** at 0° C is larger than the resistance at 45° C, the value of V_G is higher at 45° C than at 0° C and therefore, assuming that the gating voltage of the control element is fixed, at 0° C the operation is initiated at a lower value of V_C and thus it is equivalent as though the value of the voltage across the charged main discharge capacitor were effectively reduced in FIG. **2**, thereby moving the characteristic to the temperature compensating direction as shown in FIG. **23**.

Where a control element comprising a composite transistor circuit as shown in FIG. **12** is employed, an element having a positive temperature coefficient may be connected to the resistor **21**.

Lastly, means for controlling the voltage across the charged main discharge capacitor **9** will be explained. In the circuit illustrated in FIG. **1**, the resistor **2** may comprise a variable resistor to effect the adjustment of the gating voltage for the control element **1**. On the other hand, if a composite element such as is shown in FIG. **11** is employed in the said circuit, an arrangement shown in FIG. **26** results. Thus, by providing a variable resistor **30** between the anode and the gate of the composite element, the breakover voltage of the composite element itself may be adjusted and in this way the same effect as the arrangement of FIG. **1** can be achieved.

It is now apparent from the foregoing explanation that the present invention provides a novel circuitry for electronic photographic flash apparatus which is capable of ensuring the G.N value for the last radiation and has no possibility of offering underexposure and wherein the supply of energy to a DC-DC converter is effected intermittently as occasion demands so that not only the consumption of the power supply battery is low, but also the constant voltage circuit itself can be simply constructed with the addition of only a few very small-sized component parts, thereby ensuring a high degree of performance almost independent of the size of electronic photographic flash apparatus per se.

What is claimed is:

1. An electronic photographic flash apparatus comprising:

a DC power source;

a transformer having primary, secondary and feedback windings, the secondary winding being adapted to produce a high-frequency voltage;

an oscillator transistor, wherein the primary winding of said transformer and said DC power source are connected serially between the collector and emitter electrodes of said transistor, and the feedback winding coupled electromagnetically with the primary winding of said transformer is connected through a first capacitor between the base and emitter electrodes of said transistor;

a main discharge capacitor;

oscillator control means for stopping and starting oscillation of said oscillator transistor to maintain a substantially constant voltage across said discharge capacitor, said oscillator control means including

switching means having a control terminal and connected between the base and emitter electrodes of said transistor, and

voltage applying means for applying a voltage to said control terminal corresponding to the voltage across the first capacitor which is proportional to the voltage across the main discharge capacitor to control the starting and stopping of oscillation of said oscillator transistor in relation to the voltage of said discharge capacitor;

a discharge tube having a trigger circuit associated therewith connected to the output of said discharge capacitor; and

rectifier means interconnecting said main discharge capacitor and the secondary winding of said transformer.

2. An apparatus according to claim **1**, wherein said voltage applying means comprises said first capacitor and a variable resistance means connected in parallel with each other between the feedback winding of said transformer and the emitter electrode of said transistor, the control terminal of said switching means being connected to said variable resistance means.

3. An apparatus according to claim **2**, further including indicating means comprising a luminescent diode connected in series with said switching means.

4. An apparatus according to claim 2, further including indicating means for indicating the starting and stopping of oscillation of the transistor oscillator, said indicating means comprising a luminescent diode connected in parallel with said switching means, thereby to discharge an energy stored in said second capacitor through said luminescent diode.

5. An apparatus according to claim 1, wherein said voltage applying means comprises a diode and a smoothing circuit, including a variable resistor and a further capacitor connected in parallel, serially connected across the primary winding of said transformer, the control terminal of said switching means being connected to said variable resistor.

6. An apparatus according to claim 1, further including indicating means for indicating the starting and stopping of oscillation of the transistor oscillator, said indicating means comprising a series circuit of a further capacitor and a luminescent element connected on the secondary winding side of said transformer, said further capacitor being operable to pass only an AC signal component from the secondary winding.

7. An apparatus according to claim 1, further including indicating means for indicating the starting and stopping of oscillation of the transistor oscillator, said indicating means comprising a luminescent diode connected across the primary winding of said transformer, in such a polarity that the cathode of the diode is connected to one end of the primary winding which is connected to the collector of the oscillation transistor.

8. An apparatus according to claim 6, wherein said indicating means comprises a luminescent diode and a diode connected in series with said luminescent diode.

9. An apparatus according to claim 1, wherein said switching means comprises a composite transistor composed of first and second transistors, and said apparatus further comprises a diode connected in parallel with one transistor of said composite transistor, said diode having a forward voltage lower than the threshold voltage of said one transistor, thereby to stabilize the oscillation control voltage.

10. An electronic photographic flash apparatus comprising:

a DC power source;

a transformer having primary, secondary and feedback windings, the secondary winding being adapted to produce a highfrequency voltage;

an oscillator transistor, wherein the primary winding of said transformer and said DC power source are connected serially between the collector and emitter electrodes of said transistor, and the feedback winding coupled electromagnetically with the primary winding of said transformer is connected between the base and emitter electrodes of said transistor;

variable resistance means connected in parallel with said DC power source;

a main discharge capacitor;

oscillator control means for stopping and starting oscillation of said oscillator transistor in relation to the discharging of said discharge capacitor to maintain a substantially constant voltage across said discharge capacitor, said oscillator control means including

switching means having a control terminal and connected between the base and emitter electrodes of said transistor, and

voltage applying means for applying a voltage to said control terminal according to the voltage across said DC power source through a tap of said variable resistance means to control the starting and stopping of oscillation of said oscillator transistor in relation to the discharging of said discharge capacitor;

a discharge tube having trigger circuit associated therewith and connected to said discharge capacitor; and

rectifier means interconnecting said main discharge capacitor and the secondary winding of said transformer.

11. An apparatus according to claim 10, further including indicating means comprising a variable resistor connected in parallel with said DC power source and a luminescent diode connected between a given point of said variable resistor and one terminal of said power source.

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