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HIGH REPETITION RATE STROBE LIGHT

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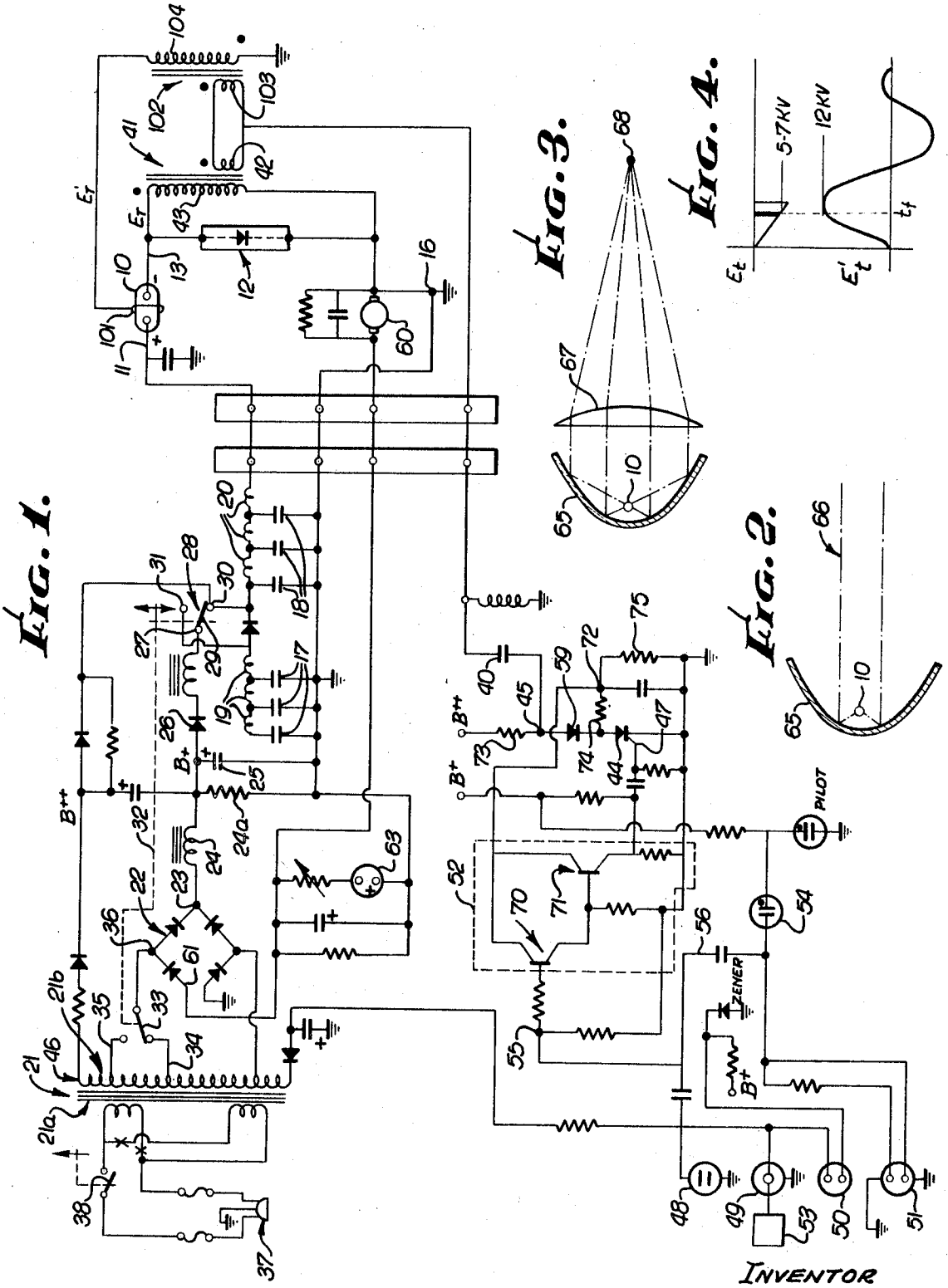


FIG. 1.

FIG. 3.

FIG. 4.

FIG. 2.

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HIGH REPETITION RATE STROBE LIGHT

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ABSTRACT OF THE DISCLOSURE

Improvements in triggering of a particular flasher circuit involve application to one flasher tube electrode of trigger voltage E_T of a polarity such that tube discharge diodes present high impedance to E_T, and application to a terminal exterior of the tube of trigger voltage E'_T to enhance tube gas ionization, $|E_T|$ and $|E'_T|$ having such time and magnitude relationship as to result in several benefits.

This invention relates generally to flasher circuits, and more particularly concerns improvements in stroboscopic light and flasher circuits of the type described in my co-pending application for U.S. Letters Patent, Ser. No. 508,039, entitled "Strobe Light," and filed Nov. 16, 1965.

In that application there was disclosed an unusually effective and simple flasher circuit that includes a flash tube, electrical charge storage means connected to discharge through the tube in response to triggered ionization of tube gas, diode means connected to provide a relatively low impedance path for such discharge, and trigger voltage supply means connected to supply to the tube a high trigger voltage of polarity such that the diode means presents a high impedance path to the trigger voltage. The present invention improves upon such a device in that less cooling of the diodes is required; substantially greater light output is obtainable for the same power input to the device; reliable flashing is obtainable at low energy discharge, i.e. short flashes occurring at high flash rates; the required trigger voltage applicable to the tube electrodes to secure flashing is less variable with temperature and aging of the apparatus; and fewer diodes are needed.

Basically, the invention concerns the provision of trigger voltage means including a terminal extending externally of and in such proximity to the tube as to enhance ionization of the gas in the tube in response to trigger voltage application to that external terminal coincidentally with trigger voltage application to the tube internal electrode. As will appear, the trigger voltage means typically includes a source of trigger voltage E_T applicable to the tube internal electrode and E'_T applicable to the external terminal, wherein E_T and E'_T both increase to flash initiating values characterized in that the absolute value of E'_T is at least twice the absolute value of E_T. In this regard, E_T is normally negative and applied to the tube cathode, while E'_T may be positive or negative.

As will appear, an unusually advantageous trigger voltage means includes transformer secondary winding sources of trigger voltage E_T applicable to the tube cathode and E'_T applicable to the external terminal, and transformer primary winding structure coupled to the secondary winding sources and adapted to receive trigger pulses.

These and other objects and advantages of the invention, as well as the details of illustrative embodiments, will be more fully understood from the following detailed description of the drawings, in which:

FIG. 1 is a circuit diagram showing one preferred form of flasher circuit incorporating the invention;

FIG. 2 is a section showing use of the flash tube as a point source of light with a reflector; and

FIG. 3 is like FIG. 2, but showing the addition of a focussing lens; and

FIG. 4 is a graph showing changes of E_T and E'_T.

The flasher circuit of FIG. 1 shows one form of flash tube **10** containing gas subject to ionization in response to application across the tube of a predetermined voltage differential. A typical usable tube is identified by the designation X–80 a product of PEK Laboratory, Sunnyvale, Calif. Connected to anode side **11** of the tube is one form of electrical charge storage means to discharge current through the tube in response to gas ionization. Also provided are diode means **12** connected to the opposite, i.e. cathode, side **13** of the tube to provide a relatively low impedance path for the discharge. Trigger voltage supply means is also connected to tube side **13** to apply to the tube a relatively high trigger voltage E_T of a polarity such that the diode means presents a relatively high impedance path thereto. Typically, the diode means may comprise silicon junction diodes **14** connected as shown between point **15** and common terminal or ground **16** for presenting high impedance to negative trigger voltage.

More specifically and as described in said copending application referred to above, the charge storage means connected to tube **11** may include multiple storage capacitors **17** and **18**, the former connected with inductance elements **19** to form one segment of a delay line and the latter capacitors connected with inductance elements **20** to form another segment of the delay line. Means is also provided to optionally charge different of the capacitors to effect control of flash intensity and flash rate upon capacitor discharge through tube **10**. For example, such means may include a transformer **21**; a full wave rectifier bridge **22** taking input voltage from the transformer, rectified DC output at **23** being filtered at inductance **24**, resistance **24***a* and capacitance **25** and supplied via diode **26** to terminal **27** of SPDT switch **28**. When switch arm **29** engages terminal **30**, only capacitors **18** are subjected to charging, since diode **100** connected between inductance **19** and **20** blocks charging of capacitors **17**. On the other hand, when switch arm **29** engages terminal **31**, all capacitors **17** and **18** are charged. The former mode is characterized by fast flash rates and lower flash intensity, whereas the latter mode is characterized by slower flash

rates and higher flash intensity or power. The delay line reduces peak currents delivered to the flash tube upon capacitor discharge.

Switch arm **29** is ganged at **32** with another SPDT switch arm **33** operable to connect different taps **34** and **35** of transformer secondary *a*1*b* with the input terminal **36** of the rectifier bridge. Thus, higher voltage is applied to terminal **36** during operation in slower flash, higher flash intensity (and duration) mode. The transformer primary **21***a* is suitably connected at **37** with AC source current via on-off switch **38**.

Turning now to the trigger voltage supply means, it may typically include a trigger charge storage capacitor **40**, a pulse transformer **41** having a low voltage primary winding **42** connected in series with the capacitor and a high voltage secondary winding **43** connected with the trigger input side **13** of tube **10**, together with means to trigger the discharge of the capacitor **40**. The latter means may typically and advantageously comprise a silicon controlled rectifier or SCR **44** connected in series with capacitor **40**, B++ voltage being supplied at junction **45** to charge capacitor **40**. Such voltage may be obtained from tap **46** of power transformer secondary winding **21***b*, as indicated. That voltage may also be applied to terminal **30** of switch **28** so as to assure a desirably high voltage charge on the capacitors **18** at the time of the first flash.

The SCR **44** has a control or switching input terminal **47** to receive amplified trigger input signals. Various pulse input points are indicated at **48–50**, whereas a sine wave input point appears at **51**. Pulse inputs are suitably amplified at **52** and applied to SCR terminal **47**. Collector voltage for transistors **70** and **71** is obtained from point **72** in voltage divider that includes resistors **73**, **74** and **75**. A source of controllable frequency stroboscopic pulses is indicated generally by clock **53**. The sine wave input point **51** is connected in series with a normally non-conducting neon bulb **54**. The latter becomes conductive during the negative portion of the sine wave trigger input signal, and a corresponding pulse is applied to the amplifier input at **55** via path **56**.

The trigger voltage supply means also includes a terminal (as for example loop **101**) extending externally of and in such close proximity to the tube **10** as to enhance ionization of the tube gas in response to application of trigger voltage E'_T to that terminal coincidentally with application of trigger voltage E_T to the tube electrode **13**. As seen in FIG. 4, E_T and E'_T increase to tube flash initiating levels at time t_f characterized in that the absolute value of E'_T, i.e. $|E'_T|$, is at least about twice the absolute value of E_T, i.e. $|E_T|$. Further, whereas E_T is negative at flash initiation, E'_T may be positive or negative at flash initiation. These relationships result in the improvements in operation discussed in the introduction. Typically, at t_f E'_T is about 12,000 volts whereas E_T is between 5,000 and 7,000 volts.

The trigger voltage supply means also includes another pulse transformer **102** having a low voltage primary winding **103** connected in series with capacitor **40** and in parallel with primary winding **42**, with polarities as indicated. Transformer **102** also includes a high voltage secondary winding **104** connected with terminal loop **101** wrapped closely about tube **10** as indicated, to supply E'_T to the loop. As a result of applying both E_T and E'_T, the gas in the tube ionizes at a much lower (½ to ⅔) level of voltage E_T than would be required in the absence of E'_T.

The use of silicon diodes is of particular advantage since the "hold off" (back) impedance can be very large and "conducting" (forward) impedance very small and switching from one state to the other very rapid. In this regard, the point source has a much lower conducting impedance than a conventional flash tube, which requires a much lower series impedance. As stated earlier, the number of diodes required is reduced significantly in view of the dual trigger voltage relationships.

Also, diode means **12** prevents reverse conduction of flash tube should the characteristics of the tube and circuit cause the discharge capacitors to end with a negative voltage. Reverse conduction of flash tube tends to degrade operation of the tube due to electrode abuse.

When the voltage across tube **10** falls sufficiently, the tube deionizes and the storage capacitors recharge. Likewise, the SCR **44** is switched off by a drop off in the output of amplifier **52**, after capacitor **40** discharges, so that capacitor **40** then recharges. Diode **59** prevents any ringing from reaching the SCR **44**.

A blower **60** has a motor connected in a circuit path from common terminal **16** to the rectifier bridge terminal **61**, so that average charging current for the discharge or storage capacitors is drawn through the blower causing it to run at a rate proportional to the power input to tube **10**. The blower fan cooling air discharge cools the tube **10**. Meter **63** also indicates average power by reading the voltage across the blower motor circuit. Cooling requirements are minimized in view of the improvements of the invention.

FIG. 2 shows the flash tube **10** in the form of a point source of light contained within and spaced from parabolic reflector **65** to yield a nearly collimated light beam **66**. A typical source **10** may be rounded and about 1 mm. in diameter, the associated reflector having a focal length of .4 inch and a 3½ inch diameter. The ionizable gas in the lamp is typically above 8 atmospheres pressure. FIG. 3 shows the same structure as in FIG. 2, and adds a lens **67** in front of the point source **10**. The lens sharply focuses the light from the reflector, generating a small spot at **68**, almost all light from source **10** is utilized in FIG. 3.

I claim:

1. In a flasher circuit, a flash tube containing electrodes and gas subject to ionization, electrical charge storage means connected to discharge through the tube in response to said ionization, diode means connected to one tube electrode to provide a relatively low impedance path for said discharge, and trigger voltage supply means including a connection to apply to said one tube electrode a trigger voltage of a polarity such that the diode means presents a relatively high impedance path thereto, said trigger voltage means including a terminal extending externally of and in such proximity to the tube as to enhance ionization of the gas in the tube in response to trigger voltage application to said terminal coincidentally with trigger voltage application to said tube electrode, said charge storage means being connected with another tube electrode and including storage capacitor means, and means to charge said capacitor means to effect control of flash intensity created by capacitor discharge through the flash tube, inductance connected to said capacitor means to provide a delay line, said trigger voltage means comprising a trigger charge storage capacitor, a transformer having primary winding means connected with the trigger capacitor and secondary winding means connected with said one tube electrode and with said terminal and sized to produce a voltage E_T applicable to said one electrode and a voltage E'_T applicable to said terminal and wherein E_T and E'_T increase to flash initiating levels characterized in that $|E'_T|$ is substantially greater than $|E_T|$, and means to trigger the discharge of the trigger capacitor and including a gate controlled rectifier connected in series with the trigger capacitor and having a control terminal, a trigger signal input connection, an amplifier connected between said input connection and said control terminal, and a source of input trigger signals.

2. The combination of claim **1**, wherein E_T and E'_T increase to flash initiating levels characterized in that $|E'_T|$ is at least about twice $|E_T|$.

3. The combination of claim **1**, wherein E_T is negative and E'_T is positive or negative.

4. The combination of claim **1**, in which said diode means and trigger voltage supply means are connected

with the tube cathode, and said charge storage means is connected with the tube anode, the diode means presenting said high impedance to negative trigger voltage.

5. The combination of claim **4**, in which said storage capacitor means includes multiple storage capacitors and said charge storage means includes means to optionally charge different of said capacitors to effect control of flash intensity created by capacitor discharge through the flash tube.

6. The combination of claim **4**, in which said diode means comprises series connected silicon diodes.

7. The combination of claim **1** wherein the tube forms a light source zone the overall cross dimension of which is less than 4 millimeters.

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