

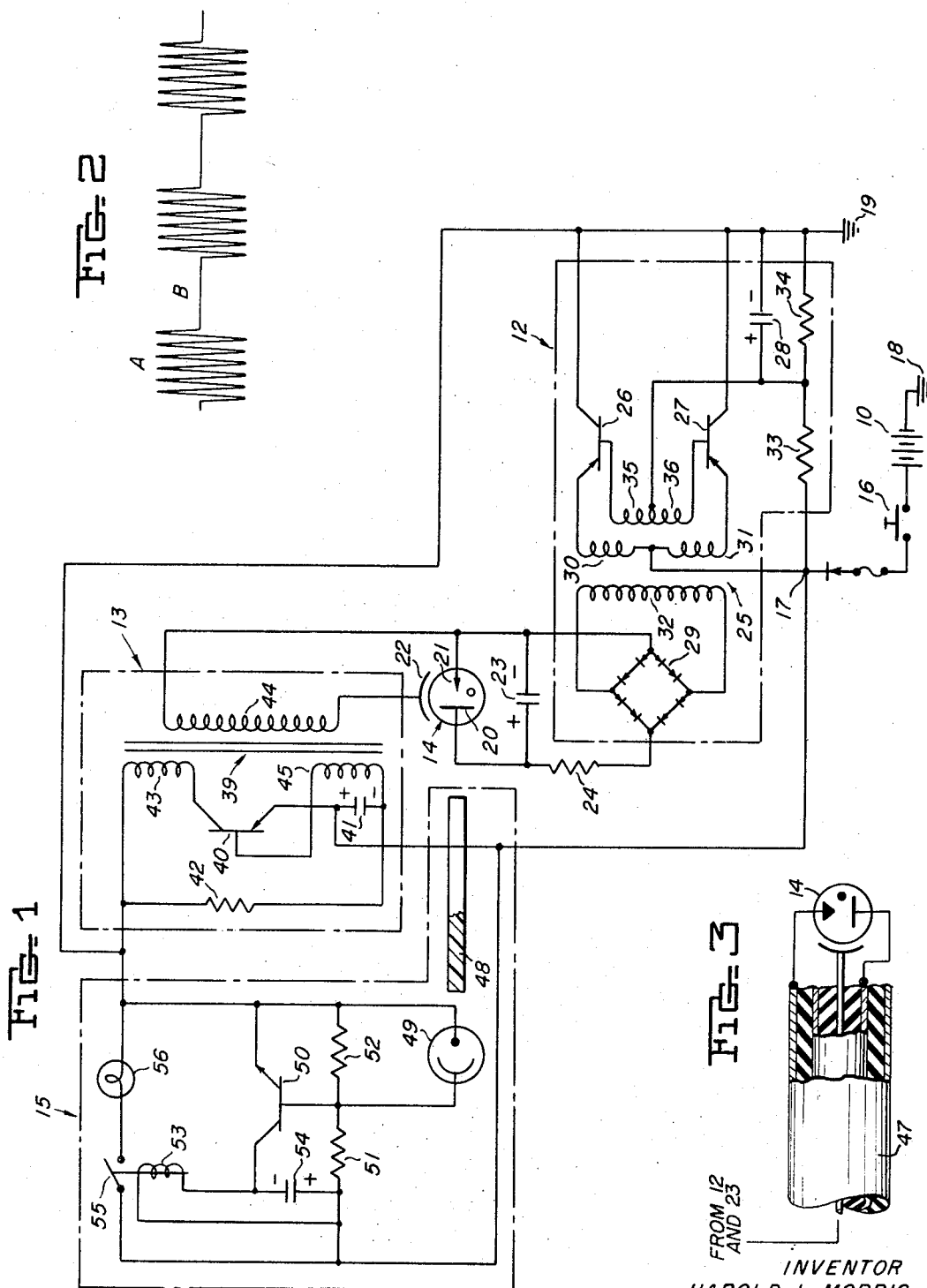
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CIRCUITS FOR ENERGIZING A FLASHTUBE

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CIRCUITS FOR ENERGIZING A FLASHTUBE

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ABSTRACT OF THE DISCLOSURE

An arrangement of electric circuits for operating a flashing lamp. The lamp requires both high-voltage, high-density D-C and pulse bursts of high-voltage, high frequency A-C. A novel circuit for producing A-C including a transistor which acts both as an oscillator and a switch. The pulse bursts may be transmitted a considerable distance through a triaxial cable.

This application is a continuation of Ser. No. 320,489, filed Oct. 31, 1963, now abandoned.

This invention relates to an improved combination of electric circuits for energizing a device which operates periodically, such as a flashing lamp.

Although the invention is not thus limited, my combination of circuits is particularly suited for energizing a gas-filled flashtube. This type of tube is available commercially and is described, for example, in a printed publication by General Electric Photo Lamp Department, Nela Park, Cleveland, Ohio, entitled "General Electric Flashtube Data Manual." One purpose for which the tube can be used as a warning light, for example on aircraft. When thus used, the tube is required to flash at regular intervals, typically forty to sixty times a minute, over a prolonged period. The tube is lighted by applying high-voltage, high-density D-C and at the same time ionizing the gas in the tube. The gas can be ionized by applying A-C, either at high voltage, high frequency, or both. Nevertheless it is apparent my circuit combination or the individual circuits embodied therein may have other applications where similar effects are sought.

An object of my invention is to provide a compact, fully transistorized combination of circuits free of moving parts for energizing a periodically operated device, such as a flashing lamp.

A further object is to provide an improved combination of the foregoing type in which A-C pulse bursts are produced at high-frequency, as well as high voltage, thus enabling the pulse to be transmitted a considerable distance and the circuit components to be located remote from the flashtube or other point of use.

A further object is to provide an improved circuit utilizing a minimum number of parts for producing high-voltage, high-frequency A-C pulse bursts at regular intervals and at a fixed or adjustable rate, as needed, for example, to ionize gas in a flashtube.

A further object is to provide means for operating a flashtube in which I avoid the more cumbersome components presently used, such as relays, cold cathode switching tubes, thyratron vacuum tubes, or mechanical interrupters.

A more specific object is to provide, in a lightweight compact packaged unit, the combination of circuits necessary to operate a flashtube from a low-voltage source, such as a battery, which unit can be located at a considerable distance from the tube, as may be necessary on aircraft.

A further object is to provide an improved device for indicating failures in a flashtube or other lamp when the lamp is located where it is not readily visible to an operator.

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In the drawings:

FIGURE 1 is a schematic wiring diagram of a preferred combination of circuits for operating a flashing lamp arranged in accordance with my invention;

FIGURE 2 is a schematic diagram of the A-C pulse form I obtain with the circuit shown in FIGURE 1; and

FIGURE 3 is a diagrammatic view illustrating how I connect the flashing lamp with the circuits of FIGURE 1 through a triaxial cable.

The combination shown in FIGURE 1 comprises a low-voltage D-C power source 10, a circuit 12 for converting low-voltage D-C from the power source to high-voltage D-C, a circuit 13 for producing high-voltage, high-frequency A-C pulse bursts, a conventional gas-filled flashtube 14, and a failure indicator 15. Conveniently the power source 10 is twelve or twenty-eight volt battery, which can be the carrier battery when the circuits are used on a vehicle. I connect the positive terminal of the power source to both circuits 12 and 13 and to the failure indicator 15 through a switch 16 and a junction point 17. I connect the negative terminal of the power source to both circuits and to the indicator through grounds 18 and 19. The flashtube 14 includes an anode 20 and a cathode 21 inside the tube and a trigger 22 outside the tube. The gas within the tube commonly is xenon. To light the tube it is necessary simultaneously to apply high-voltage, high-density D-C across its anode and cathode and also to ionize the gas by applying A-C of appropriate characteristics to its trigger and cathode. The combination also includes a capacitor 23 and resistor 24 between circuit 12 and tube 15, as hereinafter explained.

Circuit 12 can be any of several known types for producing D-C of the necessary high voltage. FIGURE 1 shows a circuit of the blocking-oscillator type, which includes a step-up transformer 25, two PNP transistors 26 and 27, a capacitor 28, and a full-wave rectifier 29. A suitable transformer is available commercially from Triad Transformer Corp., as the TR-92 Transistor Power Supply Transformer, and the instructions from the supplier include a circuit similar to that shown in FIGURE 1. Briefly, the emitters of transistors 26 and 27 are connected to the positive side of the power source via the junction point 17 and respective primary windings 30 and 31 of transformers 25, and the collectors of both transistors are connected to the negative side via grounds 18 and 19. The transformer has a secondary winding 32 connected to the input terminals of rectifier 29. I connect the base of transistor 26 to both the positive and negative sides of the power source via bias resistors 33 and 34 respectively and a tertiary winding 35 of transformer 25. I connect the base of transistor 27 in similar fashion via a tertiary winding 36. The bias resistors form a voltage divider network which is slightly unsymmetrical. Each transistor 26 and 27 alternately conducts while the other cuts off, whereby current alternately flows and ceases to flow in the two primary windings 30 and 31. The expanding and collapsing magnetic field induces A-C of stepped-up voltage in the secondary winding 32 and high voltage D-C appears at the output terminals of the rectifier 29. The magnitude of capacitor 28 determines the frequency of operation. Other types of circuits I could use for producing D-C of the necessary voltage include a ringing choke or in a stationary installation an ordinary power transformer, a vibrator inverter or a motor generator. However, I prefer the circuit illustrated because it is compact and readily produces 1,000 volts which the flashtube may require.

I connect capacitor 23 and resistor 24 in series across the output terminals of rectifier 29. The magnitudes of the capacitor and resistor vary with the power input desired for the flashtube and the repetition rate at which it flashes, since the capacitor must reach full charge be-

tween flashes. I determine the magnitude R of the resistor in ohms by the formula:

$$R = \frac{T}{7C}$$

in which:

T is the flash rate per second

C is the value of the capacitor in farads.

I determine the capacity c of the capacitor in microfarads by the formula:

$$c = \frac{2J}{V^2}$$

in which:

J is the watts-seconds per flash (for example 25)

V is the potential applied to the tube in kilovolts.

I also connect the capacitor across the anode 20 and cathode 21 of the flashtube, whereby the potential developed across the capacitor is applied to the anode and cathode, but the tube does not light unless an A-C pulse at high voltage and/or high frequency is applied to its trigger 22 to ionize the gas.

Circuit 13 for producing high-voltage, high-frequency pulse bursts includes a specially constructed pulse transformer 39, a PNP transistor 40, a capacitor 41 and a resistor 42. The transformer has primary, secondary and tertiary windings 43, 44 and 45. Transistor 40 conducts when its emitter is positive with respect to its base and its collector negative with respect to its base, but otherwise cuts off. I connect the capacitor 41 and the resistor 42 in series across the positive and negative sides of the power source 10 via the junction point 17 and ground 19, whereby the capacitor can charge at a rate determined by the magnitude of the resistor. I connect the emitter of the transistor to the positive side of the power source 10 via the junction point 17, and connect the collector to the negative side via the primary winding 43 and grounds 18 and 19. I connect the base of the transistor to one end of the tertiary winding and connect the other end of this winding between the capacitor 41 and resistor 42. I connect the ends of the secondary winding 44 to the cathode 21 and trigger 22 of the flashtube.

Closing switch 16 completes a current path from the positive side of the power source 10 through the junction point 17, emitter and collector of transistor 40, primary winding 43, and grounds 19 and 18 to the negative side of the power source. A negative potential reaches the base of transistor 40 through resistor 42 and tertiary winding 45. Since there is a voltage drop across the resistor, the negative potential on the base is less than that on the collector; hence current begins to flow through the transistor. This current passes through the primary winding 43 and produces an expanding magnetic field whose lines of force cut both the secondary and tertiary windings 44 and 45. The potential thus induced in the tertiary winding 45 is applied to the transistor base and immediately cut off current flow through the transistor. The field of the primary winding 43 collapses, and the lines of force again cut both the secondary and tertiary windings. The potential on the base of the transistor returns to the range which allows the transistor to conduct, and the process repeats. A high-voltage, high-frequency A-C pulse burst is induced in the secondary winding 44, as indicated in FIGURE 2 in portion A of the curve. This pulse burst is transmitted to the cathode 21 and trigger 22 of the flashtube and ionizes the gas therein. The capacitor 23 discharges through the anode and cathode of the tube, producing a flash.

Meanwhile capacitor 41 is charging, being connected across the positive and negative sides of the power source. The potential on the negative side of the capacitor reaches the base of transistor 40 via the tertiary winding 45. When the capacitor reaches full charge, the magnitude of negative potential on the base of the transistor approaches

the magnitude of that on the collector, whereupon the transistor ceases to conduct. The capacitor commences to discharge through the base and emitter of the transistor, and the transistor remains off. No current is induced in the secondary winding 44 during this period, as indicated in FIGURE 2 in portion B of the curve. After the capacitor has discharged, the cycle repeats. While capacitor 41 is discharging, capacitor 23 is charging to supply high voltage, high density D-C for the next cycle.

I can also equip circuit 13 with various refinements which I have not shown in the interest of simplicity. For example, the circuit can include fuses and protective diodes for preventing current pulses passing in the wrong direction, and it can include various combinations of resistors and capacitors for controlling the pulse shape. Persons skilled in the art are familiar with the use of such devices; hence no showing is deemed necessary. I wish to point out further that my pulse circuit 13 may have other application where intermittent A-C pulse bursts are sought.

In a typical installation the components of the two circuits 12 and 13 are packaged together in a compact unit, which may be located at a considerable distance from the flashtube 14. For example in an aircraft the flashtube may be on the tail assembly and the unit containing the circuit components near the center of gravity. The connection between the electronic package and the flashtube preferably is a triaxial cable 47 (FIGURE 3) to enable the voltages to be transmitted over the necessary distances, which have been up to about 40 feet. In such installations it is desirable to provide a failure indicator so that an operator immediately knows when the tube is not flashing. In installations in which the tube itself is visible to the operator, the indicator of course can be omitted.

The failure indicator 15 includes a light-conducting plastic rod 48 which extends from the vicinity of the flashtube 14 to a photocell 49. The rod can be of an acrylic polyester resin and is embedded in potting compound below the flashtube mounting. Thus the photocell receives light only from the flashtube. I connect the terminals of the photocell to the emitter and base of an NPN transistor 50. I also connect the base of this transistor to both the positive and negative sides of the power supply 10 via resistors 51 and 52, which bias the transistor for non-conduction between its emitter and collector. I connect the emitter of the transistor to the negative side of the power source and I connect the collector to the positive side via the coil of a relay 53 and a capacitor 54 in parallel. Relay 53 has a back or normally closed contact 55, which I connect in series with an indicator light 56 across the positive and negative sides of the power source. Thus light 56 comes on when the relay is deenergized.

When a flash from the flashtube 14 energizes the photocell 49, the bias on the base of transistor 50 is overcome and the transistor commences to conduct. Momentarily current flows through the transistor and through the parallel coil 53 and capacitor 54. The relay is energized and the capacitor charges. During intervals between flashes, the capacitor discharges through the relay coil and holds the relay energized, whereby contacts 55 remain open and the indicator light 56 remains unlit. If the flashtube fails to light for a predetermined period, capacitor 54 does not recharge and relay 53 is deenergized, whereupon contact 55 closes and the indicator light 56 comes on. Conveniently I adjust the capacitor 54 to light the indicator when the flashtube misses three consecutive flashes.

As a further example, I may include a second ionizer circuit 13 in the combination and operate the two ionizer circuits alternately by use of an astable switch. One such switch embodying two symmetric transistor circuits is described in a printed publication, "Transistor Circuit Design," by the Engineering Staff of Texas Instruments, In-

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corporated, published by McGraw-Hill Book Company, copyright 1963, section 32, page 423. With this arrangement two flashtubes can be operated alternately from one electronic package, for example one on the tail of an aircraft and the other under the fuselage, or alternately on the two wing tips, or in any desired sequence. Such switching technique is well-known to computer engineers, and requires no special discussion, except to show the flexibility of my invention.

From the foregoing description it is seen that my invention affords a simple, compact and highly flexible combination of circuits for operating a flashtube or other periodically energized device. The number of components is reduced to a minimum. In the ionizer circuit a single transistor serves both to turn the circuit off and on and also to act as an oscillator, an arrangement which I believe is unique.

While I have shown and described only a single embodiment of my invention, it is apparent that modifications may arise. Therefore, I do not wish to be limited to the disclosure set forth but only by the scope of the appended claims.

I claim:

1. The combination, with a low-voltage D-C power source and a gas-filled flashtube which has an anode, a cathode and a trigger, of an arrangement of circuits for operating said flashtube comprising:
 - a first circuit for producing high-voltage D-C;
 - a capacitor for developing high-density D-C;
 - means connecting said power source with said first circuit and connecting said first circuit with said capacitor;
 - a second circuit for producing pulse bursts of high-voltage, high frequency A-C at spaced intervals, said second circuit including:
 - a pulse transformer having primary, secondary and tertiary windings, each of which windings has first and second ends;
 - one side of said power source being connected to the first end of said primary winding and through a resistance to the first end of said tertiary winding;
 - a transistor having collector, base and emitter electrodes connected respectively to the second end of said primary winding, the second end of said tertiary winding, and the other side of said power source; and
 - means isolated from said base electrode causing said transistor to act as a switch for turning the A-C output of the second circuit off and on, as well as an oscillator when the output is on;
 - conductors connecting said capacitor with said anode and cathode to transmit D-C thereto; and
 - conductors connecting the ends of said secondary winding with said trigger and cathode to transmit A-C thereto and ionize the gas in said flashtube;
 - said circuits being remote from said flashtube, and said conductors being embodied in a triaxial cable.
2. A combination as defined in claim 1 in which said last-named means includes a second capacitor connected between the first end of said tertiary winding and the last-mentioned side of said power source.
3. A combination as defined in claim 1 in which said circuits are embodied in a compact unit.
4. A combination as defined in claim 1 further comprising a device connected to said power source for indicating when said flashtube fails.
5. A combination as defined in claim 1 further comprising a device for indicating when said flashtube fails,

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said device including a light-conducting plastic rod adjacent said flashtube, photoelectric means adjacent said rod, a relay circuit connected to said photocell and said power source, an indicator connected to said relay circuit, and means for actuating said relay circuit when the flashtube misses a predetermined number of flashes.

6. The combination, with a low-voltage D-C power source and a gas-filled flashtube which has an anode, a cathode and a trigger, of an arrangement of circuits for operating said flashtube comprising:

- a first circuit for producing high-voltage D-C;
- a first capacitor for developing high-density D-C;
- means connecting said power source with said first circuit and connecting said first circuit with said first capacitor;

a second circuit for producing pulse bursts of high-voltage, high-frequency A-C at spaced intervals, said second circuit including:

- a pulse transformer having primary, secondary and tertiary windings, each of which windings has first and second ends;

one side of said power source being connected to the first end of said primary winding and through a resistance to the first end of said tertiary winding;

a transistor having collector, base and emitter electrodes connected respectively to the second end of said primary winding, the second end of said tertiary winding, and the other side of said power source;

a second capacitor connected between the first end of said tertiary winding and the last-mentioned side of said power source;

said transistor acting both as a switch for turning the A-C output of the second circuit off and on and as an oscillator when the output is on;

conductors connecting said first capacitor with said anode and cathode to transmit D-C thereto; and

conductors connecting the ends of said secondary winding with said trigger and cathode to transmit A-C thereto and ionize the gas in said flashtube;

said circuits being embodied in a compact unit remote from said flashtube and said conductors being embodied in a triaxial cable.

7. A combination as defined in claim 6 including means for indicating when said flashtube fails.

8. A combination as defined in claim 6 further comprising a device for indicating when said flashtube fails, said device including a light-conducting plastic rod adjacent said flashtube, photoelectric means adjacent said rod, a relay circuit connected to said photocell and said power source, an indicator connected to said relay circuit, and means for actuating said relay circuit when the flashtube misses a predetermined number of flashes.

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