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APPARATUS FOR OPERATING GASEOUS DISCHARGE LAMPS FROM A D.C. SOURCE

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FIG. 1

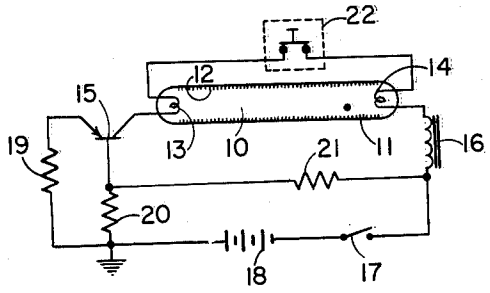


FIG. 2

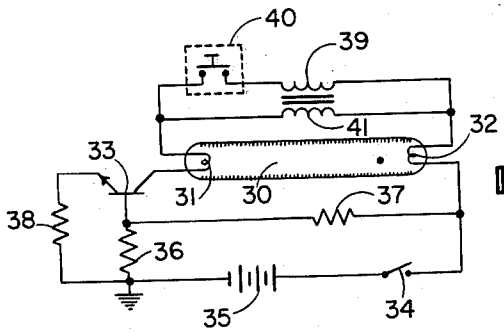
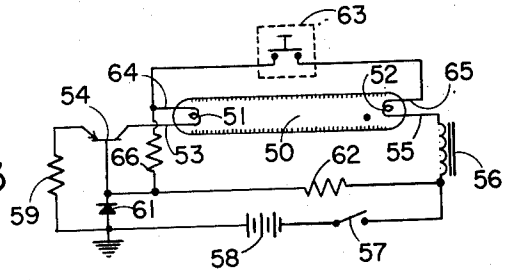


FIG. 3



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APPARATUS FOR OPERATING GASEOUS DISCHARGE LAMPS FROM A D.C. SOURCE

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This invention relates to apparatus for operating gaseous discharge devices from a D.C. power supply. More particularly, it is concerned with apparatus for regulating the flow of current from a D.C. power supply through a fluorescent lamp.

Fluorescent lamps are generally employed in association with A.C. power supplies and utilize transformers, chokes, or other reactive impedances to regulate current flow through the lamp by offsetting the negative resistance which occurs across a lamp when a conductive arc is produced within the lamp. When the source of power is D.C., it is common practice to employ an inverter circuit to permit A.C. operation of the lamp. With a power supply of this type a reactive impedance such as a choke may still be used as the current regulator or "ballast." Resistance ballasts or incandescent lamps may be connected in series with a fluorescent lamp in order to operate the lamp directly on D.C., but such arrangements operate at very low efficiencies.

It is an object of the present invention to provide an improved apparatus for operating gaseous discharge devices directly from a D.C. source.

More specifically, it is an object of the invention to provide an improved apparatus for controlling the flow of current from a D.C. source through a fluorescent lamp.

Briefly, in accordance with the objects of the invention a transistor is connected in series with a gaseous discharge lamp and a D.C. power supply is connected across the gaseous discharge lamp and the transistor. The transistor is biased for operation at a condition of constant collector current and provides a high dynamic impedance in series with the negative resistance of the lamp.

Additional objects, features, and advantages of apparatus according to the invention will be apparent from the following detailed discussion and the accompanying drawings wherein:

FIG. 1 is a schematic diagram of apparatus according to the invention employing a PNP transistor and having a first arrangement for starting the lamp.

FIG. 2 is a schematic diagram of apparatus according to the invention employing an NPN transistor and having another arrangement for starting the lamp, and

FIG. 3 is a schematic diagram of a modification of the apparatus according to the invention shown in FIG. 1.

FIG. 1 shows a gaseous discharge lamp **10** of the well-known fluorescent type which comprises a glass envelope **11** filled with an inert gas, such as argon or mercury vapor, and having its inner surface coated with a fluorescent material **12**. Illumination is produced by excitation of the fluorescent coating by an arc discharge through the gas in the envelope which is ionized by electrons emanating from electronically emissive heaters or filaments **13** and **14** located at opposite ends of the envelope. One terminal of the first filament **13** is connected directly to the collector of a PNP transistor **15**. One terminal of the second filament **14** is connected through an inductance in the form of a choke coil **16**, which initiates the arc discharge through the lamp, and a main switch **17** to the negative terminal of a D.C. power source shown as a battery **18**. The positive terminal of the battery is connected directly to ground. The emitter of the transistor is connected to ground through an emitter resistance **19**, and the base is connected to ground through a first base

resistance **20**. A second base resistance **21** is connected from the base of the transistor to the connection between the choke and the main switch. The other terminals of both lamp filaments are connected to each other through a switch **22** for starting the lamp. Although any of various known automatic or semiautomatic switching arrangements may be employed as the starting switch, a normally-open push-button switch is illustrated in order not to confuse the explanation with details not directly pertinent to the invention.

When the apparatus of FIG. 1 is energized by closing the main switch **17**, the voltage drop across the lamp between the two filaments **13** and **14** is not sufficient to initiate a discharge arc through the gas. The filaments must usually be preheated first for a short period of time as by current flow through the two filaments. A temporary current path through the two filaments in series which is in shunt with the high impedance of the unfired lamp is provided by closing the normally-open starting switch **22**. The preheating current also flows through the transistor **15**, which is biased for conduction in a manner to be explained hereinafter, and through the choke **16**. When the filaments have been heated by the preheating current sufficiently to emit electrons and ionize the gas in the regions adjacent the filaments, the switch **22** is reopened. The sudden cessation of current flow when the starting switch is reopened induces a high voltage in the choke. A high voltage pulse thus occurs across the lamp between the two filaments. Because of the preliminary ionization of the gas in the lamp obtained by preheating, an arc discharge takes place in the gas between the two filaments. After the discharge has been started, current flow from the power supply enables the discharge to maintain itself. If it is desirable to provide some heating current through the lamp filaments after the lamp has started, a resistance may be connected between the filaments in shunt with the starting switch. The ionized gas within the envelope excites the fluorescent material to produce illumination.

Complete ionization of the gas within the lamp creates a negative resistance to current flow through the lamp. This negative resistance must be offset by a "ballast" arrangement in order to limit the flow of current. The transistor **15** is biased by its associated biasing network so as to provide the necessary impedance to current flow through the lamp. The voltage divider consisting of the two base resistances **20** and **21** connected in shunt with the battery together with the emitter resistance **19** establishes a fixed bias on the transistor which causes it to operate at substantially constant collector current. The components for the transistor biasing network are chosen so as to provide the desired current flow through the lamp.

The apparatus according to the invention as shown in FIG. 2 includes a fluorescent lamp **30** of the type employed in the apparatus of FIG. 1 having two electron emitting filaments **31** and **32**. In order to illustrate that apparatus according to the invention may utilize either PNP or NPN transistors, an NPN transistor **33** is shown in FIG. 2 with appropriate connections to the D.C. power supply in order to provide proper polarities for operation. One terminal of the first lamp filament **31** is connected directly to the collector of the NPN transistor. One terminal of the second filament **32** is connected through a main switch **34** to the positive terminal of a battery **35**. The negative terminal of the battery is grounded. A first base resistance **36** is connected from the base of the transistor to ground, and a second base resistance **37** is connected between the base of the transistor and the first terminal of the second filament. An emitter resistance **38** is connected from the emitter of the transistor to ground.

The apparatus of FIG. 2 employs a starting arrangement which has both the preheating circuit and the discharge initiating inductance connected between the second terminals of the two filaments in shunt with the lamp. The primary winding 39 of a transformer is connected between the second terminals of the filaments in series with a starting switch 40, a normally-open push-button switch being shown in the figure. The secondary winding 41 of the transformer is also connected between the two filaments in shunt with the primary winding and the switch.

With the main switch 34 closed, the starting arrangement functions in the following manner. The starting switch 40 is closed to provide a temporary current path through the filaments, the primary winding 39 of the transformer, and the transistor 33, which is biased to conduction. After the filaments have been preheated sufficiently, the starting switch 40 is reopened, thus interrupting current flow through the primary winding and inducing a high voltage in the secondary winding 41. Since this voltage is applied across the preheated filaments of the lamp, a discharge arc takes place through the lamp and the lamp lights. In the event that the particular transformer and lamp employed might be such as to cause the current due to the high voltage across the secondary winding to flow through the transistor circuit rather than through the lamp, a blocking diode may be placed in the connection between the collector and the first filament. The diode is connected so as to permit normal collector current flow through the transistor, and the terminals of the secondary winding are connected so that the induced high voltage is negative at the first filament and positive at the second. The diode thus blocks current flow due to the voltage on the secondary winding from flowing through the transistor.

In a manner analogous to that employed in the apparatus of FIG. 1, the NPN transistor 33 is biased by the biasing network of the three resistances to operate at constant collector current and thus offset the negative resistance characteristic of the lamp. In the apparatus shown in FIG. 2, leakage current will flow through the secondary winding 41 of the transformer while the lamp is lighted. If the resistance of the winding is high, losses are negligible. However, if the losses are not considered to be negligible, a suitable manual or automatic switching arrangement may be used to disconnect the secondary winding after the lamp has fired. Alternatively, a diode may be placed in series with the secondary winding so as to provide a high impedance to current flow through the winding during operation of the lighted lamp without affecting the starting of the lamp.

The apparatus of FIG. 3 is generally similar to that of FIG. 1 but includes a modification in the transistor biasing network for stabilizing current flow and a modification in the filament preheating circuit for obtaining preheating current in excess of operating current through the lighted lamp. The fluorescent lamp 50 is of the same type as those shown in FIGS. 1 and 2, and has a first filament 51 and a second filament 52 at opposite ends of the glass envelope. One terminal 53 of the first filament is connected to the collector of a PNP transistor 54. One terminal 55 of the second filament 52 is connected through an inductive choke 56 and a main switch 57 to the negative terminal of a battery 58. The positive terminal of the battery is grounded. The emitter of the transistor is connected through an emitter resistance 59 to ground. The base of the transistor is connected to ground through a diode 61, and is also connected through a second base resistance 62 to the connection between the choke 56 and the main switch 57. A starting switch arrangement 63, shown as a normally-open push button switch, is connected between the second terminals 64 and 65 of the first and second filaments, respectively. A preheating resistance 66 is connected between the second terminal 64 of the first filament 51 and the base of the transistor.

With the main switch 57 closed, the lamp is fired as in the apparatus of FIG. 1 by temporarily closing the starting switch 63. Current flows through the filaments in series bypassing the high impedance of the unfired lamp and thus preheating the filaments. Because of the voltage drop across the preheating resistance 66, the voltage drop across the first filament 51 is greater than it would otherwise be. The bias on the transistor is thus greater causing additional collector current to flow through the transistor and also through the filaments. After the starting switch 63 is reopened and the arc discharge takes place within the lamp, the preheating resistance has no effect and the current flow through the transistor and the lamp is reduced by the amount of the additional collector current.

If the characteristics of the lamp are such that less current is desired for preheating than for operation of the lighted lamp, a resistance may be connected between the second terminal 64 of the first filament and the emitter rather than betwen the second terminal and the base. With this arrangement, the increased voltage across the first filament reduces the bias on the transistor, thus reducing the collector current through the transistor and the filaments.

The use of a diode 61 as the biasing resistance between the base of the transistor and ground illustrates an alternative technique for biasing the transistor. With this arrangement, the effects of fluctuations in the battery voltage are reduced so as to maintain the light output of the lamp more nearly constant. The diode provides nonlinear resistance between the base of the transistor and ground. Therefore, as the battery voltage changes, the value of the resistance of the diode also changes thus altering the bias on the transistor. The change in transistor bias tends to offset the change in the collector voltage so as to maintain the collector current more nearly constant.

As an example of a typical embodiment of apparatus according to the invention, a Sylvania type 1-F4T5/W fluorescent lamp 10 having low voltage firing characteristics was employed in apparatus of the type shown in FIG. 1. This lamp had a sustaining voltage of 31 volts at 120 milliamperes. The transistor 15 was a Sylvania type 2N242 PNP power transistor. An iron core choke of 320 millihenries was employed as the discharge initiating inductance 16. Resistance of 82 ohms, 2700 ohms, and 10 ohms were used for the first base resistance 20, the second base resistance 21, and the emitter resistance 19, respectively, of the biasing network. A D.C. power supply 18 of 45 volts operated the apparatus. The current through the lamp was approximately 120 milliamperes and a light output of normal brilliance was produced.

What is claimed is:

1. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting a gaseous discharge lamp in series with said transistor, means for applying a D.C. supply voltage across the lamp and transistor, and biasing means for biasing said transistor to obtain substantially constant current through the transistor and the lamp.

2. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting a gaseous discharge lamp in series with said transistor, means for applying a D.C. supply voltage across the lamp and transistor, biasing means for biasing said transistor for operation at substantially constant collector current, and starting means for providing a high voltage across said lamp to initiate discharge therethrough.

3. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting a first filament of a gaseous discharge lamp to the collector of the transistor, means for connecting a D.C. power supply in series with the transistor and the

lamp, resistance biasing means connected to the base and the emitter of the transistor for biasing the base with respect to the emitter for operation of the transistor a substantially constant collector current, and starting means for providing a high voltage across said lamp to initiate discharge therethrough.

4. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting a first filament of a gaseous discharge lamp to the collector of the transistor, a D.C. power supply, circuit means for connecting the D.C. power supply to a second filament of the gaseous discharge lamp, a resistance network connected to the emitter and the base of the transistor and having a portion thereof in shunt with the power supply for biasing the transistor for operation at substantially constant collector current, preheating means for providing a temporary conduction path from the D.C. power supply through the filaments in shunt with the lamp to cause current flow through the filaments in series, and arc discharge initiating means for providing a high voltage across the lamp to initiate discharge therethrough in response to the opening of said temporary conduction path.

5. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting a first filament of a gaseous discharge lamp to the collector of the transistor, a D.C. power supply, circuit means for connecting the D.C. power supply to a second filament of the gaseous discharge lamp, a resistance voltage divider connected in shunt with the power supply, a connection between the base of the transistor and a point along the voltage divider, a resistance connected between one end of the voltage divider and the emitter of the transistor, said voltage divider and said resistance being adapted to bias the transistor for operation at substantially constant collector current, normally-open switching means adapted to be closed to provide a temporary conduction path through the filaments in shunt with the lamp for causing current flow through the filaments in series to preheat the filaments, and inductive means for providing a high voltage pulse across the lamp to initiate discharge therethrough between the filaments in response to the opening of said switching means and consequent cessation of current flow through said conduction path.

6. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting one terminal of a first filament of a gaseous discharge lamp directly to the collector of the transistor, a D.C. power supply, an inductance, circuit means for connecting the inductance between one terminal of a second filament of the gaseous discharge lamp and the D.C. power supply, a resistance voltage divider connected in shunt with the power supply, the base of the transistor being connected to a point along the voltage divider, a resistance connected between one end of the voltage divider and the emitter of the transistor, said voltage divider and said resistance being adapted to bias the transistor for operation at substantially constant collector current, and a normally-open switching means connected between another terminal of the first filament and another terminal of the second filament in shunt with the lamp and adapted to be closed to provide a temporary conduction path through the filaments for causing current flow through the filaments in series to preheat the filaments and through the inductance, opening of said switching means after preheating of said filaments inducing a high voltage in said inductance whereby arc discharge is initiated through the lamp.

7. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting one terminal of a first filament of a gaseous discharge lamp to the collector of the transistor, a D C. power supply, circuit means for connecting one terminal of a second filament of the gaseous discharge lamp to the

D.C. power supply, a resistance voltage divider connected in shunt with the power supply, the base of the transistor being connected to a point along the voltage divider, a resistance connected between one end of the voltage divider and the emitter of the transistor, said voltage divider and said resistance being adapted to bias the transistor for operation at substantially constant collector current, a transformer having a primary winding and a secondary winding, the secondary winding being connected between another terminal of the first filament and another terminal of the second filament in shunt with the lamp, one end of the primary winding of the transformer being connected to the other terminal of one of said filaments, and a normally-open switching means connected between the other end of the primary winding and the other terminal of the other of said filaments and adapted to be closed to provide a temporary conduction path through the filaments and the primary winding of the transformer for causing current flow through the filaments in series to preheat the filaments, opening of said switching means after preheating of said filaments stopping current flow through the primary winding and inducing a voltage thereacross thus inducing a high voltage across said secondary winding whereby an arc discharge is initiated through the lamp between the preheated filaments.

8. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting one terminal of a first filament of a gaseous discharge lamp to the collector of the transistor, a D.C. power supply, circuit means for connecting the D.C. power supply to one terminal of a second filament of the gaseous discharge lamp, a resistance voltage divider connected in shunt with the power supply, the base of the transistor being connected to a point along the voltage divider, a resistance connected between one end of the voltage divider and the emitter of the transistor, said voltage divider and said resistance providing an emitter-base biasing network adapted to bias the transistor for operation at substantially constant collector current, normally-open switching means connected between another terminal of the first filament and another terminal of the second filament and adapted to be closed to provide a temporary conduction path through the filaments in shunt with the lamp for causing current flow through the filaments in series to preheat the filaments, a resistance connected between the other terminal of the first filament and the emitter-base biasing network for altering the bias on the transistor and consequently the collector current while said normally-open switching means is closed, and inductance means for providing a high voltage pulse across the lamp to initiate discharge therethrough between the filaments in response to the opening of said switching means and consequent cessation of the current flow through said conduction path.

9. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting a first filament of a gaseous discharge lamp to the collector of the transistor, a D.C. power supply, circuit means for connecting the D.C. power supply to a second filament of the gaseous discharge lamp, a resistance voltage divider including a nonlinear resistance device, said voltage divider being connected in shunt with the power supply, the base of the transistor being connected to a point along the voltage divider, a resistance connected between one end of the voltage divider and the emitter of the transistor, said voltage divider and said resistance being adapted to bias the transistor for operation at substantially constant collector current, said nonlinear resistance device being adapted to maintain the bias on the transistor despite changes in the voltage of the power supply in order to stabilize the collector current, normally-open switching means adapted to be closed to provide a temporary conduction path through the filaments in shunt with the lamp for causing

current flow through the filaments in series to preheat the filaments, and inductance means for providing a high voltage pulse across the lamp to initiate discharge therethrough between the filaments in response to the opening of said switching means and consequent cessation of current flow through said conduction path.

10. Apparatus for operating a gaseous discharge lamp including in combination a transistor, circuit means for connecting one terminal of a first filament of a gaseous discharge lamp directly to the collector of the transistor, a D.C. power supply, an inductance, circuit means for connecting the inductance between one terminal of a second filament of the gaseous discharge lamp and the D.C. power supply, a resistance voltage divider connected in shunt with the power supply, said voltage divider including a resistance connected between one terminal of the D.C. power supply and the base of the transistor and a nonlinear resistance device connected between the base of the transistor and the other terminal of the power supply, an emitter resistance connected between the emitter of the transistor and the other terminal of the power supply, said voltage divider and said emitter resistance being adapted to bias the transistor for operation at substantially constant collector current, said nonlinear resistance device being adapted to maintain the bias on the transistor despite changes in the voltage of the power supply in order to stabilize the collector current, normally-open switching means connected between another terminal of the first filament and another terminal of the second filament and adapted to be closed to provide a temporary conduction path through the filaments in shunt with the lamp for causing current flow through the filaments in series to preheat the filaments and through the inductance, and a resistance connected between the other terminal of the first filament and the base of the transistor for increasing the bias on the transistor and consequently the collector current while said normally-open switching means is closed, opening of said switching means after preheating of said filaments stopping the flow of current through said inductance and inducing a high voltage in said inductance whereby an arc discharge is initiated between the filaments in the lamp.

11. Apparatus for operating a gaseous discharge lamp including in combination a PNP transistor, circuit means for connecting one terminal of a first filament of a gaseous discharge fluorescent lamp directly to the collector of the transistor, a D.C. power supply, an inductive choke coil, circuit means for connecting the inductive choke coil between one terminal of a second filament of the gaseous discharge fluorescent lamp and the negative terminal of the power supply, a resistance voltage divider consisting of two resistances connected in shunt with the power supply, the base of the transistor being connected to the connection between the two resistances, an emitter resistance connected between the emitter of the transistor and the positive terminal of the power supply, said voltage divider and said emitter resistance being adapted to bias the transistor for operation at substantially constant collector current, and a normally-open switching means connected directly between another terminal of the first filament and another terminal of the second filament in shunt with the lamp and adapted to be closed to provide a temporary conduction path through the filaments for causing current flow through the filaments in series to preheat the filaments and through the inductive choke coil, opening of said switching means after preheating of said filaments stopping the flow of current through the inductive choke coil and inducing a high voltage in said coil whereby arc discharge is initiated through the lamp.

References Cited in the file of this patent

FOREIGN PATENTS

793,582 Great Britain ---------- Apr. 16, 1958