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GASEOUS GLOW TUBE CIRCUITS

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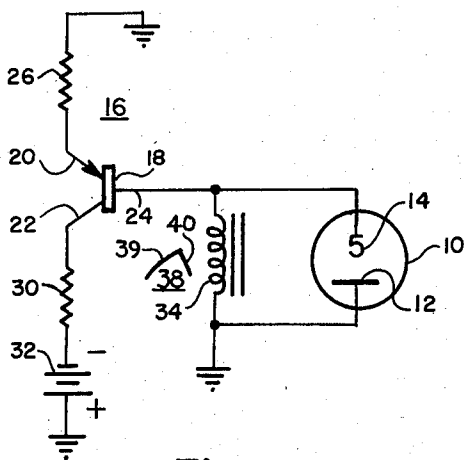


Fig. 1

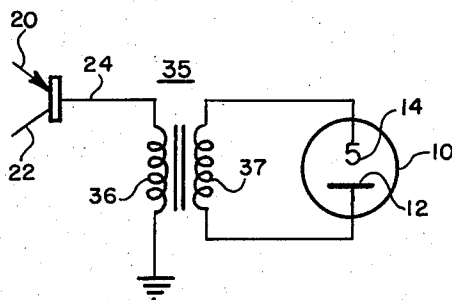


Fig. 2

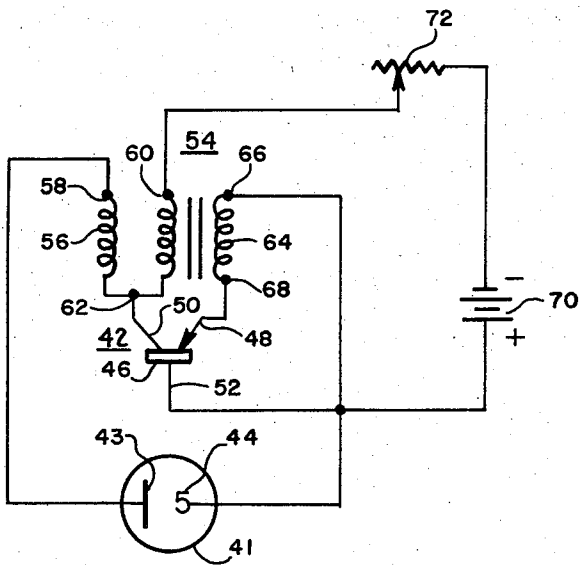


Fig. 3

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GASEOUS GLOW TUBE CIRCUITS

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This invention relates to gaseous glow tubes and particularly to improved circuits for operating the same.

One type of gaseous glow tube includes a gas-filled envelope which contains a stack of cathode indicator elements, for example, numbers, letters, or the like, which are adapted to glow individually when the proper operating voltage is applied between them and an anode electrode. Such a tube is also known as a cathode glow tube. Ordinarily, such a tube requires a comparatively high D.C. operating voltage, for example, about 170 volts, to cause a cathode to glow. However, there are many circuits, in which such tubes might be used, in which considerably lower voltages are available and it would be desirable to be able to operate such glow tubes with such lower voltages.

Accordingly, one object of the invention is to provide an improved circuit for operating a gaseous glow tube.

Another object of the invention is to provide an improved circuit for operating a normally high voltage cathode glow tube with a low voltage power source.

Still another object of the invention is to provide a circuit for transforming low voltage D.C. to high voltage D.C. and obtaining the high voltage D.C. directly from a transformer.

In brief, a circuit according to the invention, for use with a gaseous glow tube including an anode and at least one glow cathode, includes means for generating a series of pulses of high voltage from a low voltage power source and applying the high voltage pulses across the glow tube so that only the cathode is caused to glow. This voltage generating means comprises essentially a blocking oscillator and includes an electron discharge device which is powered by a low voltage direct current source and which is adapted to produce a series of generally asymmetrical (for example, sawtooth) output current waves, each wave comprising one portion having a slow rate of change and another portion having a rapid rate of change.

An inductive device is connected between the discharge device and the glow tube, and the asymmetrical current waves are applied thereto. In response to the slowly changing portion of each current wave, the inductive device generates a low voltage pulse of one polarity. In response to the rapidly changing portion of each current wave, the inductive device generates a high voltage pulse of opposite polarity. The high voltage pulse is applied across the glow tube in such polarity that the cathode is negative with respect to the anode. This voltage pulse is of sufficient magnitude to exceed the cathode glow threshold potential and it thereby causes the cathode electrode to glow. The low voltage pulse is applied across the glow tube in reverse polarity so that the anode is negative with respect to the cathode. However, the low voltage pulse is of insufficient magnitude to exceed the anode glow threshold and the anode does not glow. If the current waves and the resultant high voltage pulses are of sufficiently high frequency, the cathode glow appears to be continuous.

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The invention is described in greater detail by reference to the single sheet of drawings wherein:

Fig. 1 is a schematic representation of a circuit embodying the invention;

Fig. 2 is a schematic representation of a modification of the circuit of Fig. 1; and

Fig. 3 is a schematic representation of a modified circuit embodying the invention.

An oscillator circuit embodying the invention is shown in Fig. 1 and includes a gaseous glow tube 10 comprising a gas-filled envelope containing an anode electrode 12 and at least one cathode electrode 14 which may be in the form of a letter, numeral, or the like. The tube 10 may be, for example, a type 6844 indicator tube in which the cathodes have an operating glow threshold voltage of about 170 volts. Power for operating the glow tube 10 is derived from an oscillator circuit which includes a transistor 16 of a type which provides alpha gain, such as a point contact transistor. The transistor includes a body 18 of semiconductor material (e.g. of N-type conductivity), an emitter electrode 20, a collector electrode 22, and a base electrode 24.

The electrodes of the transistor are biased in conventional fashion, the emitter electrode 20 being biased in the forward direction with respect to the base 24 and the collector 22 being biased in the reverse direction with respect to the base. To obtain the proper bias voltages for a transistor having a body of N-type conductivity, the emitter electrode 20 is connected through a suitable bias resistor 26 to a source of reference potential such as ground. The collector electrode 22 is connected through a current limiting resistor 30, if necessary, to the negative terminal of a suitable power source such as a battery 32, the positive terminal of which is grounded. The base electrode 24 of the transistor 16 is connected to the cathode 14 of the glow tube 10, and the anode 12 of the glow tube is connected to ground. An inductor 34, which may be a single coil of wire, is connected across the glow tube between the cathode and the anode thereof and between the base electrode 24 of the transistor and ground. If it is desired to operate the oscillator circuit at comparatively low frequencies, the inductor 34 is wound on a magnetic core.

In a modified circuit shown in Fig. 2, a step-up transformer 35 is provided in place of the single coil inductor 34 of Fig. 1 in order to obtain higher output voltages. The transformer 35 includes a primary winding 36 connected between the base electrode 24 of the transistor 16 and ground and a secondary winding 37 connected between the anode 12 and cathode 14 of the glow tube 10. The proper winding ratio is used to keep the transistor back voltage within safe limits. The secondary winding 37 of the transformer is used to isolate electrically the indicator tube circuit from the transistor circuit. If this is not necessary, an autotransformer configuration may be used to obtain voltage amplification with fewer transformer turns. Such a configuration is shown in Fig. 3 and is described below.

The oscillator of Fig. 1 is essentially a blocking oscillator which generates a series of asymmetrical waves of current 38, for example sawtooth waves, which pass through the inductor 34. Each sawtooth wave 38 includes a portion 39 (for example, the rising portion) having a slow exponentially decreasing rate of change and a portion 40 (the decaying portion) having a rapid rate of change. The magnitude of the voltage developed across the inductor 34 by the current flow therethrough is a function of its inductance and the combined inductor resistance and the resistance of the inductor discharge path through the emitter in the reverse direction to ground.

In operation of the circuit of Fig. 1, when the circuit

is energized, current begins to flow between the base and collector electrodes 24 and 22, respectively, of the transistor 16. This current increases substantially exponentially, and, preferably, the circuit parameters are designed so that the current increases slowly. As the current increases slowly through the inductor 34, a relatively low voltage is generated thereacross, the magnitude of which is proportional to the rate of change of the current. The voltage generated across the inductor drives the base electrode 24 negative and the transistor current increases to a maximum value. This generated voltage is of such polarity that the anode 12 of the glow tube 10 is negative with respect to the cathode 14 thereof. If this voltage were sufficiently high, the anode would glow, and anode glow, ordinarily, is undesirable. However, since the rate of change of current is low, the generated voltage does not cause the anode to glow.

As the exponentially rising portion 39 of the current wave 38 approaches its peak, the rate of change of current decreases, and, finally, a point is reached at which insufficient voltage is generated across the inductor 34 to keep the transistor in its high conducting state. The current flow is then reversed and decreases rapidly, as represented by the negative portion 40 of the sawtooth wave. This action is accompanied by a rapid collapse of the magnetic field around the inductor and by the generation across the inductor of a voltage pulse of large magnitude. This pulse also appears across the glow tube in such polarity that the cathode is negative with respect to the anode, and glows. As the inductor is thus discharged, the base voltage again becomes negative and the emitter becomes positive and is biased in the forward direction. The transistor begins to pass current again and the cycle is repeated. The cathode of the glow tube is caused to glow on each rapidly changing portion 40 of each current sawtooth wave 38, and if the wave frequency is sufficiently high, a cathode would appear to have a steady glow.

The circuit of Fig. 1 has been employed to produce, from a low voltage supply source of a few volts, high voltage pulses sufficient to cause the cathodes of a type 6844 indicator tube to glow. The circuit produced pulses of about 200 volts with an inductor having an inductance of about 5.4 millihenrys and a D.C. resistance in the range of 100 to 1500 ohms.

Referring to Fig. 3, the circuit modification shown therein includes a gaseous glow tube 41 and a transistor 42. The glow tube includes an anode 43 and at least one cathode glow indicator electrode 44. The transistor 42 is a P-N-P junction type transistor and comprises a body 46 of semiconductor material, an emitter junction electrode 48, a collector junction electrode 50, and a base electrode 52. A transformer 54 is provided including a first autotransformer coil 56 having terminals 58 and 60 and a center tap 62 and a second coil 64 having terminals 66 and 68. The coils are wound on a suitable magnetic core, for example, a ceramic cup core (not shown). The transistor 42 is connected in the circuit as follows. The emitter electrode 48 is connected through the coil 64 to the base electrode 52 and to the positive terminal of a power source such as a battery 70. The collector electrode 50 is connected to the center tap 62 of the coil 56 and the terminal 60 is coupled through a variable current limiting resistor 72 to the negative terminal of the battery 70. The resistor 72 is preferably a variable resistor so that the current flow in the glow tube and the resulting brightness of the cathode glow can be adjusted. The terminal 58 of the coil 56 is connected to the anode 43 of the glow tube 41, and the base electrode 52 of the transistor is connected to the terminal 66 of the coil 64.

In operation of the circuit of Fig. 3, when the circuit is energized and the normal supply voltages are applied, the transistor 42 begins to conduct and current flows through the collector-to-base circuit and through the

coil 56. The magnetic flux generated by this current in the magnetic core of the transformer 54 is coupled to the coil 64, and current flow is induced in the circuit of the emitter 48. The mutual coupling of the two coils 56 and 64 is regenerative and the transistor current flow increases comparatively slowly to a maximum value at which the transistor is cut off. A comparatively rapid cutoff effect at maximum current can be achieved if the magnetic core of the transformer 54 is permitted to saturate.

As described above with respect to Fig. 1, this buildup of current generates a voltage across the coil 56 which biases the anode 43 negative with respect to the cathode 44. However, this voltage is of insufficient magnitude to cause the anode to glow. When saturation current has been reached, the magnetic flux stops changing and the transistor rapidly stops conducting. When this happens, the magnetic field in the transformer collapses very quickly and produces a rapid current change, and a sharp voltage pulse of high magnitude is obtained across the coil 56. This voltage appears across the glow tube in such polarity that the cathode is negative with respect to the anode and the magnitude of the voltage pulse is sufficient to cause the cathode to glow.

Typical values of the components of the circuit of Fig. 3 for exciting a type 6844 cathode glow tube are as follows:

Transistor: P-N-P junction type GT34N.

Winding 56: 300 turns, 200 between terminals 58 and 62.

Winding 64: 20 to 40 turns.

Battery 70: 4.5 volts.

With the circuit connections as shown in Fig. 3, the battery 70 adds a direct current bias to the glow tube so that the battery potential and the potential of both sections of coil 56 operate in series to provide the voltage for igniting the glow tube. This reduces to a minimum the number of turns of wire required in the transformer 54 for attaining the required cathode glow potentials.

The circuits of the invention described herein provide high voltages at low operating pulse repetition rates with a minimum number of circuit elements. Separate resistors may be eliminated by the inclusion of the desired resistance in the transformer (without overload windings because of low current requirements), and capacitors may be omitted since their effect on time constant may be compensated for by the resistance of the transistor current flow paths. In addition, since the circuit may be operated at comparatively low frequencies, problems due to radio frequency radiation are reduced. Moreover, the circuits of the invention provide direct current directly from a transformer without the need for rectifying devices. Thus, a simplified and improved direct current-to-direct current voltage step-up system is provided.

What is claimed is:

1. An electrical circuit including a gaseous indicator tube having a cathode electrode in the form of an indicator character adapted to glow and be viewed and an anode electrode which does not glow, circuit means for generating a generally sawtooth wave of current having a slowly rising portion and a rapidly decaying portion, inductive means coupled between said circuit means and said tube for generating a comparatively high voltage pulse from the rapidly decaying portion of said wave and a comparatively low voltage pulse from the slowly rising portion, the high voltage pulse exceeding the glow threshold potential of said cathode and the low voltage pulse being insufficient to exceed the glow threshold of said anode, and means for applying said pulses to said tube so that the cathode is pulsed negative with respect to the anode by said high voltage pulse and the cathode is thereby caused to glow.

2. An electrical circuit including a gaseous indicator tube containing an anode electrode which does not glow and a cathode electrode in the form of an indicator

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character adapted to glow and be viewed when a voltage is applied between it and said anode; a P-N junction transistor having emitter, collector, and base electrodes; an inductor comprising first and second magnetically coupled coils; said first coil being connected between said emitter electrode of said transistor and both said cathode of said tube and said base electrode; said second coil being connected between said base electrode and said anode of said tube; a supply potential coupled in the base-collector circuit of the transistor; and a connection between said collector electrode and an intermediate tap on said second coil.

3. An electrical circuit including a gaseous indicator tube containing an anode electrode which does not glow and a cathode electrode in the form of an indicator character adapted to glow and be viewed when a voltage is applied between it and said anode; a transistor having emitter, collector, and base electrodes; said base electrode being connected to the cathode of said tube; the anode of said tube being connected to a source of reference potential; and an inductor connected across said tube and between said base electrode of said transistor and said source of reference potential.

4. An electrical circuit including a gaseous indicator tube containing an anode electrode which does not glow and a cathode electrode in the form of an indicator character adapted to glow and be viewed when a voltage is applied between it and said anode; an alpha gain transistor having emitter, collector, and base electrodes; said base electrode being connected to the cathode of said tube; the anode of said tube being connected to a source of reference potential; and an inductor connected across said tube and between said base electrode of said transistor and said source of reference potential.

5. An electrical circuit including a gaseous indicator tube containing an anode electrode which does not glow and a cathode electrode in the form of an indicator character adapted to glow and be viewed when a voltage is applied between it and said anode; a point contact transistor having emitter, collector, and base electrodes; said base electrode being connected to the cathode of said tube; the anode of said tube being connected to a source of reference potential; and an inductor connected across

said tube and between said base electrode of said transistor and said source of reference potential.

6. An electrical circuit including a gaseous indicator tube having a cathode electrode in the form of an indicator character adapted to glow and be viewed when a threshold potential is exceeded and an anode electrode which does not glow, an inductor connected between the anode and cathode electrodes, and means coupled to the inductor generating a sawtooth current waveform in such direction that high voltage pulses exceed the threshold potential of the cathode electrode.

7. Means for generating direct-current directly at the winding of an inductor comprising in combination, periodic means generating a current wave through said inductor, said wave having two distinctly different rates of change, and a threshold device coupled to said winding responsive to potentials generated only during one of the rates of change of current.

8. A direct current to direct current voltage step-up system comprising in combination, a current waveform generator operable at low voltage and supplying a periodic current waveform having portions with at least two different rates of change, reactive means coupled to receive the current waveforms and responsive to the portion of the current waveform having the greatest rate of change to generate a voltage of greater magnitude than said low voltage, and utilization means responsive to the greater magnitude voltage coupled to said reactive means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,136,924	Reitherman	Nov. 15, 1938
2,447,304	Atkins	Aug. 17, 1948
2,448,169	Browner	Nov. 15, 1949
2,505,667	Futterman	Apr. 25, 1950
2,681,996	Wallace	June 22, 1954
2,701,309	Barney	Feb. 1, 1955
2,745,012	Felker	May 8, 1956
2,756,366	Maynard	July 24, 1956
2,757,243	Thomas	July 31, 1956
2,769,939	Williams	Nov. 6, 1956
2,780,767	Janssen	Feb. 5, 1957