

[54] FLASH TUBE HAVING IMPROVED CATHODE

3,753,028 8/1973 Renaud 313/346 R

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[57] ABSTRACT

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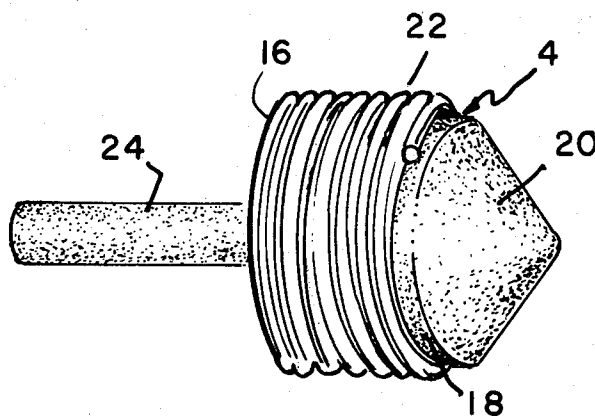
An injection-triggered xenon flash tube having an elongated glass envelope with anode and cathode electrodes sealed in the ends thereof. The cathode comprises a pressed and sintered pellet of powdered tantalum and barium aluminate with a 100 percent pitched tungsten coil wound about the cylindrical sidewall of the pellet.

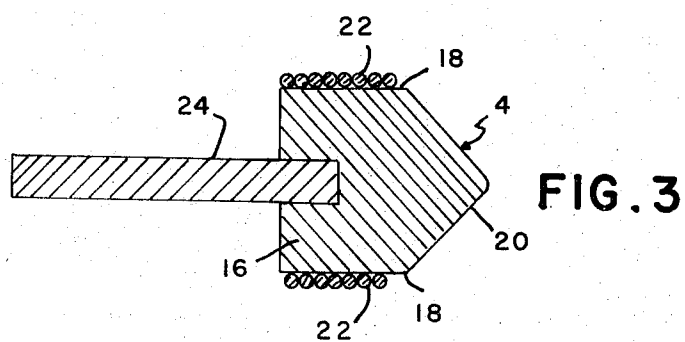
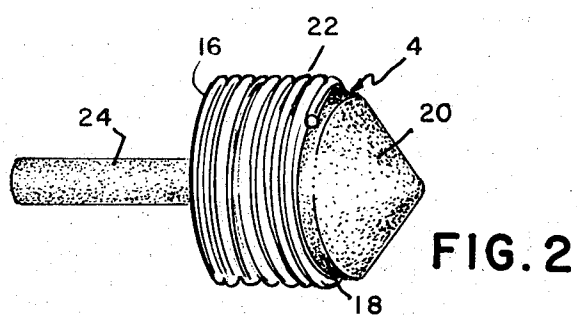
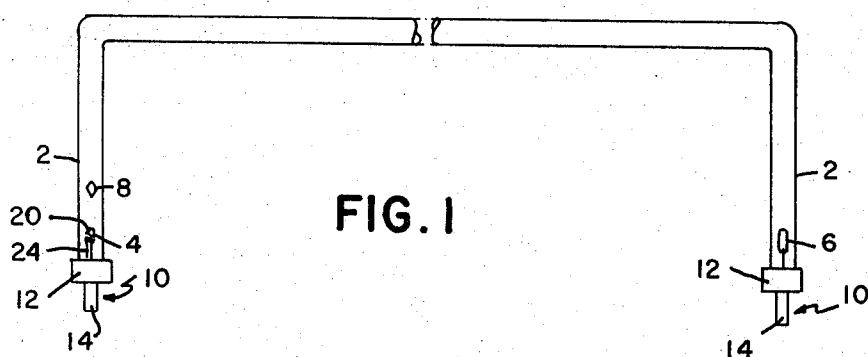
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8 Claims, 3 Drawing Figures





FLASH TUBE HAVING IMPROVED CATHODE

BACKGROUND OF THE INVENTION

This invention relates generally to electric discharge lamps and, more particularly, to a long life cathode structure for an injection-triggered flash tube.

Flash tubes generally comprise two spaced apart electrodes within a sealed glass envelope having a rare gas fill, typically xenon, at a sub-atmospheric pressure. Such lamps are connected across a large capacitor charged to a substantial potential, which is, however, insufficient to ionize the xenon fill gas. Upon application of an additional pulse of sufficient voltage, the xenon is ionized, and an electric arc is formed between the two electrodes, discharging the large capacitor through the flash tube, which emits a burst of intense light, usually of short duration. In some cases the pulse voltage is applied between an external trigger wire wrapped around the envelope and the electrodes. However, in other cases an external wire is not feasible since it may result in undesirable arcing between the trigger wire and a proximate lamp reflector or else the high potential applied to the external trigger wire might be hazardous to operating personnel.

In those cases, the lamp may be internally triggered by applying the pulse voltage directly across the lamp electrodes; this is also referred to as injection triggering. Usually the voltage required is about 30 to 50 percent higher than that required to trigger the same lamp with an external trigger wire. This poses no particular problem in itself, since the lamp operating circuit can be designed to supply sufficient pulse voltage to the lamp.

with respect to the efficiency and reliability of lamp operation, however, it is desirable to substantially reduce the trigger voltage required to strike an arc in an injection-trigger flash tube. For example, a lower trigger voltage will shift the starting characteristic curve (a plot of trigger voltage vs. anode, or supply, voltage) to a lower level and thereby enlarge the reliable operating region. This permits the fill gas pressure to be increased (which shifts the characteristic curve upward) and yet still retains reliable starting characteristics. An increased fill pressure results in a brighter light output during flashing and, provides improved light output maintenance, as higher gas pressures enhance conduction of heat from the electrodes to keep them cooler during operation. A higher fill pressure also reduces peak currents in the flash tube to thereby provide a longer operating life. Advantages of economy are also provided, as a reduction in the energy and peak voltage required to ignite the flash tube will mean less expensive regulating circuits in the power supply design.

One factor having a significant effect on starting voltage over the life of the lamp is the electrode design, and particularly the cathode construction. In the past, many designs for cathodes have been proposed to the art. One commonly used design, referred to as a "banner electrode," comprises one or more coils of tungsten wire wound on a lead-in conductor, with a coating of emissive material contained in the interstices of the coils. Another cathode design which is very commonly used in flash tubes comprises a pressed and sintered pellet, having somewhat the shape of a bullet, with the emissive materials homogeneously mixed with a powdered refractory metal.

The "banner electrode" provides better cooling during operation since, due to greater surface area, it radiates heat more efficiently in addition to increased dissipation of heat by conduction through the lead-in conductor and the gas fill. Since the emissive materials are in relatively thin layers at the surface, however, those active materials are more subject to depletion over the life of the lamp. And with significant depletion of the emissive materials, the required trigger voltage increases, and the useful life of the flash tube is shortened.

On the other hand, a properly activated sintered pellet can generally provide a higher degree of reliability by maintaining the initial low starting level over the life of the flash tube, due to the fact that the emissive materials are mixed within the body and not just a surface coating. Under certain high current density conditions, however, a temporary depletion of the emissive materials on the outer surface layers may occur, with resulting higher trigger levels and shortened lamp life.

SUMMARY OF THE INVENTION

Accordingly it is an object of the present invention to provide an improved electric discharge lamp wherein an electrode is employed which will remain a stable electron emitter over the life of the lamp even under high current density conditions.

It is a particular object to provide an injection-triggered flash tube having a cathode design which assures that a low starting, or trigger, voltage is maintained over a much longer useful lamp life.

Briefly, these objects are attained by employing a cathode electrode comprising a pressed and sintered pellet containing an electron emitting material, preferably an alkaline earth compound, and a 100 percent pitched coil of a refractory metal wire, such as tungsten, wound about the cylindrical sidewall of the pellet. The pellet-coil assembly is axially aligned with the arc discharge path and the significant portion of the arc discharge emission occurs at the inner end of the pellet. The 100 percent pitched tungsten coil covers nearly the entire side wall of the pellet and thereby provides a relatively impermeable barrier for preventing evaporation of emissive material from the sidewall of the pellet. In addition, the large surface area provided by the coil promotes more efficient heat radiation and thereby reduces the temperature of the cathode, which in turn reduces sputtering off of emissive materials. Accordingly, efficient cathode emission and the low trigger voltages associated with alkaline earth metal activators are preserved for a significantly longer period of time to provide improved efficiency, reliability and light output, and extended lamp life.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention will be more fully described hereinafter, in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates an injection-triggered flash tube employing a cathode electrode in accordance with the invention;

FIG. 2 is an enlarged perspective view of the cathode employed in the flash tube of FIG. 1; and

FIG. 3 is a side elevation in section of the cathode shown in FIG. 2.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to FIG. 1, the flash tube comprises an hermetically sealed, light-transmitting envelope 2 formed of an elongated piece of hard glass tubing (e.g., Corning Number 7740 glass) and having a cathode electrode 4 sealed within one end of the envelope and an anode electrode 6 sealed within the other end. The envelope is filled with a rare gas, such as xenon, at a sub-atmospheric pressure (e.g., 35 Torr) and is constricted to define an exhaust tip 8. At each end of the envelope is secured an end cap 10 comprising a shoulder portion 12 and a metal terminal portion 14 which is electrically connected to the electrode at that end of the lamp. During operation, application of a trigger voltage pulse across the lamp terminals causes an arc discharge to occur between electrodes 4 and 6 along a path defined by the shape of envelope 2.

A preferred embodiment of the cathode electrode 4 according to the invention is shown in FIGS. 2 and 3. The cathode comprises a pressed and sintered pellet 16 having a substantially cylindrical sidewall 18 and a tapered end 20 which points toward the inside of the flash tube. In composition, the pellet comprises a substantially homogeneous mixture of a powdered refractory metal, such as tantalum or tungsten, and an electron-emitting material, preferably an alkaline earth compound such as barium aluminate or a triple carbonate, which when properly activated typically requires a lower starting voltage than materials such as thorium or zirconia. In order to reduce the temperature of the cathode during operation and prevent evaporation of emissive material from the cylindrical sidewall of the sintered pellet, a 100 percent pitched coil 22 of refractory metal wire, such as tungsten, is securely wound about substantially the entire cylindrical sidewall 18 of pellet 16. The tightly wound coil 22 is particularly suitable for high speed assembly processes and, thus, economically provides a relatively impermeable barrier to side evaporation of emissive materials, which thereupon preserves the more favorable emission characteristics and useful lamp life for an extended period of time.

A refractory metal rod 24, generally formed of molybdenum or tungsten, is axially disposed within the cathode pellet 16 at the rear end thereof. Pellet 16 may be pressure formed around the rod 24, or the pressed and sintered pellet may initially contain an axial bore within which the rod 24 is inserted and secured by a heat shrink process. Either the rod 24 or a tungsten lead-in wire extension thereof is sealed through the end of the glass envelope 2 and electrically connected to terminal 14. In this manner, the wire-wound, cylindrical pellet is axially aligned with the tubular envelope 2 and, thus, the arc discharge path. Consequently, the tapered end 20 of the pellet serves as one terminal of the arc discharge path, and with the refractory metal coil 22 tightly wound about the pellet sidewall, substantially all of the electron emission occurs at this tapered end of the cathode. End 20 of the cathode pellet may be spherical or formed in a more conical-like shape.

According to one specific implementation of a flash tube according to the invention, the length of the horizontal portion of the tubular glass envelope in FIG. 1 is approximately 21 inches; the length of each of the two vertical sections of the envelope is about 7.5 inches; and the diameter of the envelope is about 0.390

inch. The anode electrode is a rolled tantalum type, and the cathode electrode comprises a pressed and sintered pellet 16 comprising a substantially homogeneous mixture of powdered tantalum and barium aluminate. Pellet 16 is mounted on a molybdenum rod 24 and has a 100 percent pitched coil 22 of 0.019 inch diameter tungsten wire securely wound about nearly the entire length of its cylindrical sidewall. The overall length of pellet 16 is about 0.375 inch, and the pellet diameter is about 0.165 inch.

Prior to sintering the cathode, the composition of pellet 16 consists essentially of about 89.5 percent by weight of tantalum, about 10 percent by weight of $\text{Ba}_3\text{Al}_2\text{O}_6$ and about 0.5 percent by weight of nickel. The proportion of tantalum may range from about 75 percent to 95 percent; the amount of $\text{Ba}_3\text{Al}_2\text{O}_6$ may range from about 5 percent to 25 percent; and the nickel may range from about 0 percent to 1 percent. The nickel functions to reduce the temperature required to shrink the pellet 16 on rod 24 to a level below that at which significant amounts of barium will be emitted from the pellet.

During the process of exhausting the lamp envelope, induction heat is applied to outgas the cathode and thereby activate the cathode pellet 16 so that the barium aluminate contained therein is converted to a nearly free barium state.

After exhaust, the lamp is filled with xenon at a pressure of about 35 Torr.

The operating voltage range is from 2,000 to 3,500 volts DC; this has also been referred to as the anode or supply voltage. The minimum peak trigger voltage in the injection mode is about 20,000 volts DC (open circuit). Upon testing a set of lamps of the type described above against a set of lamps having a similar construction except that the coil 22 is eliminated from the cathode, the lamps without the coil operated an average of 75 hours (one flash every 4 seconds) before becoming extremely difficult to start, apparently due to depletion of emissive material from the cathode, whereas the set of lamps having cathode structures according to the invention have operated satisfactorily for as long as 750 hours.

Although the invention has been described with respect to a specific embodiment, it will be appreciated that modifications and changes may be made by those skilled in the art without departing from the true spirit and scope of the invention. For example, it is contemplated that the described coil-pellet electrode can be employed in other electric discharge devices, such as mercury arc or sodium arc lamps, in addition to the "cold cathode" flash tube described herein.

What we claim is:

1. An electric discharge lamp comprising: an hermetically sealed, light transmitting envelope; a rare gas in said envelope; and a pair of electrodes in said envelope, one disposed at each end thereof, between which an arc discharge path is defined during operation of said lamp; at least one of said electrodes comprising a pressed and sintered pellet having a substantially cylindrical sidewall and composed of a substantially homogeneous mixture including a powdered refractory metal and an electron-emitting material, said cylindrical pellet being axially aligned with said arc discharge path, and a 100 percent pitched coil of refractory metal wire securely wound about the cylindrical sidewall of said pellet.

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2. A lamp according to claim 1 wherein the electron-emitting material in said pellet comprises an alkaline earth compound.

3. A lamp according to claim 2 wherein said coil about the pellet is a winding of tungsten wire.

4. A lamp according to claim 3 wherein the composition of said pellet comprises a substantially homogeneous mixture of powdered tantalum and barium aluminate.

5. A lamp according to claim 4 wherein the composition of said pellet prior to sintering consists essentially of from about 75 percent to 95 percent by weight of tantalum, about 5 percent to 25 percent by weight of $Ba_3Al_2O_6$ and about 0 percent to 1 percent by weight of nickel.

6. The device of claim 1 wherein said lamp is an in-

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jection-triggered flash tube, said rare gas is xenon, and the electrode comprising said pellet with said coil wound thereabout is the cathode of said flash tube.

7. The flash tube of claim 6 wherein the electron-emitting material in said pellet comprises an alkaline earth compound, and said coil of refractory metal wire is wound about substantially the entire cylindrical sidewall of said pellet.

8. The flash tube of claim 7 wherein said coil is wound of tungsten wire, said pellet has a tapered end pointing toward the inside of said flash tube and providing one terminus of said arc discharge path, the composition of said pellet comprises a substantially homogeneous mixture of powdered tantalum and barium aluminate, and said cathode is activated.

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