

[54] **XENON FLASH TUBE WITH INTERNAL REFLECTOR**

[75] Inventors: **Robert P. Bonazoli**, Hamilton;  
**Robert J. Cosco**, Chelsea, both of  
Mass.

[73] Assignee: **GTE Sylvania Incorporated**,  
Danvers, Mass.

[22] Filed: **Oct. 4, 1971**

[21] Appl. No.: **186,162**

[52] U.S. Cl. .... **313/113, 313/192, 313/197,**  
**313/226, 313/306**

[51] Int. Cl. .... **H01j 17/12**

[58] Field of Search ..... **313/113, 188, 170,**  
**313/162, 306, 226, 224, 192; 315/349**

[56] **References Cited**

**UNITED STATES PATENTS**

2,596,697	5/1952	Kreff	313/188 X
3,070,723	12/1962	Peek et al.	313/113
3,256,456	6/1966	Harris et al.	313/113

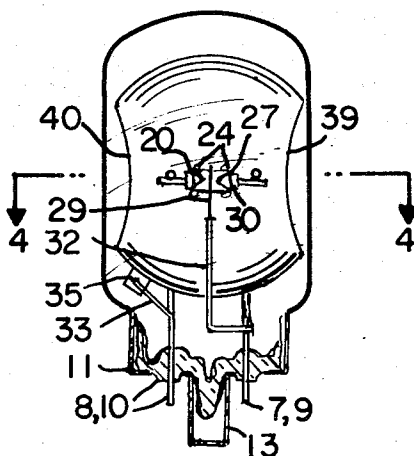
3,449,615	6/1969	Tucker et al.	313/226
2,196,392	4/1940	Hansell	313/162 X
3,222,567	12/1965	Smith	313/113 X
2,966,607	12/1960	Thouret	313/113

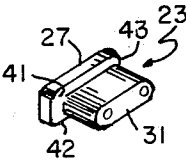
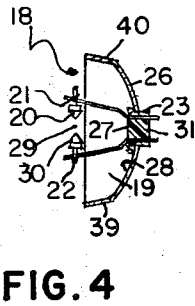
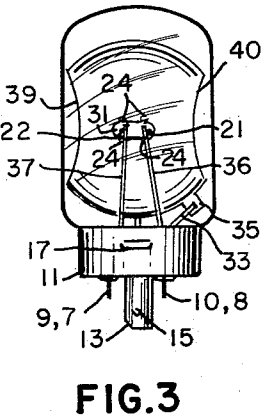
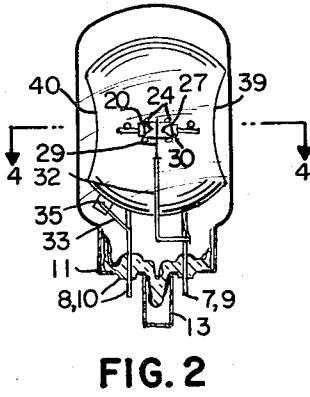
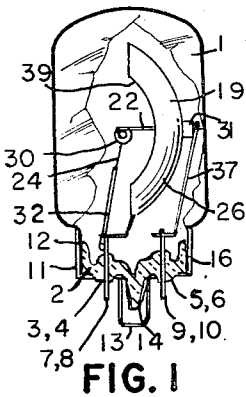
*Primary Examiner*—Alfred L. Brody  
*Attorney*—Norman J. O'Malley et al.

[57] **ABSTRACT**

A xenon flash tube having a glass bulb within which an ellipsoidal reflector is supported so as to be spaced from the walls of the bulb. Anode and cathode electrodes in the bulb are located to provide an arc gap positioned near one focus of the reflector and are supported on wires held by an insulating button in the reflector. A fine wire trigger electrode is mounted in the bulb so that the free end thereof is disposed between the anode and cathode electrodes. In addition to xenon, a gaseous fill may include a dopant, such as helium, to increase the hold-off voltage and prevent self-ionization.

**10 Claims, 8 Drawing Figures**





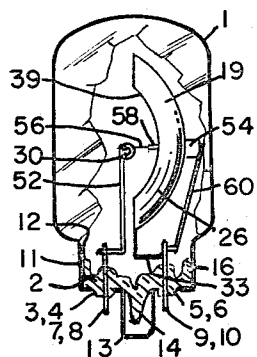


FIG. 6

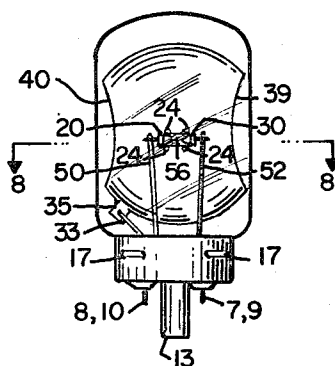


FIG. 7

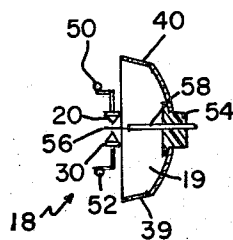


FIG. 8

## XENON FLASH TUBE WITH INTERNAL REFLECTOR

### BACKGROUND OF THE INVENTION

This invention relates generally to electric discharge lamps and, more particularly, to an internally triggered xenon flash tube adapted for use in projection systems or other applications requiring a high concentration of light energy on a limited area for a very short time duration.

Flash tubes are designed to produce high luminance flashes of light of extremely short duration for uses such as photographic applications, timing of reciprocating and rotating machinery, and airport approach lighting systems. The rising need for projection systems requiring illumination of a small aperture for a very short time duration (100 microseconds or less), however, provides a more recent application for which flash tubes would appear to be quite useful. Such projectors may be used in computer print out devices, graphic arts systems, or motion picture film systems. The conventional approach to a projection system of this type would employ a small xenon flash tube in conjunction with a condenser lens to image the arc onto the aperture or film gate. When the aperture is very small, however, optical alignment of the components in such a system (namely, the aperture, condenser lens, and flash tube) is very critical. Hence, when the flash tube is changed, a realignment of the optical system would generally be required. Further, the optical efficiency of such a system is relatively poor thereby requiring greater input energy per flash to properly illuminate the aperture. An external reflector could be employed behind the flash tube to enhance light output, however, this raises additional alignment difficulties and requires a relatively large enclosure, with consequent cumbersomeness and expense.

### SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved flash tube for applications such as a projection system.

It is another object of the invention to provide a flash tube for efficiently illuminating a small aperture in a compact projection system which is substantially free of alignment problems.

Briefly, these objects are attained in a flash tube having a concave reflector supported inside an hermetically sealed envelope and spaced from the walls thereof. Anode and cathode electrodes are mounted within the envelope whereby the arc gap therebetween is disposed in a fixed relationship to the reflector between a light transmitting portion of the envelope and the concave reflector. A trigger electrode is mounted within the envelope with the free end thereof being disposed between the anode and the cathode electrodes. The gaseous fill for the flash tube envelope comprises one of the rare gases, preferably xenon, and may include a dopant such as helium, to increase the ionization potential and thereby provide higher hold-off voltages in order to prevent self-ionization.

The anode and cathode electrodes may be supported on wires held by an insulating button contained in the reflector, and the reflector and electrode assembly thereby formed may be supported from one end of the lamp by electrically-conducting extensions of the electrode support wires and at least one "floating" support

wire connected to the reflector itself. The envelope may comprise a tubular glass bulb, with the electrode and support wires connected to respective lead-in wires sealed to the base of the bulb to act as contact prongs.

### BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a side profile view, partly cut away, of one embodiment of a flash tube according to the invention;

FIG. 2 is a front profile, partly cut away, view of the same embodiment;

FIG. 3 is a back profile view;

FIG. 4 is a sectional view on line 4—4 of FIG. 2;

FIG. 5 is an enlarged view of the insulator button through which the lead-in wires extend through the reflector in the embodiment of FIGS. 1—4;

FIG. 6 is a side profile view, partly cut away, of an alternative embodiment of a flash tube according to the invention;

FIG. 7 is a front profile view of the embodiment of FIG. 6; and

FIG. 8 is a sectional view on line 8—8 of FIG. 7.

### DESCRIPTION OF PREFERRED EMBODIMENT

The present invention achieves the above-mentioned objects by a unique flash tube construction which represents a radical departure from prior art arc discharge devices. In particular, the need for an external reflector and a condenser system in the projection apparatus is eliminated by virtue of a flash tube structure wherein an ellipsoidal reflector formed of sheet metal is mounted within the flash tube bulb independent of its tubular glass walls and in a fixed reflecting relationship with respect to the arc gap between the main electrodes of the device. In this manner, the internal reflector acts as a condenser by collecting nearly a full hemisphere of light and focusing it directly on a film gate a short distance outside of the bulb. As a result, a significantly more efficient and compact optical system is provided. In addition, alignment problems are significantly reduced as the main electrodes are accurately positioned during production so that the arc is nearer the focus of the reflector, thereby providing a completed lamp which is properly focused and aimed.

Internally mounted reflectors have been previously used in incandescent projection lamps, as described by U.S. Pat. Nos. 2,980,818 and 3,256,456; however, to our knowledge, independently mounted internal reflectors have never been used in arc discharge devices. We have discovered that such a reflector can be advantageously employed in a flash tube in accordance with the teachings of this invention.

Referring to FIGS. 1—4, an envelope comprising a tubular glass bulb 1 is hermetically sealed at one end to a glass wafer 2, which is a substantially flat portion of the bulb, having the nubs 3,4,5 and 6 through which lead-in wires 7,8,9 and 10 extend. A metal cap 11 is fixed to the bulb 1 by cement 12, and extends over the bottom of the wafer 2, the cap 11 having holes through which the nubs 3,4,5 and 6 extend. A cylindrical projection 13 from cap 11 extends around the sealed exhaust tube 14, and has the usual key 15 for alignment when placed in a socket, such as that shown in U.S. Pat. No. 3,200,363.

The outside surface 16 of cylindrical cap 11 is tapered inward toward the bottom of the lamp to facilitate insertion into a socket such as mentioned. The taper is about 1.5°, and is sufficient to allow insertion of the cap 11 into such a socket freely enough to allow rotation until the key 15 is inserted into the keyway of the socket, whereupon the cap 11 can be pushed further into the socket and held therein by the projections 17 extending outward in three positions around the cap circumference.

The reflector and electrode assembly 18 comprises: a concave, sheet metal reflector 19; an anode electrode 20 connected to an electrically-conducting support wire 21; a cathode electrode 30 connected to an electrically-conducting support wire 22; and an insulating button 23 through which the support wires 21 and 22 extend and in which they are firmly held. The anode electrode may comprise a cone-shaped body of sintered tungsten, and the cathode electrode may comprise a cone-shaped body of sintered barium aluminate in tungsten. The support wires 21 and 22 are relatively rigid and shaped to form the illustrated configuration by bending or the use of welded segments so as to position the anode and cathode electrodes to form an arc gap at the desired location. Button 23, preferably of a ceramic material, is secured to the reflector by means of crimping, or staking, the sheet metal reflector at points 24 to retain the flange 27 against the face 28 of reflector 19.

The reflector 19 is mounted in the flash tube with its axis perpendicular to the longitudinal axis of the tubular bulb 1 and provides an approximate focus of reflected light at an aperture or film gate a short distance outside the bulb.

Referring to FIG. 5, ceramic button 23 comprises a flat sleeve 31, shown as being approximately rectangular in shape but with its short sides rounded, which extends through the reflector 19 through a slot therein shaped to provide a sliding fit for the sleeve, and a flange 27, also approximately rectangular in shape but having one of its short sides straight or flat in shape and the other rounded, at least on the back of the flange, to form a group of three points 41, 42 and 43 which bear against the face of reflector 19 around the slot therein to fix the position of button 23 and reflector 19.

The reflector and the anode and cathode electrodes are thus held firmly but resiliently together in a proper reflecting relationship, and can be attached as a unit to the wafer 2 by electrically-conducting support wires 33, 36 and 37. Wire 33 is welded to a tab 35 on reflector 19, and the wires 36 and 37 are welded to the electrode support wires 21 and 22 respectively. The support wires 33, 36 and 37 are then welded at their bottom ends to the lead-in contact pins 8, 10 and 9 respectively, thereby providing a firmly-fixed shock-resistant mount.

Also mounted inside the bulb is a trigger, or starting, electrode 29, which may comprise a length of fine tungsten wire, the free end of which lies between the two main electrodes 20 and 30. As illustrated, the fine wire trigger electrode 29 may be connected to a rigid, electrically-conducting support wire 32 which is welded at its bottom end to lead-in contact pin 7. To support the arc discharge and to provide the desired light output, bulb 1 is filled with one of the rare gases, typically xenon. The pressure of the fill gas will depend upon a number of application factors including the op-

erating voltage; however, it will generally be desirable to provide a pressure approximately equal to or slightly less than atmospheric pressure. The gaseous fill may also include a dopant, such as helium, to increase the hold off voltage and prevent self-firing of the flash tube, although the necessity for a dopant will also be dependent upon application and desired operating characteristics affecting parameters such as fill pressure and operating voltage.

The exhaust tube 14 can be sealed by methods now well known to the art, for example as shown in U.S. Pat. No. 2,837,880.

In order to provide the largest possible useful reflecting surface in a given size tubular bulb, the perimeter of the reflector is made non-circular, that is the reflector has two sides 39 and 40 "cut off" to a slightly bowed configuration, as shown in the drawing. The reflector can be cut off on each side in a plane at about 15° to the plane of the front of the reflector.

In the specific embodiment herein described, the reflector is substantially ellipsoidal, that is, a surface of revolution of the curve

$$y^2 = 2(0.880)x - 0.650x^2$$

about the Y axis.

The curve described is sufficiently different from an exact ellipsoid to give a maximum of diffused reflected light at an aperture or film gate located about 1.75 inches from the plane of the front of the reflector. This is the approximate location of the far focal point of the reflector and falls a short distance outside of the bulb. The arc gap between electrodes 20 and 30 is located approximately at the near focus of the reflector, about 0.520 inch from the apex of the face of the reflector.

A reflector of spherical surface, with the arc gap about half way between the center of curvature and the surface can also be used, but it will give a smaller amount of light at the film gate. A true ellipsoid is also effective, but in order to avoid an image at the film gate, it should be used with the arc gap, or the film gate, or both, slightly off focus.

The insulating button 23 can be of any good refractory material; for example, we have used a ceramic manufactured by Clowes Ceramics, Chattanooga, Tenn., known as "Steatite" 4450-50, composed of 86 percent talc, 8 percent Feldspar and 6 percent ball clay.

The reflector can be made of a copper sheet of a grade free from any appreciable scratches on the reflecting side. The copper piece can be cut out to the desired shape and pressed between a concave and convex die of such shape to give the desired curvature. The copper is then polished, nickel plated, polished again and then coated with a silver reflecting surface by evaporation of the silver thereon in a manner well known to the art.

Alternatively, the reflector may be made from glass. For example, a glass piece can be ground to the desired concave curvature on one side and the concave portion coated with reflecting metal.

The bulb 1 may have a diameter of about 1½ inch, being known in the industry as a T-12 bulb, of lime glass, and the diameter is reduced to about 1-3/32 inch at the neck portion in the inside of cap 11.

The alignment of the arc gap and the reflector with each other is, as previously explained, independent of the remainder of the lamp construction. However, the

direction of the beam, that is the direction in which the reflector-electrode unit faces, is determined by the position in which it is held in the support wires. Alignment of the beam can be accomplished by adjusting the support and lead-in wires, or by fixing their shape and position on the glass wafer 2 before the wafer is sealed to the bulb. Cap 11 is then cemented onto the bulb in a proper position to align the bulb properly in the socket of the type mentioned.

In one embodiment according to the invention, electrodes 20 and 30 are spaced approximately 0.100 inch apart and, as previously mentioned, are electrically connected to rear base pins 10 and 9. The trigger electrode 29 is electrically connected to the front base pin 7, and the other front base pin 8 to which the reflector support wire 33 is connected, is electrically floating with respect to the flash tube operating circuit. The gaseous fill comprises 95 percent xenon and 5 percent helium at a pressure of 725 Torr. This specific embodiment of the flash tube is intended for operation at 1,000 volts DC with a capacitor of 0.1 MFD at a flash rate of 100 per second (0.05 joules per flash and 5.0 watts). When a trigger pulse of approximately 5,000 volts is applied to the trigger electrode the lamp flashes with a duration (measured to 1/2 peak) of approximately 6 microseconds. The arc length and position are adjusted as described to give maximum radiant energy through a  $0.080 \times 0.100$  inches aperture placed at the far focus of the ellipsoidal reflector. The reflector diameter is chosen such that the reflected beam will fill an  $f 1.6$  objective lens located behind the aperture. The position of the electrodes can be adjusted slightly to defocus the image of the arc source in order to improve uniformity at the aperture.

Various modifications of the device described can be made by a person skilled in the art without departing from the spirit and scope of the invention. For example, the fill pressure, gas composition, electrode design, and arc length can be adjusted to suit particular electrical output requirements. In addition, as illustrated by FIGS. 6-8, the main electrodes may be connected to the front lead-in pins and the trigger electrode may be held by the ceramic button in the reflector. More specifically, the anode electrode 20 may be connected through a rigid, electrically conducting support wire 50 directly to the front lead-in pin 8, and cathode electrode 30 may be connected through a rigid, electrically conducting support wire 52 directly to the front lead-in pin 7. A ceramic button 54 is mounted in the reflector in the same manner as that described with respect to the embodiment of FIGS. 1-4, with the configuration of button 54 being similar to that shown in FIG. 5 except that only one through hole is provided for holding a support wire. A fine wire trigger electrode 56 is connected to a rigid, electrically-conducting support wire 58 held in the ceramic button 54. In this manner the trigger electrode wire is positioned horizontally with its tip located between the main electrodes 20 and 30. An additional electrically-conducting support wire 60 is then employed to connect the other end of wire 58 to the rear lead-in pin 9. In this alternate construction, the reflector support wire 33 is connected to base pin 10, which is electrically floating when the flash tube is operatively connected. Components of the flash tube which are identical to those shown in FIGS. 1-4 have been identified with the same reference numerals.

What we claim is:

1. A flash tube comprising: an hermetically sealed envelope having a light-transmitting portion, a rare gas in said envelope at a pressure of approximately 1 atmosphere or less, a concave reflector supported inside said envelope and spaced from the walls thereof, anode and cathode electrodes mounted within said envelope whereby the arc gap therebetween is disposed in reflecting relationship to said reflector between the light-transmitting portion of said envelope and said concave reflector, and a trigger electrode mounted within said envelope with the free end thereof disposed between said anode and cathode electrodes.

2. A flash tube according to claim 1 wherein said envelope contains a gaseous filling comprising a rare gas and a dopant.

3. A flash tube according to claim 2 wherein said rare gas is xenon.

4. A flash tube according to claim 3 wherein said dopant is helium.

5. A flash tube comprising: an hermetically sealed envelope having a light-transmitting portion, a rare gas in said envelope, a concave reflector supported inside said envelope and spaced from the wall thereof, anode and cathode electrodes mounted within said envelope whereby the arc gap therebetween is disposed in reflecting relationship to said reflector between the light-transmitting portion of said envelope and said concave reflector, an insulating button in said reflector, an electrically conducting support wire held in said button, and a trigger electrode connected to said support wire and thereby mounted within said envelope with the free end of said trigger electrode disposed between said anode and cathode electrodes.

6. A flash tube comprising: an hermetically sealed envelope having a light-transmitting portion, a rare gas in said envelope, a concave reflector supported inside said envelope and spaced from the walls thereof, an insulating button in said reflector, first and second electrically-conducting support wires held in said button, anode and cathode electrodes connected to said first and second support wires, respectively, and thereby mounted within said envelope with the arc gap therebetween disposed in reflecting relationship to said reflector between the light-transmitting portion of said envelope and said concave reflector, a third electrically-conducting support wire mounted at one end of said envelope and projecting toward said anode and cathode electrodes between said reflector and said light transmitting portion of the envelope, and a trigger electrode connected to said third support wire and thereby mounted within said envelope with the free end of said trigger electrode disposed between said anode and cathode electrodes.

7. A flash tube according to claim 6 wherein said anode electrode comprises a cone-shaped body of sintered tungsten, said cathode electrode comprises a cone-shaped body of sintered barium aluminate in tungsten, and said trigger electrode comprises a length of fine tungsten wire terminated between said anode and cathode electrodes.

8. A flash tube according to claim 6 wherein said envelope is a tubular glass bulb having a substantially flat portion, and further including lead-in wires sealed through said flat portion of said bulb to act as external contact prongs, said third support wire being connected to a first one of said lead in wires, a fourth support wire connected between said reflector and a sec-

7

ond one of said lead-in wires, a fifth support wire connected between said first support wire and a third one of said lead-in wires, and a sixth support wire connected between said second support wire and a fourth one of said lead-in wires, said reflector thereby being supported by said fourth, fifth and sixth support wires.

9. A flash tube according to claim 8 wherein said

8

bulb contains a gaseous filling comprising a rare gas and a dopant.

10. A flash tube according to claim 9 wherein the gaseous fill in said bulb comprises about 93 percent xenon and about 5 percent helium at a pressure of about 725 Torr.

\* \* \* \* \*

10

15

20

25

30

35

40

45

50

55

60

65