United States Patent

Retzer et al.

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[54] **CURRENT-RATED SHORT-ARC LAMP FOR LIGHT PROJECTION APPARATUS**

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[52] **U.S. Cl.**..................................**313/214,** 313/184

[51] **Int. Cl.**...**H01j 17/20**

[58] **Field of Search**..............................313/184, 214

[56] **References Cited**

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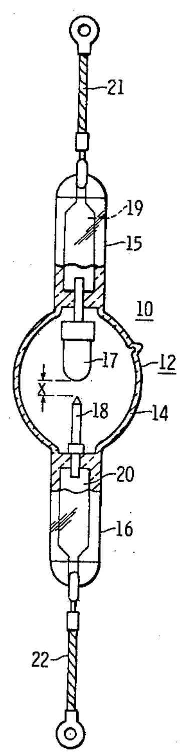
[57] **ABSTRACT**

A direct-current short-arc xenon lamp is mounted in prefocused relationship with either a parabolic or an ellipsoidal reflector so that the optical axis of the reflector is aligned with the longitudinal axis of the lamp. The spacing between the lamp electrodes is smaller than that used heretofore and the focal point of the reflector is located at a predetermined position along the arc path. The lamp is rated and operated at a predetermined current within a range of from 70 to 200 amperes and the electrodes are spaced from 4.6 to 7.0 millimeters apart, depending upon the particular operating-current rating of the lamp. When the lamp is operated in a horizontal position, a magnet located adjacent the lamp and outside of the reflector is used to prevent upward bowing of the arc. In the case of a movie projection system, the shorter and more intense arc increases the screen lumens and decreases the power (watts) consumed by the lamp.

5 Claims, 4 Drawing Figures



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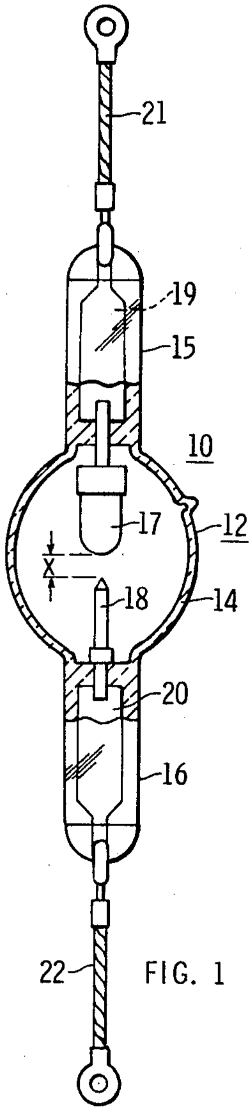

FIG. 1

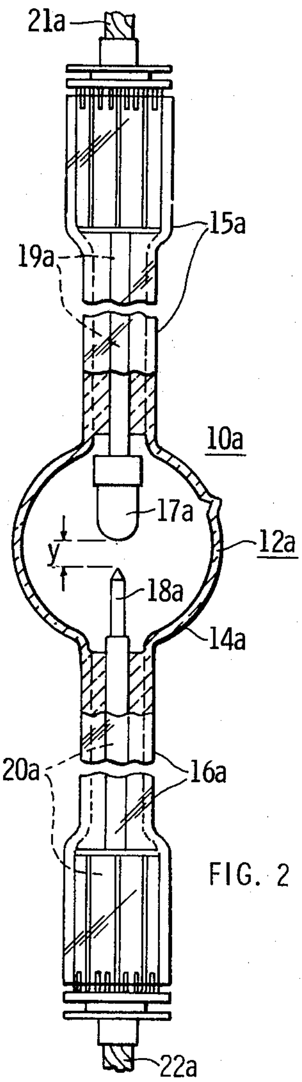

FIG. 2

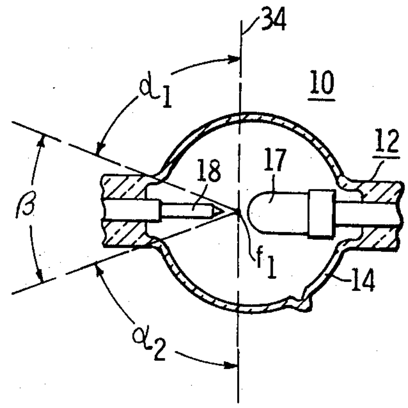

FIG. 4

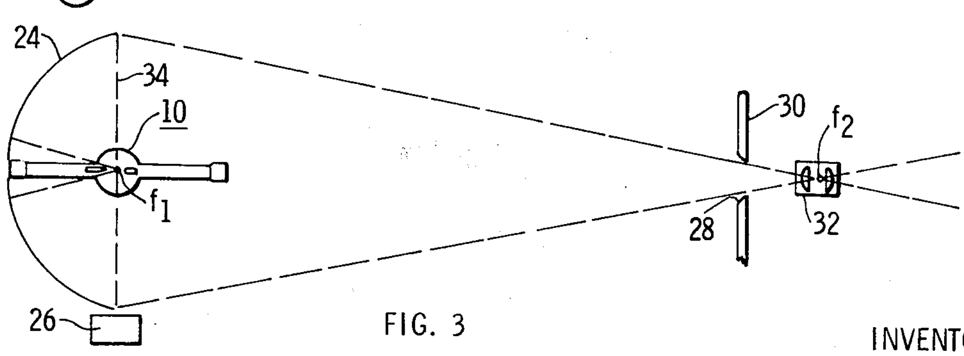

FIG. 3

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CURRENT-RATED SHORT-ARC LAMP FOR LIGHT PROJECTION APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to apparatus for producing and projecting concentrated beams of light and has particular reference to an improved short-arc lamp adapted for use in search lights or with film projectors of the type employed in movie theaters and drive-ins.

2. Description of the Prior Art

Short-arc lamps having a xenon fill gas are well known in the art and are conventionally designed for vertical operation on a direct current power source with the anode or positive electrical terminal located above the cathode. Such lamps are operated at a predetermined wattage rating. The arc lengths and wattage ratings are chosen to accommodate the optical systems with which the lamps are to be used. A short-arc lamp of this type is disclosed in U.S. Pat. No. 3,351,083 issued Nov. 7, 1967 to J. P. Kearney.

Xenon short-arc lamps are used with great advantage in the movie projection systems for theaters and the like instead of the carbon-arc light sources heretofore employed. In such applications the film gate is usually filled by means of a condenser lens or lenses and, in some cases, a small auxiliary spherical reflector that is properly focused relative to the lamp is also used in conjunction with the main ellipsoidal reflector.

More recently, an improved projection system has been adopted wherein a conventional xenon short-arc lamp is operated horizontally in conjunction with an ellipsoidal reflector and a properly located permanent magnet that controls the position of the arc. The cathode "hot spot" is positioned at the nearest foci of the reflector, thus permitting the latter to collect light through an angle of 360° from the "hot spot" without the use of an auxiliary spherical reflector. While this arrangement provides higher screen lumens, the lamps were rated according to wattage in the customary manner. However, since wattmeters are expensive, it has been the practice to operate such lamps by measuring the lamp current with an ammeter. As a result, such wattage-rated lamps are frequently operated at wattages higher than their rated wattage because the projectionist uses a higher published current value with a high voltage lamp instead of with a low voltage lamp as required in order to provide a rated lamp wattage. Under these conditions, the lamp is overloaded and frequently fails prematurely.

SUMMARY OF THE INVENTION

The foregoing and other disadvantages of the prior art projection systems and short-arc lamps are avoided in accordance with the present invention by rating the lamps on the basis of current rather than wattage and by shortening the arc length so that this parameter is correlated with the current rating. The arc path or electrode spacing is reduced to a minimum value for the low current lamps and is increased in a controlled manner for lamps having higher current ratings. In all cases, however, the arc path is shorter than that heretofore employed in conventional lamps of comparable size.

Since the improved lamps are current rated, they can be readily operated at the loading for which they are designed in film projection systems now in use that are equipped with ammeters for measuring the lamp current. Premature failure of the lamps due to overloading is thus eliminated.

In addition, since the arc path is shorter, the optical coupling with the reflector is "tighter" and more of the generated light is beamed into the film gate and, hence, onto the screen. The system is, accordingly, more efficient. In one comparative test, the screen lumens were increased 12 percent using a current-rated lamp that operated at a wattage that was 15 percent lower than that required by a conventional lamp.

BRIEF DESCRIPTION OF THE DRAWING

A better understanding of the invention will be obtained by referring to the exemplary embodiments shown in the accompanying drawing, wherein:

FIG. 1 is an elevational view, partly in section, of an 80 ampere xenon short-arc lamp embodying the invention;

FIG. 2 is a similar view, on a reduced scale, of a 150 ampere short-arc lamp;

FIG. 3 is a schematic representation of a film projection system which includes the improved projector-lamp unit of the invention; and

FIG. 4 is an enlarged fragmentary cross-sectional view of the bulbous portion of the improved lamp illustrating the relationship between the arc path and the focal point of the ellipsoidal reflector and the resultant optical coupling.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. **1** there is shown a short-arc lamp **10** that is designed for operation on a direct-current power source at a current of from 70 to 125 amperes and has an envelope **12** of quartz, or other suitable high-temperature material. The envelope has a generally spherical bulbous portion **14** that is terminated by two laterally extending sealing arm portions **15** and **16**. These arm portions are disposed opposite one another and are aligned with the longitudinal axis of the lamp **10**. An anode **17** is anchored in sealing arm **15** and a cathode **18** is anchored in arm **16**, as shown. The anode **17** and cathode **18** are aligned with one another along the lamp axis and are spaced apart a predetermined distance x, depending upon the particular current rating of the lamp **10**. In the case of the **80** ampere lamp illustrated in FIG. **1**, the arc length x is 5.2 ± 0.2 mm. The arc length is varied according to the current rating and for this size lamp varies from 4.6 mm. for a nominal current rating of 70 amperes to 5.9 mm. for a nominal current rating of 125 amperes. The current loading thus varies from 15.2 amperes per mm. of arc length at the low end of the aforesaid operating-current range of 21.2 amperes per mm. of arc length at the high end of the range.

The anode **17** and cathode **18** are made of solid tungsten and are connected to suitable lead-in conductor assemblies **19** and **20** sealed within the arms **15** and **16**, respectively in the usual manner. These lead-in assemblies are, in turn, fastened to external power leads **21**, **22** which are connected to the D.C. power supply (not shown).

The bulbous portion **14** of the lamp envelope **12** is filled with xenon gas at a pressure of at least one atmosphere and preferably several atmospheres. Other suitable rare gases, such as argon, krypton, etc., may also be used either alone or in combination with xenon.

FIG. 2 EMBODIMENT

In FIG. **2** there is shown (on a reduced scale relative to FIG. **1**) a similar short-arc lamp **10*a*** that is designed for operation at a predetermined current within a range of from 125 to 200 amperes. The envelope **12*a*** is composed of quartz, or other suitable refractory material, and has a spherical bulbous portion **14*a*** that is terminated by two oppositely-disposed sealing arms **15*a*** and **16*a***. Lead-in assemblies **19*a*** and **20*a*** are sealed within the arms **15*a*** and **16*a***, respectively, and are fastened to the anchored ends of the associated electrodes **17*a***, **18*a*** and the external power leads **21*a*** and **22*a***. The lead-in assemblies and lamp terminals may be of the type disclosed in the aforementioned U.S. Pat. No. 3,351,803, if desired.

In this embodiment, the anode **17*a*** and cathode **18*a*** are spaced further apart to provide an arc length *y* that varies from 5.9 mm. to 7 mm. depending upon the specific operating-current rating of the lamp **10*a*** within the aforesaid range of from 125 to 200 amperes. Hence, for a lamp rated at 125 amperes (nominal) the arc length *y* is about 5.9 mm. (equivalent to a current loading of 21.2 amperes per mm. of arc length). For a lamp rated at 200 amperes, the arc length is about 7.0 mm. and the current loading per mm. of arc length is thus approximately 28.6. The current loading employed in the lamps embodying the invention accordingly varies from approximately 15 to 29 amperes per mm. of arc length.

The envelope **12*a*** is filled with xenon at a pressure of at least one atmosphere as in the case of the FIG. **1** embodiment, and preferably several atmospheres of xenon. Other suitable gases and gas mixtures can also be used.

PROJECTION APPARATUS (FIGS. 3–4)

In FIG. **3** there is shown a movie projection system which employs the improved current-rated lamp of the present invention. As illustrated, the apparatus comprises the improved short-arc lamp **10** that is mounted horizontally within an ellipsoidal reflector **24** in prefocused relationship with the reflector surface. The nearest foci f_1 of the reflector **24** is located at a particular point along the arc path defined by the lamp electrodes which will give optimum uniformity of light intensity desired on screen. This, of course, will vary due to the characteristics of the particular projector and screen combination involved. In addition, the longitudinal axis of the lamp **10** is aligned with the optical axis of the reflector. Thus, the light generated by the lamp **10** is concentrated by the reflector **24** into a beam which passes through the opening **28** of the film gate **30** of the projector and converges at the projector lens **32** which is located at the second foci f_2 of the reflector.

A permanent magnet **26** (or other suitable magnetic-field generating means) is located proximate the lamp **10** and outside of the reflector **24** at a position such that the magnetic flux exerts a downward force on the arc. This prevents the arc from bowing upwardly due to

convection currents within the lamp **10** and keeps the arc aligned with the optical axis of the projector system.

As shown in FIG. **4**, the physical orientation of the lamp electrodes **17**, **18** and the foci f_1 of the ellipsoidal reflector **24** is such that the focal plane **34** passes through a predetermined portion of the arc stream which will provide the uniformity of light on the screen as discussed above. The compact arc is thus tightly coupled optically with the reflector and provides large "-pick-up" angles α_1 and α_2 and a relatively small "shadow" angle β. A proportionately larger amount of the generated light is thus collected by the reflector and directed into the film gate aperture of the projector. Of course, the focal plane **34** does not have to be tangent to the periphery of the reflector **24** (as shown in FIG. **3**) but can be located inwardly from the reflector periphery to provide proportionately larger "pick-up" angles α_1 and α_2 than those shown in FIG. **4**. In other words, a "deeper" reflector can be used than that shown in the drawing.

COMPARATIVE TEST DATA

Comparative test data on various current-rated lamps made in accordance with the invention and conventional wattage-rated lamps are given below in Table I.

Lamp	Current (Amps.)	Arc Length (mm.)	Current Loading (Amps./mm.Arc	Watts	Screen Lumens
A(stnd.)	150	10.0	15.0	6000	35,000
B	150	6.5	23.0	4800	40,000
C(stnd.)	80	6.8	11.7	2480	13,400
D	80	5.3	15.1	2160	15,000
E	100	5.2	19.2	2700	25,000

As will be noted, the standard 6,000 watt conventional lamp A (wattage-rated) had a longer arc length and a much lower current loading per mm. of arc length than the improved current-rated lamp B of the same size. Lamp B thus operated at 4,800 watts rather than 6,000 watts and provided more screen lumens when used in a film projection system of the type shown in FIGS. 3 and 4.

The same is true of improved lamp D versus conventional lamp C which was rated at 2500 watts. When both lamps were operated at 80 amperes (the rating of lamp D), the standard lamp operated at 2,480 watts and delivered 13,400 screen lumens. Improved lamp D, in contrast, delivered 15,000 screen lumens at 2,160 watts — an increase of 12 percent in the light intensity and a reduction of 15 percent in the power (watts) consumed by the lamp.

Lamp E had an arc length of 5.2 mm. and a current rating of 100 amperes. Its current loading was thus 19.2 **amps. per mm. of arc length and it delivered** 25,000 screen lumens at 2,700 watts.

The "ultra-short" arc lamps of the present invention thus provide many advantages over conventional wattage-rated lamps. Since smaller arc lengths are used, the arc voltage is decreased and the lamp operates at a lower wattage. This permits smaller less expensive quartz bulbs to be used for the same current loading, or retention of the same bulb sizes as are presently used — thus providing a lower wattage loading per unit of bulb surface and a greater safety margin with respect to possible bulb failure during operation.

The same average arc brightness can be obtained with the improved lamps with lower fill gas operating pressures, thus providing an additional safety factor. For selected lamp currents, higher average arc brightness will be obtained when conventional gas operating pressures are used.

Due to the extremely small arc lengths employed, the improved lamps are very stable and, in some applications, may eliminate the need for the magnet now used to maintain arc stability. The lamps are also easier to start, give good color rendition and reduce the costs of operating the lamps. They improve the capability of lamp operation in any position and thus perform well in applications, such as "follow spot" projection and searchlights, where parabolic reflectors might also be used.

We claim as our invention:

1. A short-arc lamp for operation on a direct-current power source at a predetermined current within the range of from about 70 to 200 amperes and having a rating that corresponds to said predetermined operating current, said lamp comprising:

a light-transmitting envelope having a bulbous portion and a pair of laterally extending oppositely disposed arm portions,

a cathode and an anode anchored in and extending from the respective arm portions into the bulbous portion of said envelope,

an ionizable gas within said envelope consisting essentially of xenon, argon, krypton and mixtures thereof at a pressure of at least 1 atmosphere, and

lead-in conductor means sealed through each of said envelope arm portions and connected to the associated anode and cathode, respectively,

said anode and cathode being aligned with one another and spaced apart a distance such that they define an arc path which is from about 4.6 to 7.0 millimeters long and is so correlated with respect to the current rating of the lamp that the current loading is approximately 15 amperes per mm. of arc length at the lower limit of said operating current range and approximately 29 amperes per mm. of arc length at the upper limit of said operating current range.

2. A short-arc lamp as set forth in claim 1 wherein said ionizable gas consists essentially of xenon.

3. A short-arc lamp as set forth in claim 2 wherein the bulbous portion of said envelope is of generally spherical configuration.

4. A short-arc lamp as set forth in claim 2 wherein;

said lamp has a nominal operating current rating of from 70 to 125 amperes, and

the cathode-anode spacing is within the range of from about 4.6 to 5.9 millimeters.

5. A short-arc lamp as set forth in claim 2 wherein;

said lamp has a nominal operating current rating of from 125 to 200 amperes, and

the cathode-anode spacing is within the range of from about 5.9 millimeters to 7.0 millimeters.

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