March 19, 1963 A. A. BOTTONE 3,082,345

ELECTRIC LAMP

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FIG. 1.

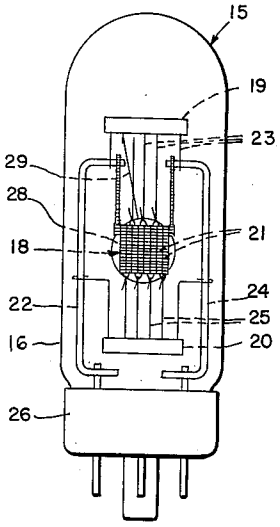



FIG. 2.

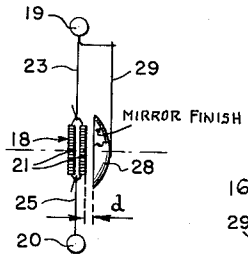



FIG. 4.

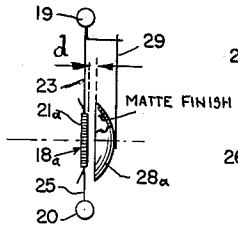



FIG. 3.

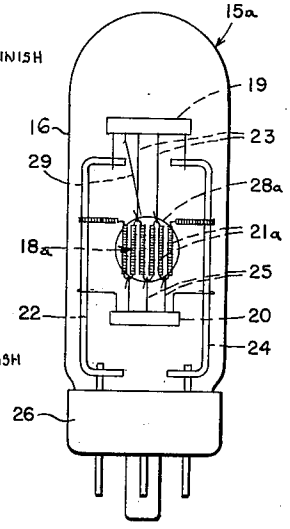



FIG. 5.

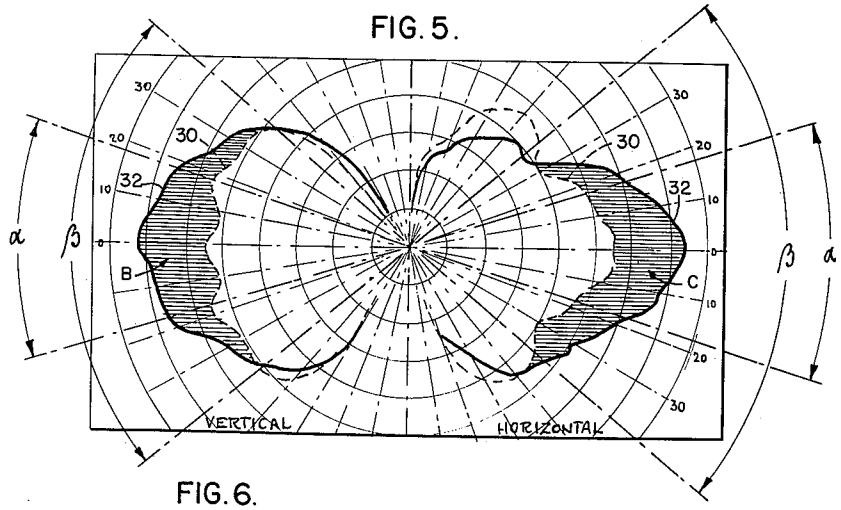



FIG. 6.

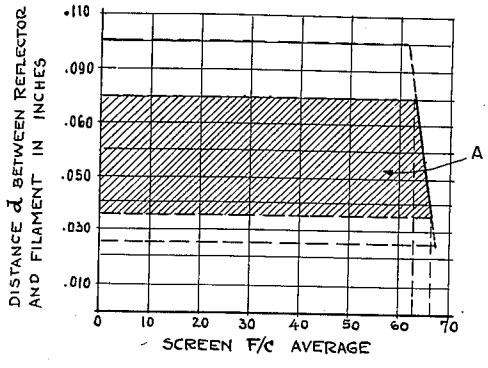
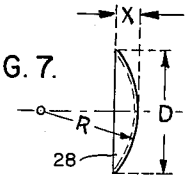



FIG. 7.




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FIG. 8.

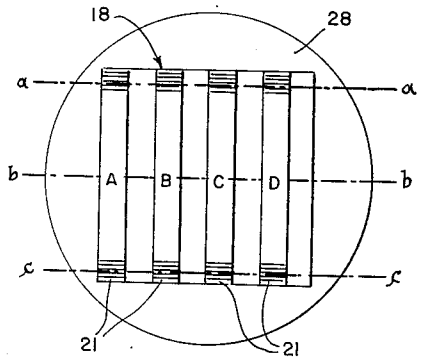



FIG. 9.

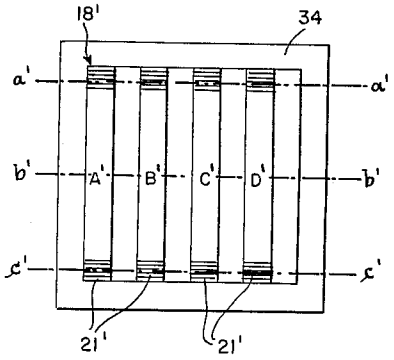



FIG. 10.

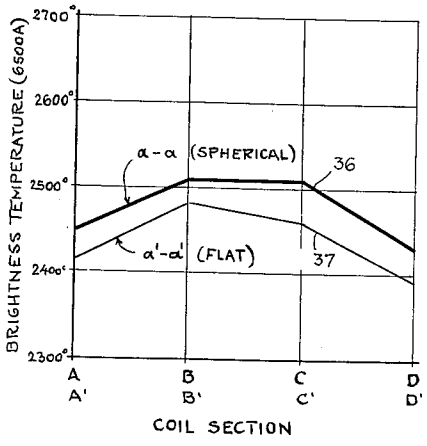
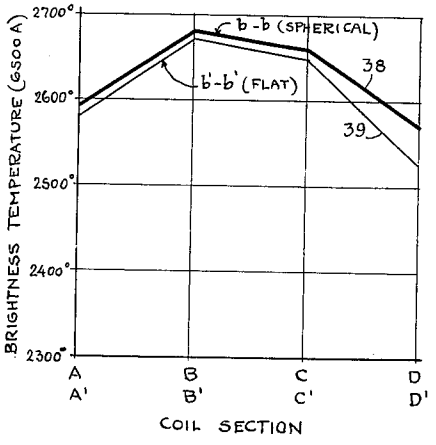



FIG. 11.



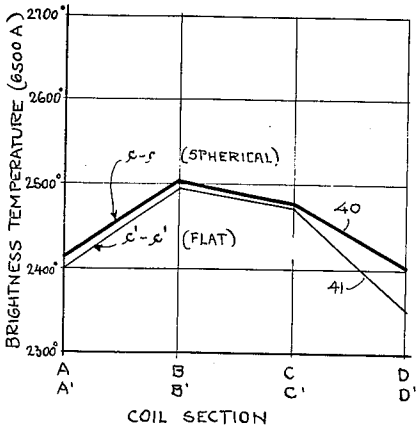




FIG. 12.

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3,082,345

# ELECTRIC LAMP

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11 Claims. (Cl. 313—113)

This invention relates to electric lamps and, more particularly, to an electric incandescent projection lamp having an improved light output.

As is well-known, the primary objectives in the design of incandescent projection lamps is to provide a light source that is as bright as possible and which will illuminate the film gate or aperture of the projector, and thus the screen, as uniformly as possible. Generally speaking, the brighter and more evenly illuminated the screen the more brilliant and life-like will be the pictures projected thereon.

In order to concentrate as much light as possible in the projector's optical system, it has been the practice heretofore to place a reflector in the projector housing behind the lamp to collect light that would otherwise be wasted. More recently there have been introduced lamps wherein a flat reflector of refractory metal such as molybdenum is mounted inside of the lamp behind the filament. While these so-called "proximity reflector" lamps constitute a distinct improvement over the previous arrangement in that they eliminated the costly and inefficient external reflectors and increased the useful light output of the lamp, it would be desirable to increase the useful light output of projection lamps even further and to achieve a more uniform distribution thereof in the optical system of the projector and on the screen.

It is accordingly the general object of this invention to provide an improved incandescent projection lamp that has a higher and more uniform light output than lamps having flat proximity reflectors.

It is another object of this invention to provide an incandescent projection lamp having an internally mounted reflector that is rugged and convenient and inexpensive to make and assemble.

A further and more specific object is to provide a proximity reflector for an incandescent projection lamp having a planar type filament which reflector not only causes the filament to operate at a higher and more uniform temperature but directs more light into the optical system of the projector compared to the prior art reflectors of this type.

The foregoing objects, and others which will become apparent as the description proceeds, are achieved according to this invention by employing an internally mounted reflector that is of concave configuration and fabricated from a refractory material the reflectivity whereof increases with temperature. In addition, the thermal mass of the reflector is such and the reflector is located in such proximity to the filament that it incandesces when the latter is energized. Because of its configuration and the fact that it unexpectedly operates at a higher average temperature than a flat shield of the same material and overall dimensions under the same conditions, the concave reflector is able to reflect and focus both heat and light with greater efficiency resulting in a marked increase in both the intensity and uniformity of the light concentrated on the screen.

A better understanding of the invention will be obtained by referring to the accompanying drawings wherein:

FIG. 1 is a front elevational view of an electric incandescent projection lamp incorporating the invention;



FIG. 2 is a side elevational view of the filament and reflector assembly together with the supporting members associated therewith employed in the lamp shown in FIG. 1;

FIG. 3 is a front elevational view of a projection lamp similar to that shown in FIG. 1 but having a monoplane type filament;

FIG. 4 is a side elevational view of the reflector and filament assembly employed in the lamp shown in FIG. 3;

FIG. 5 is a graphic representation comparing the light distribution patterns in both the vertical and horizontal directions of projection lamps having a standard flat reflector and the concave reflector according to the present invention;

FIG. 6 is a graph illustrating the correlation between the screen brightness and proximity of the concave reflector to the filament;

FIG. 7 is an enlarged side view of a preferred form of concave reflector of the type shown in FIGS. 1 to 4;

FIGS. 8 and 9 are enlarged front elevational views of a biplane type filament disposed in front of the circular-shaped spherical reflector of this invention and a prior art square-shaped flat reflector, respectively, illustrating the lines along which the temperature of the front row of coil sections was measured for comparative purposes; and

FIGS. 10 through 12 are graphs comparing the temperature distribution along the upper, central and lower portions, respectively, of the aforesaid front rows of coil sections when the filaments were normally operated in front of the concave and flat proximity reflectors illustrated in FIGS. 8 and 9, respectively.

While the present invention may be advantageously employed with various types of precision lamps having incandescent light sources of planar configuration, it is particularly adapted for use in incandescent projection lamps and has accordingly been so illustrated and will be so described.

In FIG. 1 there is shown a 500 watt T10 projection lamp **15** according to the present invention which lamp generally comprises a sealed tubular envelope **16** containing an axially-extending biplane filament **18** that is supported in substantially symmetrical relation with the lamp axis by means of upper and lower bridge members **19** and **20** and a pair of rigid parallel-spaced lead-in conductors **22** and **24**. The bridge members are fabricated from suitable insulating material, such as high-temperature glass, and are aligned one above the other in a common plane along with the filament **18**. The filament is pendently held in this position by a plurality of support wires **23** and **25** that are embedded in the upper and lower bridge members **19** and **20**, respectively, and engage the uncoiled loop segments of the filament **18** which connect the coil sections **21** thereof. These coil sections are positioned parallel and in side-by-side relation in two parallel planes to form the usual generally square-shaped grid.

The aforesaid lead-in conductors electrically connect with a suitable base member **26** attached to the sealed end of the envelope and, together with the bridge members **19** and **20** and support wires **23** and **25**, constitute an upstanding frame assembly that supports the filament **18** in the desired position within the lamp. The lamp has the usual filling of inert gas, such as nitrogen at a pressure of 1000 mm. of mercury for example.

In accordance with the present invention a concave reflector **28** of selected material is positioned behind the biplane filament **18** in substantial alignment therewith. As shown in FIG. 1, and with greater particularity in FIG. 2, the reflector **28** preferably comprises a circular member of spherical configuration the axis whereof is substantially normal to the plane of the filament and the

concave surface whereof is disposed toward a planar face of said filament.

As will also be noted in the foregoing figures, the reflector **28** is positioned close to and directly behind the biplane filament **18** and is of such diameter that it circumscribes the square-shaped grid portion thereof formed by the two parallel rows of coil sections **21**. As a specific example, good results have been obtained in the case of the 500 watt T10 biplane lamp **15** here shown by maintaining the reflector-to-filament spacing "*d*" (that is, the distance between the plane tangent to the peripheral edge of the reflector **28** and a plane tangent to the proximate surface of the rear row of coil sections **21**, as shown in FIG. 2) between about 0.025" and 0.100". It has been found that the screen brightness is directly proportional to the proximity of the concave reflector **28** to the filament **18**, the average screen foot candles increasing as the spacing between the aforesaid members decreases. As illustrated in FIG. 6, the average screen brightness of the aforesaid 500 watt T10 lamp when operated in the particular projector employed in this test increased from about 61 foot candles at a spacing of 0.100" to about 67 foot candles at a spacing of 0.025". In order to achieve a screen brightness as high as possible without requiring too tight a spacing tolerance or possibly causing the reflector to subsequently touch and short-out part of the filament under shock or vibration conditions, the filament-to-reflector spacing "*d*" is preferably maintained between about 0.035" and 0.070", which preferred range is represented by the shaded region "A" in the graph shown in FIG. 6.

In addition to being located close to the filament, the concave reflector **28** is fabricated from refractory metal that has a sufficiently high melting point to withstand the high temperatures which prevail in the region adjacent the filament, and which also has a reflectivity which increases with temperature. There are several metals which meet both of the aforesaid requirements and are thus suitable for use as reflector material, namely, molybdenum, tungsten and tantalum. Molybdenum, for example, has a melting point of 2895° K. and a reflectance value at 1800° K. of 0.633. At 2000° K. the reflectance value is 0.638 or about 0.8% higher. The same properties are also exhibited in varying degrees by the other two metals. In order to make the reflector **28** as reflective as possible, at least the concave surface thereof is provided with a mirror finish as indicated in FIG. 2.

It is also essential according to the present invention to keep the thermal mass of the reflector **28** as low as possible and of such magnitude that the reflector is heated to incandescence when the filament **18** is energized. This can be achieved by fabricating the reflector **28** from a thin sheet of molybdenum, for example, that will heat up rapidly but remain substantially rigid. While the reflector **28** may be of parabolic or ellipsoidal configuration if desired, it is spherical in the particular form here shown and, as illustrated in FIG. 7, constitutes a spherical segment of circular configuration that has predetermined radius of curvature R, diameter D, and depth X. As a specific example, in the case of the 500 watt T10 lamp **15** shown in FIG. 1, the aforesaid requirements as regards thermal mass, rigidity, and enhanced reflectance at elevated temperatures can be conveniently met by stamping a spherical reflector **28** of circular configuration having a radius of curvature "R" of 0.375", a diameter "D" of 0.475" and a depth "X" of 0.080" from a molybdenum sheet 0.005" thick that has a mirror finish on both sides. It has been found that when a reflector having these dimensions is placed approximately 0.035" from the biplane filament **18** of the aforesaid 500 watt T10 lamp **15**, the surface of the reflector remote from the filament has an average brightness temperature (6500 A.) of 1542° whereas a flat reflector of square configuration having the same overall dimensions and fabricated from the same material, has an average surface temperature (6500 A.) of 1473° at the same spacing. The aforesaid higher operating temperature of the concave reflector **28** was totally unexpected insofar as the reflector surface curves away from the filament and at its apex is 0.080" from the proximate face of the filament, or more than twice again as far from the filament as the corresponding part of the flat reflector. Due to this temperature difference the reflectivity of the instant molybdenum spherical reflector is over 0.4% higher in the red region of the spectrum, over 0.3% higher in the blue region of the spectrum, and over 0.3% higher on the average over the visible region of the spectrum than a flat reflector of identical thickness, overall dimension, etc.

Since the radius of curvature, diameter, thickness and spacing of the reflector from the filament will obviously vary depending upon the size and wattage rating of the filament, it will be understood that the design parameters set forth above in connection with the 500 watt T10 lamp merely illustrate one specific type of reflector and that other reflectors of a similar functional character but different shape, dimensions and spacing etc. may be used without departing from the spirit and scope of this invention.

It has also been found that the average screen lumens in the case of 500 watt T12 biplane filament lamps is 11% higher when the circular reflector **28** of spherical configuration above-described is used compared to identical lamps having flat reflectors, and over 15% higher than that obtained with a conventional lamp and an external reflector mounted in the projector. In addition, the average corner-to-center ratio or uniformity of the light concentrated on the screen is improved by 2.5% compared to lamps having flat reflectors. While the reason for such a marked improvement in both the screen brightness and light uniformity obtained through the use of a concave rather than a flat reflector is not perfectly understood at present, it is believed that the inherent tendency of a concave surface to cause rays impinging thereon to converge rather than diverge, coupled with the fact that the concave reflector **28** has a higher operating temperature and thus constitutes a better and more efficient reflector than a flat reflector, enables the concave reflector to direct more heat and light back toward the filament. As a result, more light is reflected past the filament and out of the lamp toward the condensing lens of the projector's optical system, and more heat is focused onto the filament causing it to operate at a higher and more uniform temperature—which further increases the directionality and intensity of the light emanating from the lamp.

This theory is supported by data such as the graph shown in FIG. 5, which is a comparative representation of the light distribution patterns in terms of relative candle power for 500 watt T12 biplane lamps having flat versus spherical reflectors. The broken line **30** is the light distribution pattern for the lamp having the flat reflector and the solid line **32** that of the lamp having the spherical reflector. As shown by the shaded areas B and C between these two sets of curves, the spherical reflector not only has a higher light output in both the vertical and horizontal planes but concentrates the light in a much narrower beam. This, in turn, concentrates more light in the condensing lens of the projector as evidenced by the angles $\alpha$ and $\beta$ superimposed over the light distribution patterns, which angles correspond to the standard 35° and 80° acceptance angles for the condensing lens systems employed in movie and slide projectors, respectively.

The aforesaid theory also seems to be supported by the effect on the filament temperature produced by concave and versus flat reflectors, which effect will now be discussed. As shown in FIG. 8, the brightness temperature of the front row of coil sections **21** (that is, coils A, B, C and D) of a biplane filament **18** operated in front of a spherical reflector **28** was measured at preselected

points along parallel lines *a*—*a*, *b*—*b*, *c*—*c* which traverse the upper, central and lower portions of the filament surface, respectively. As shown in FIG. 9, comparative readings at the same points along line *a'*—*a'*, *b'*—*b'*, *c'*—*c'* were also made of the coil sections A' through D' of an identical biplane filament **18'** operated in front of a flat square-shaped reflector **34** of the same thickness and overall dimensions as the concave circular shaped reflector **28**.

The temperature gradients of the aforesaid coil sections along the upper, central and lower portions of the filaments for the spherical versus the flat reflectors are plotted in FIGS. 10 through 12, respectively. As will be noted, in each case the filament operated at a higher and more uniform temperature with the spherical reflector **28** than with the flat reflector **34**. This is shown by the fact that the curves **36**, **38** and **40** corresponding to the temperature gradient of the filament **18** across the upper, central and lower portions thereof are located above and do not slope as sharply at the ends (and are thus flatter) than the corresponding curves **37**, **39** and **41** for the filament **18'** which was operated in front of the flat reflector **34**. The temperature readings in each case correspond to the brightness temperature (6500 A.) of the front surface of the various coil sections at identical points.

It has been observed that when a lamp having a monoplane type filament and a concave reflector with a mirror finish is operated in certain types of projectors a series of undesirable dark areas or "shadows" appear on the screen. Apparently, these are diffused images of the spaces between the coil sections of the filament which are projected onto the screen by the concave mirror reflector. It has been found that this problem can be very conveniently overcome by etching or otherwise treating the reflector to provide a concave surface that has a matte finish, that is, one which is irregular or roughened.

In FIG. 3 there is shown a 300 watt T10 lamp **15***a* which is identical in construction with the 500 watt lamp **15** shown in FIG. 1 except that it has a monoplane type filament **18***a* (which comprises a plurality of parallel spaced coil sections **21***a* arranged in a single plane), and a circular concave reflector **28***a* the concave surface whereof has a matte finish, as indicated in FIG. 4.

It should also be noted that the reflectors **28** and **28***a*, by virtue of their concavity, are inherently rigid and can thus be held in operative position behind their respective filaments by means of a single support member **29**, as shown in FIGS. 1 through 4, which member is attached to the upper bridge member **19** for example. In contrast, at least two supports are required to hold a flat reflector in place and even then it has a tendency to warp and twist out of shape in use.

As will be apparent from the foregoing, the objects of the invention have been achieved by providing an electric incandescent projection lamp that has a higher and more uniform light output. In addition, a proximity reflector has also been provided which, by virtue of its configuration and the material from which it is fabricated, improves both the performance and ruggedness of the projection lamps in which it is employed.

While several embodiments have been illustrated and described in detail, it is to be understood that various modifications in the configuration, arrangement and spacing of parts can be made without departing from the spirit and scope of the invention.

I claim:

1. An electric incandescent projection lamp comprising, a sealed envelope, a concentrated filament of planar configuration supported within said envelope, and a thin metal concave reflector supported adjacent said filament with its concave surface disposed toward a planar face thereof, said reflector being fabricated from refractory metal the reflectivity whereof increases with temperature, and the thermal mass of said reflector and the spacing between said reflector and filament being such that said reflector incandesces when the filament is energized.

2. An electric incandescent projection lamp as set forth in claim 1 wherein, said filament comprises a plurality of interconnected coil sections that are aligned one with another and form a grid that extends along the axis of said envelope, and said concave reflector is of circular configuration and aligned with said grid.

3. An electric incandescent projection lamp as set forth in claim 1 wherein, said envelope is of elongated configuration, said filament comprises a plurality of interconnected parallel-spaced coil sections arranged to form a grid of planar configuration that extends along the longitudinal axis of said envelope, and said concave reflector is of circular configuration and such diameter that it circumscribes said filament.

4. An electric incandescent projection lamp as set forth in claim 1 wherein the concave surface of said reflector has a mirror finish and is symmetrical about an axis that is transverse to the plane of said filament.

5. In an electric incandescent projection lamp, the combination of a coiled sectional filament of planar configuration, and a thin metal reflector of concave configuration substantially circumscribing and located adjacent a face of said planar filament in such proximity thereto that said reflector incandesces when said filament is energized, the concave surface of said reflector being disposed toward said filament, and said reflector being fabricated from a refractory metal selected from the group consisting of tungsten, molybdenum and tantalum.

6. The combination of a coiled sectional planar filament and a concave refractory metal reflector as set forth in claim 5 wherein, said filament is held in a predetermined plane by an upstanding frame assembly, and said reflector is rigidly held in operative relation with said filament by a single support attached to said frame assembly.

7. In an electric incandescent projection lamp, the combination of a biplane type filament, and a thin metal spherical reflector of circular configuration located adjacent a planar face of said filament in such proximity thereto that said reflector incandesces when said filament is energized, the axis of said reflector being substantially normal to the plane of said filament and the concave surface of said reflector having a mirror finish and being disposed toward said filament, said reflector being fabricated from a refractory metal selected from the group consisting of tungsten, molybdenum and tantalum.

8. In an electric incandescent projection lamp, the combination of a monoplane type filament, and a thin metal concave reflector of circular configuration substantially circumscribing and located adjacent said filament in such proximity thereto that said reflector incandesces when said filament is energized, the concave surface of said reflector having a matte finish and being disposed toward said filament and symmetrical about an axis that is substantially normal to the plane thereof, said reflector being fabricated from a refractory metal selected from the group consisting of tungsten, molybdenum and tantalum.

9. An electric incandescent projection lamp as set forth in claim 1 wherein: said lamp has a rating of about 500 watts; said concave reflector comprises a circular segment of a sphere and is fabricated from a refractory metal selected from the group consisting of tungsten, molybdenum and tantalum; and the spacing between the peripheral edge of said reflector and the proximate plane surface of said filament is between about 0.025" to 0.100".

10. An electric incandescent projection lamp as set forth in claim 9 wherein the spacing between the peripheral edge of said reflector and the proximate plane surface of said filament is between about 0.035" and 0.070".

11. An incandescent projection lamp having a rating of approximately 500 watts comprising: a generally

tubular envelope; a coiled refractory wire filament of planar configuration supported and sealed within said envelope; and a concave molybdenum reflector of circular configuration supported adjacent said filament with its concave surface disposed toward and in substantial alignment with a planar face of said filament; said reflector constituting a spherical segment having a radius of curvature of about 0.375", a diameter of about 0.475", a depth of about 0.080", and a thickness of about 0.005"; the spacing between the peripheral edge of said reflector and the proximate plane surface of said filament being approximately 0.035".



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