United States Patent

Rosendahl

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[54] **CONDENSER SYSTEM FOR HIGH INTENSITY LIGHT SOURCE**

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[73] Assignee: **The United States of America as represented by the Secretary of the Navy**

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[52] **U.S. Cl.** **240/41.3,** 353/97, 353/102

[51] **Int. Cl.**.....**F21v 13/04**

[58] **Field of Search** 240/41.3, 41.35, 41; 353/55, 353/56, 97, 100, 102; 355/78, 133

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[57] **ABSTRACT**

An elliptical mirror is utilized in combination with a xenon arc projection lamp and a high melting point metal stop to provide in one embodiment an improved vertical axis point light source for point light source projectors, and in another embodiment to provide a condensed, vertical axis beam which is annular in section for panoramic projectors using transparencies having an azimuthal scene recorded in annular form.

1 Claim, 3 Drawing Figures

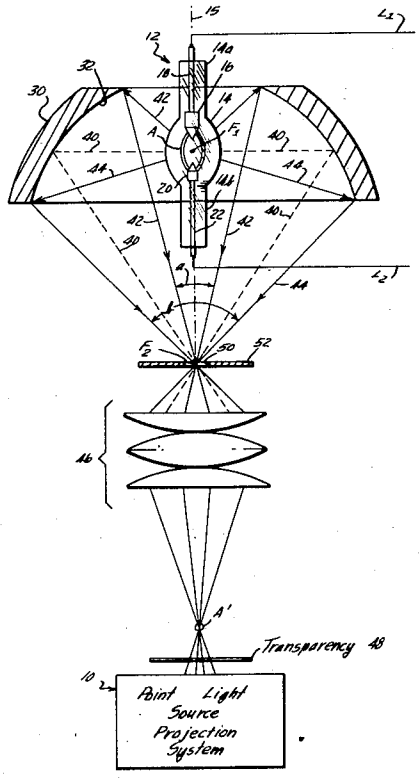
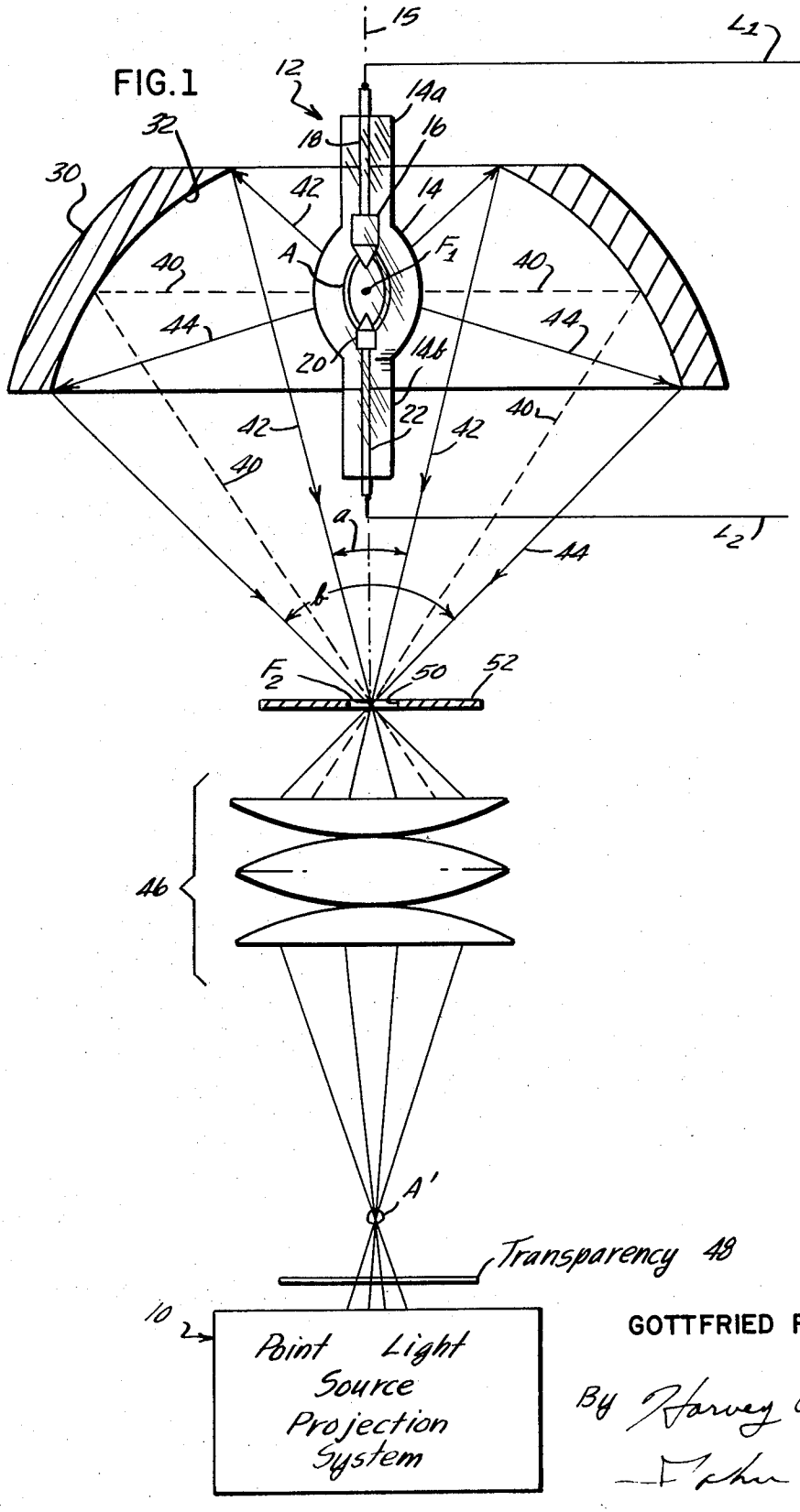


FIG. 1



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FIG. 3

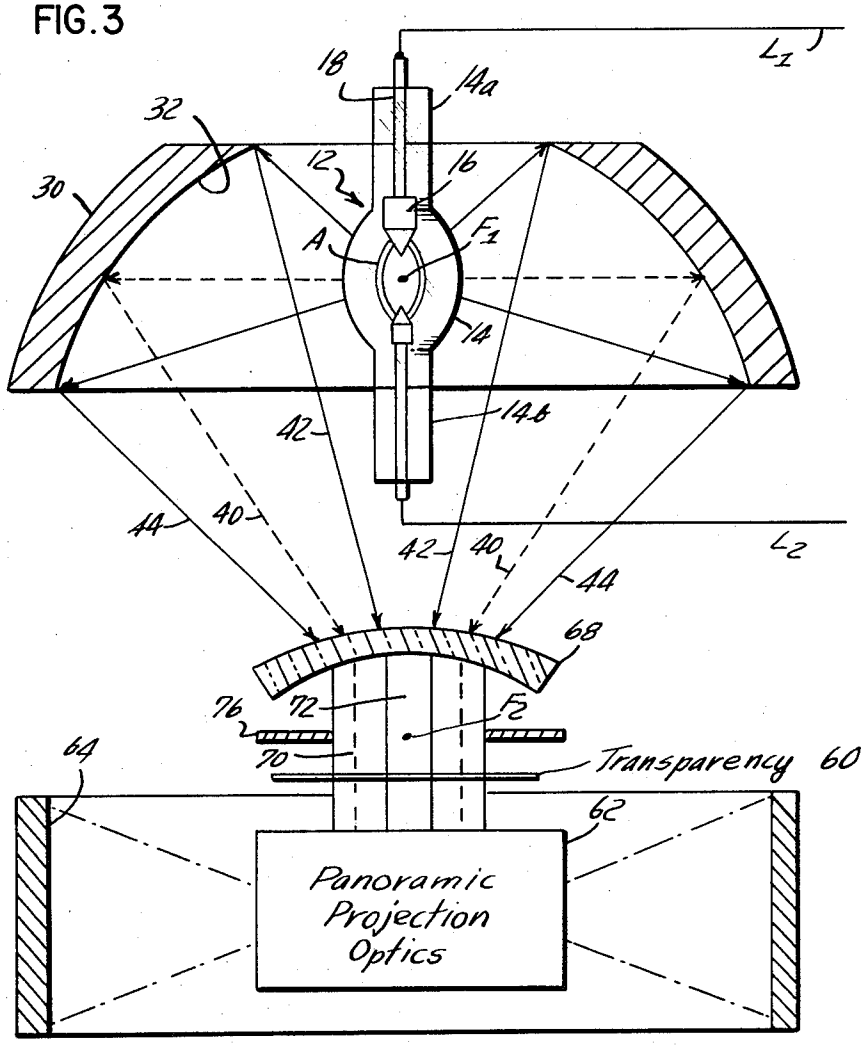
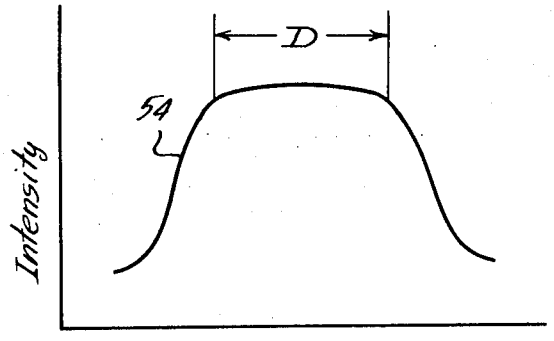


FIG. 2



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CONDENSER SYSTEM FOR HIGH INTENSITY LIGHT SOURCE

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

Various projection and display devices require a high intensity light source. One commonly used high intensity light source is the xenon "arc" lamp. Use of the xenon arc projection lamp has been limited to use with condenser arrangements wherein the direction of light propagation from the projector is generally horizontal. The construction of xenon projection lamps is characterized by a glass envelope having a bulbous central portion and diametrically opposed tubular portions extending therefrom. Tungsten electrodes define a gap within the bulbous portion of the envelope while elongated electrode supporting and conductive leads extend in opposite directions through the tubular portions. The electrodes, gap, and electrode supporting leads all lie on a common axis. These lamps are required to be operated with the axis of the electrodes disposed in a vertical or nearly vertical position.

Operating the lamps with the electrode axis vertical is satisfactory for applications using condenser systems following the conventional approach wherein the condensed light beam axis is in a horizontal direction. There are, however, applications which require a condensed light beam which has a vertical axis. The requirement of a vertical light beam axis contradicts the usual requirement that a xenon arc lamp be burned with the electrode axis vertical, provided the condenser system follows the conventional approach. It will be appreciated that this is so inasmuch as the tubular portions of the envelope, as well as the electrode supports or leads and the electrodes themselves, obstruct the efficient emission of light in a vertical sense.

Additionally, light sources such as the xenon arc lamp are generally characterized by light emission from a rather small luminous area; and within this area the luminance is strongly non-uniform. These characteristic features are contrasted by, for instance, the pure carbon or high intensity (so called Beck) arc lamp and require special attention in the form of carefully adapted condenser systems, in order to utilize the light to the highest possible degree without compromising uniformity of screen illumination within acceptable standards. Xenon arc lamps have been used to some degree in combination with an elliptical reflector in schlieren projection systems. In those systems, typified by the conventional projection system produced by the Dojun Koki Co. of Japan, it is desired to provide even illumination over a relatively wide field, whereas the instant invention is concerned mainly with a combination which will provide an effective point light source.

In the art of simulators and trainers there is a need for high intensity light source and condenser systems which can efficiently provide light propagation in a vertical sense, either upwardly or downwardly. One such need is in a point light source vertical projection system (see U.S. Pat. No. 3,135,160 for a horizontally oriented point light source system). Another is in conjunction with a panoramic or around the horizon projection system utilizing an annular transparency and requiring a vertical axis condenser system and illumination of a cone between 25° and 85° from the condenser axis.

SUMMARY OF THE INVENTION

With the foregoing in mind, it is a principal object of this invention to provide, in combination with a projection lamp (such as a xenon lamp) which requires burning in an approximately vertical position, a condenser system which will utilize the light emitted around the entire equatorial zone and brought out in the direction of the longitudinal axis of the lamp, that is in a vertical direction.

As another object the present invention aims to provide an improved light source or condenser arrangement utilizing a generally elliptical mirror having a central opening for accommodating a vertically extending, elongated portion of a projection lamp, the mirror having first and second focal points along the vertical axis thereof, the light emitting portion of the lamp being centered at the first focal point, and a stop or lens being located at the second focal point.

Still another object of this invention is the provision of a light source and condenser of the foregoing character which is relatively simple and inexpensive to manufacture and to align or adjust, and which compensates for a rather large source of emission and which is aspherical in shape.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention will become apparent from the following detailed description when read in conjunction with the accompanying sheet of drawings forming a part of this specification, and in which:

FIG. **1** is a diagrammatic illustration of an improved, vertical axis condenser system embodying the present invention, showing the same as used in conjunction with a point light source projection system;

FIG. **2** is a graphical illustration showing the relationship between a stop element of the system of FIG. **1** and the illumination in the plane of that stop element; and

FIG. **3** is a diagrammatic illustration of another embodiment of the invention as used with panoramic projection system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the form of the invention which is illustrated in FIG. **1** in association with a point light source projection system **10**, there is provided a xenon arc projection lamp **12**. The lamp **12** is of conventional construction including a transparent envelope **14** having diametrically opposed tubular portions **14***a*, **14***b* having their long axes arranged vertically, or substantially so. These axes may be said to define the vertical axis **15** of the lamp **12**. A tungsten electrode or anode **16** is supported by a lead **18** which extends vertically through the tubular portion **14***a*. A tungsten electrode or cathode **20** is supported by a lead **22** which is axially aligned with the lead **18** and extends through the tubular portion **14***b*. The envelope is filled with the gas xenon at a number of atmospheres pressure. Upon an appropriate starting

pulse, and thereafter with a direct current voltage on the order of 200 volts applied via lines L_1 and L_2 across the leads **18** and **22**, a bell shaped arc A is established and maintained between the electrodes **16** and **20**. The arc A emits an intense white light, suitable for projection, through the side walls of the envelope **14**.

Surrounding the projection lamp **12** is an elliptical concave mirror **30** having an inner reflecting surface **32** which constitutes a portion of a surface of revolution about an axis which is coincident with the vertical axis **15** of the lamp **12**. The elliptical mirror **30** has a central aperture or opening **34** through which the bulb portion **14***a* extends and is configured so that a first focal point F_1 thereof is located at the center of the arc A, while the second or remote focal point F_2 is located along the axis **15** at a substantial distance below the lamp **12**.

There results from the aforedescribed combination of the lamp **12** and the elliptical mirror **30** a conical zone of occlusion which subtends an angle *a*, and a zone of illumination which subtends a maximum angle *b*. The elliptical mirror **30** is selected to have the focal point F_2 far enough down the axis **15** that the ratio of the angle *a* to the angle *b* is approximately as 25 is to 85, or 0.295.

The rays **40** emanating horizontally from the arc A will be anastigmatic in their reflection and mergence at the remote focal point F_2. These rays may be considered the central or chief rays of the unoccluded part of the illumination cone. The resulting image of the arc A, if formed by the chief rays **40** alone, would also be free of spherical aberrations. However, rays outside the chief rays, such as rays **42** and **44**, will be subject to astigmatism. There will also be coma present in the image at F_2. These aberrations may be compensated for in the lens system **46** which serves principally to render a reduced and better defined image A′ of the arc A, which will better serve as essentially a pin-point light source for projecting a scene, recorded on a transparency **48**, through the projection system **10**. The lens system **46** follows well known principles for a lens triplet and need not be described in detail.

In order to prevent stray light from entering the system and degrading the quality of the image A′, an aperture **50** of diameter D is defined by a stop member **52** arranged in the plane of the focal point F_2. Since a large amount of heat is produced at F_2, the stop member **52** is advantageously formed of a high melting point metal such as tantalum or titanium. As is illustrated by curve **54** in FIG. **2** the intensity of illumination in the plane of the stop member **52** and second focal point F_2 is characterized by a plateau, the width of which is determinative of the diameter D of the aperture **50**.

A particular advantage of the described system over a conventional imaging system is that the light distribution in the image at F_2 has rotational symmetry, thus overcoming the conventional strong non-uniformity of the arc image in a conventional system.

Referring now to FIG. **3**, in which reference numerals corresponding to those in the foregoing description identify corresponding parts, there is illustrated another embodiment of the invention which is shown in conjunction with panoramic projection means including a transparency **60** and panoramic projection optics **62**. The transparency **60** and optics **62** form no part of the invention per se. Suffice it to say that in the projection system with which this embodiment of the invention is most advantageously used, the transparency **60** comprises an azimuthal scene recorded in annular form, and when properly illuminated the optics **62** project the scene onto a suitably curved screen **64**.

In this embodiment, the lamp **12** and elliptical mirror **30** are substantially the same as described earlier. However, the lens means **46** and stop member **52** are replaced by a negative lens means **68** deployed ahead of the focal point F_2. The lens means **68** serves to defocus the converging rays represented by **40**, **42**, and **44** and to form them into parallel rays. The resulting light constitutes a condensed beam **70** of light which is annular in section in that it surrounds a central occluded zone **72**.

Again, stray light is excluded by an aperture **74** defined by a stop member **76**. The light beam **70** of annular section is of a size to correspond to the annularly recorded scene on the transparency **68**, thereby obtaining the most efficient use of the light output of the lamp **12**.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a vertical axis condenser system for use with a high intensity light source such as a xenon arc lamp:

a portion of an annular, concave, ellipsoidal mirror having a central opening concentric with the major axis of said mirror;

said mirror being disposed with said major axis vertically oriented, and said mirror having first and second focal points on said axis, said first and second focal points being adjacent and remote, respectively, with respect to said mirror;

said mirror being disposed about a high intensity light source with the light source at said first focal point, said mirror projecting rays of light emitted by the light source into a cone of illumination which forms a first image of the source at said second focal point and a cone of occlusion within said cone of illumination;

said first image being characterized by a high intensity central portion;

stop means formed of high melting point material disposed in a plane extending through said second focal point and normal to said axis, said stop means having an aperture therein with its center on said axis said aperture having a diameter D which limits the passage of light from the light source to the high intensity central portion of said first image; and

lens means disposed beyond said second focal point having its rear focal point at said second focal point and operative to form a reduced second image at a third focal point along said axis, said reduced second image being only of the light transmitted by said aperture whereby said reduced second image is effective as a point light source for use in point light source projection means.

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