June 13, 1967 G. R. BIRD ET AL 3,325,666

INERT LAMP REFLECTOR

Filed July 24, 1964

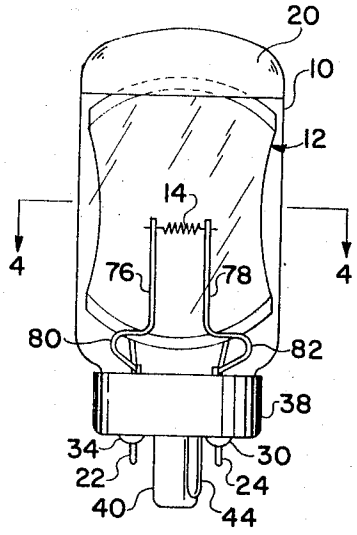


FIG. 1

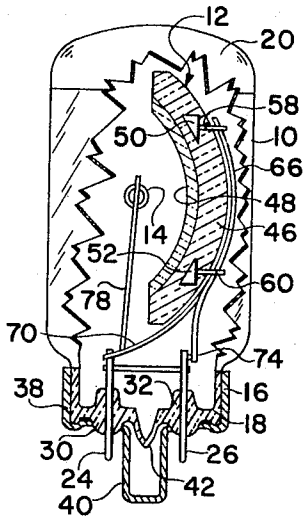


FIG. 2

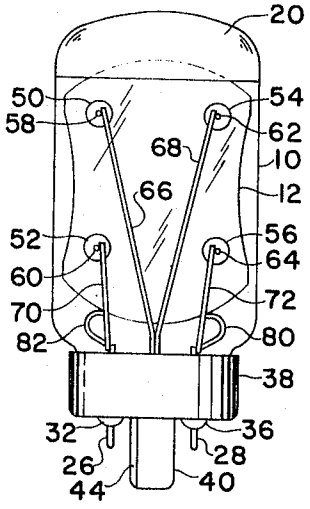


FIG. 3

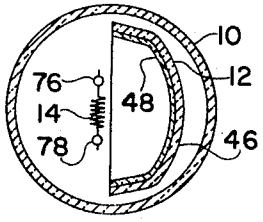


FIG. 4

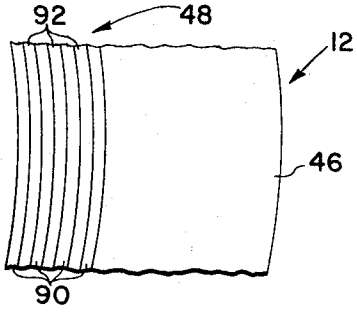


FIG. 5

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INERT LAMP REFLECTOR

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This invention relates to electric incandescent lamps and more particularly to lamps adapted or designed to project carefully controlled or substantially collimated light beams such, for example, as slide or moving-picture projection lamps, photoflood lamps, and the like.

A principal object of the present invention is to provide a new and improved incandescent lamp adapted to project a beam of light in a predetermined direction and comprising an enclosure or bulb having an electrical energy-translation element or filament sealed therein and a curved reflector so positioned within the bulb as to reflect light emitted by the filament.

Another object of the invention is to provide an incandescent lamp of the above type in which the filament comprises tantalum carbide and the envelope of the lamp includes a carbon-containing atmosphere.

Still another object of the invention is to provide a dichroic reflector which will resist heat and the reactive gases of the lamp atmosphere.

A still further object of the invention is to provide an incandescent lamp of the character described in which the reflector comprises a plurality of layers of alternately high- and low-refractive-index substances, the high-refractive-index substance comprising a refractory metal oxide selected from the group consisting of tantalum pentoxide, thorium dioxide, zirconium dioxide and hafnium dioxide.

Other objects of the invention will, in part, be obvious and will in part appear hereinafter.

The invention accordingly comprises the products possessing the features, properties and the relation of elements which are exemplified in the following detailed disclosure, and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing wherein:

FIGURE 1 is a front view of one embodiment of a lamp according to the invention;

FIG. 2 is a side view, with parts cut away, of the lamp of FIGURE 1;

FIG. 3 is a rear view of the lamp;

FIG. 4 is a sectional view of the lamp of FIGURE 1, taken along the lines 4—4; and

FIG. 5 is an exaggerated, diagrammatic fragmentary sectional view of the reflector of the present invention.

Electric incandescent lamps provided with an internal reflector which is spaced or separated from the lamp bulb or envelope are well known. Lamps of this type which are adapted for providing or projecting a high concentration of light energy are described, for example, in U.S. Patents 2,979,634 and 2,980,818. In these patents, there is disclosed a projection lamp or the like which comprises a light-transmitting bulb having supported therein a filament and a reflector of the desired curvature which is separate from the bulb. The filament and the reflector are aligned or positioned with respect to one another so as to

be very close and in reflecting relationship. In order to give good life, the lamps are preferably filled with an inert gas such as nitrogen to reduce evaporation from the filament which is usually a coiled tungsten wire.

It is very desirable that lamps of the above type provide as high a brightness and efficiency as is possible. The brightness and efficiency of lamps utilizing a tungsten incandescent body or filament is no greater than that obtainable at the melting point of tungsten which is about 3380° C. Brightnesses and efficiencies higher than that obtainable with tungsten can be obtained with lamps of the above type by utilizing a filament comprising tantalum carbide (TaC). However, when such a carbide filament is utilized, it is necessary to provide a lamp atmosphere comprising sufficient carbon to prevent the carbide filament from deteriorating or decomposing at operating temperatures into an undesirable subcarbide or free metal and carbon. This lamp atmosphere, which can be termed a carbide-maintaining atmosphere, can be provided by a number of materials or sources. For example, satisfactory atmospheres can be provided by initially introducing into the bulb a gaseous mixture comprising a hydrocarbon and hydrogen or a hydrocarbon, hydrogen and nitrogen or a halogenated hydrocarbon and hydrogen or the like. Incandescent lamps having a filament comprising tantalum carbide positioned within a carbide-maintaining atmosphere are more fully described, for example, in U.S. Patents 2,596,469, 3,022,438 and 3,022,439.

It has been found that while projection lamps or the like provided with a heretofore suggested reflector and a filament comprising tantalum carbide produced very desirable brightness and efficiencies, they had relatively short useful lives due to the rapid and severe deterioration of the reflector. This deterioration of heretofore proposed internal lamp reflectors is believed to be due to the very high operating temperatures to which the reflector is subjected and to the attack or action upon the reflector, at elevated temperatures, of reactive gases such, for example, as reducing gases, halogens or the like, which are present in the carbide-maintaining atmosphere.

In the present invention, an incandescent lamp is provided which contains an internal reflector that is highly resistant to heat and to attack by reactive gases which may be present in the lamp bulb. In one embodiment of the invention, there is provided an incandescent lamp which comprises a bulb having a light-transmitting portion, the bulb having supported or mounted therewithin, in reflecting relationship, a filament and a curved internal reflector which comprises a plurality of layers of alternately high- and low-refractive-index materials, the high-refractive-index material comprising a refractory metal oxide selected from the group consisting of tantalum pentoxide, thorium dioxide, zirnconium dioxide and hafnium dioxide. The low-refractive-index material can be any one of many commonly used in the production of interference filters, for example, an alkali metal or alkaline earth metal fluoride. Thus, one preferred reflector comprises a reflecting surface or coating composed of an odd number of layers of alternately high and low indices of refraction deposited or laid down upon the concave surface side of a suitable support such as, for example, glass, the high-refractive-index layer comprising tantalum pentoxide and the low-refractive-index layer comprising a metal fluoride such as magnesium fluoride.

In one preferred embodiment of the invention, an incandescent lamp of the above type is provided wherein the bulb includes a filament comprising tantalum carbide and a carbon-containing atmosphere for maintaining the desired carbide filament structure at operating temperatures.

While the drawings illustrate a specific lamp or structure, that is, a projection lamp for, say, a slide or motion-picture projector, and the invention will be described in connection with this lamp, it should be understood that the invention may, advantageously, be employed in conjunction with incandescent lamps generally, for example, photoflood lamps or other related structures adapted to project a high concentration of light energy.

Referring now to the figures, a tubular bulb or envelope **10** having a light-transmitting portion encloses a reflector **12** and a filament **14** which is positioned at or near the focus of the reflector **12**. The bulb which is generally of a high-transmissive materal such as glass is sealed at the neck portion **16** thereof to a disc or wafer-like glass header **18**. As illustrated, the neck portion **16** of the bulb is of a smaller diameter than the main portion of the bulb. The other end of the bulb is rounded, as shown, and can be covered by a coating **20**, which can be of a colored or black ceramic or enamel glaze suitable for sealing to the bulb. The use of this coating increases the radiation of heat from the top of the bulb so as to prevent overheating of the bulb.

In order to provide supports and external contacts, electrically conducting lead-in wires or pins **22**, **24**, **26** and **28** of an appropriate metal are sealed through individual nubs **30**, **32**, **34** and **36** of the glass header **18**.

A metal cap **38** is attached to the neck **16** of the bulb **10** by a suitable cement, and carries an outwardly projecting piece **40**, which covers and protects the sealed exhaust tube **42**, and, together with the keyway **44**, also serves to center the lamp in its socket. The glass nubs **30**, **32**, **34** and **36** pass through holes in the bottom of the cap **38** so that the lead-in contact wires **22**, **24**, **26** and **28** are insulated from the cap.

The reflector **12** comprises a curved support or base member **46** having a convex and a concave side. A light-reflecting coating **48** is provided on the concave side of the reflector **12**. The nature of the light-reflecting coating or surface will be discussed in detail hereinafter. The convex back surface of the support **46** which can, for example, be of glass, is provided with nubs **50**, **52**, **54** and **56**. A short wire **58**, **60**, **62** and **64** extends out of each nub, and is sealed therein. Support wires **66**, **68**, **70** and **72** are secured to the aforementioned short wires, one of the latter wires to each support wire. The longer support wires **66** and **68** extend downwardly and toward each other, being curved slightly to conform to the curvature of the reflector support **46**, and are attached at their bottom ends to a metal cross-wire **74**, which extends between the lead-in wires **26** and **28**, being secured to each of them. Wires **60** and **64**, extending from nubs **52** and **56**, respectively, are affixed to support wires **70** and **72**. The support wires **70** and **72** curve downwardly around the convex back of the support **46** and are joined to lead-in wires **22** and **24**, respectively.

In order to support and make electrical connections with the filament **14**, electrically conductive metal support wires **76** and **78** are secured, e.g., welded, to the ends thereof, one wire to each end. The filament support wires **76** and **78** are curved to form bights **80** and **82** at their bottom ends and are attached near these ends to the support wires **70** and **72**, respectively, which, as above stated, are attached to the lead-in wires **22** and **24**.

In addition to the above-described means for firmly supporting the reflector **12** and the filament **14** within the bulb **10** and in the desired optical relationship or alignment with each other, other well known support means may be employed. For example, the reflector can be supported inside the bulb and held firmly in the proper reflecting relationship to the filament in the manner described in U.S. Patent 2,980,818.

As shown in the figures, the elongated coiled filament **14**, to which the reflector **12** is in correct reflecting relationship, is supported within the bulb so that its axis is transversely disposed to the longitudinal axis of the bulb. The concave reflector **12**, supported in spaced relation inside the bulb **10**, is shown as having its axis transverse to that of the filament and to the longitudinal axis of the bulb, so as to reflect or direct light from the filament **14** in the direction of maximum light emission of the filament outwardly through the tubular walls of the bulb. Substantially elliptical or spherical reflectors can be utilized, the positioning of a filament with respect to such reflectors to obtain desired collimated light beams being well known in the art.

In order to get as large a useful reflecting surface as possible into a tubular bulb, or into a bulb having a circular opening through which the reflector is to be inserted, the perimeter of the reflector **12** is made non-circular, that is, the reflector has its sides cut off to a slightly curved configuration as shown in the figures. The reflector can, appropriately, be cut off at each side in a plane at about 15° to the plane of the front of the reflector. The specific reflector configuration shown in the drawing is more fully described in U.S. Patents 2,980,818 and 2,994,799.

The filament can be of any desired configuration as, for example, straight, coiled, crimped, coiled-coil or otherwise shaped. Preferably, however, either an elongated coiled filament or a coiled-coil filament is employed in the lamps described. The filament size is preferably such that it is small compared with the reflector.

The filament may comprise an electrically-conductive refractory material such as tungsten, in which instance the lamp is usually provided with a suitable pressure of of an inert gas such as nitrogen, argon, or the like. Preferably, however, the electrically incandescent body or filament comprises tantalum carbide since it provides a higher brightness than conventional tungsten filaments. When a filament comprising tantalum carbide is utilized in a lamp of the character described, the lamp must be provided with a suitable carbon-containing atmosphere in order to maintain the desired carbide filament structure at operating temperatures. If the lamp is devoid of or contains insufficient carbon in the atmosphere at operating temperatures, decarburization of the filament takes place and results in the rapid deterioration and failure of the filament.

Heretofore, it has been proposed to employ an atmosphere the elements of which interact with each other and with the carbide filament so as to substantially retard or prevent decarburization of the tantalum carbide filament. The preferred carbide-maintaining atmosphere can be provided by initially introducing into the lamp a suitable pressure of a gaseous mixture comprising hydrogen and hydrocarbon such as acetylene, ethylene, benzene, etc., or a gaseous mixture comprising hydrogen and a halogenated hydrocarbon such as carbon tetrachloride, trichloroiodomethane, etc., or a gaseous mixture comprising hydrogen, a hydrocarbon and nitrogen. An inert gas of low heat conductivity such, for example, as argon can also be included as a gaseous lamp filling. Incandescent lamps comprising a tantalum carbide filament positioned within a carbide-maintaining atmosphere are known in the art as shown, for example, in U.S. Patents 2,596,469, 3,022,438 and 3,022,439. Accordingly, the teachings thereof, particularly with respect to the carbide-maintaining atmospheres which can be utilized, are incorporated by reference herein.

The use of a filament comprising tantalum carbide in projection lamps, or the like, is particularly desirable since its very high melting point permits the lamp to be operated at temperatures which are well above the melting

point of tungsten. The higher temperatures produce a higher or greater brightness than that obtainable with conventional filaments such as tungsten. It has been found, however, that heretofore-proposed internal lamp reflectors are severely attacked and quickly rendered useless when subjected to the higher operating temperatures associated with carbide-maintaining atmospheres. The severe and rapid deterioration of the reflector can be attributed to the very high temperatures generated by the closely located filament and to the action at the aforesaid temperatures of reactive gases, e.g. reducing gases, halogens or the like, which are present in the carbide-maintaining atmosphere.

In the present invention, an internal lamp reflector is provided which is highly resistant to heat and to attack by reactive gases, particularly reducing gases and halogens which are present in the carbide-maintaining atmosphere. The present reflector may, appropriately, be termed a dichroic reflector, in the sense that it reflects light rays of one wavelength and transmits light rays of another wavelength, or a multilayer dielectric reflector, in the sense that its layers are individually optically transparent but together reflecting. The reflector comprises a curved support **46**, which can be of glass, quartz, or the like, having a multilayer light-reflecting coating or surface **48** on the concave side thereof. The light-reflecting coating **48** comprises a plurality of layers **90** of a high-refractive-index material or substance alternated with a plurality of layers **92** of a low-refractive-index material or substance. The high-refractive-index material is a white refractory metal oxide and more particularly a refractory metal oxide selected from the group consisting of tantalum pentoxide (Ta_2O_5), thorium dioxide (ThO_2), zirconium dioxide (ZrO_2) and hafnium dioxide (HfO_2). The low-refractive-index material can be any one of the many commonly used in the production of reflection-reducing coatings and dichroic filters, for example, a metal fluoride. In one embodiment of the invention the low-refractive-index material is selected from the group consisting of the alkali metal and alkaline earth metal fluorides. Among the suitable metal fluorides which can be used, mention may be made of lithium fluoride (LiF), sodium fluoride (NaF), calcium fluoride (CaF_2), magnesium fluoride (MgF_2) and cryolite (Na_3AlF_6).

The dichroic reflector of the present invention can be formed by utilizing well-known vacuum coating techniques for the deposition of thin films or layers of dielectric materials. Through variation of the multilayer coating, the transmission and deflectivity characteristics of the reflector can be varied. The thickness, number, sequence and composition of the individual layers are carefully controlled so as to provide a reflector which will substantially reflect most of the light rays from the filament which are incident thereupon and yet pass or transmit a large part of the heat radiation. In other words, there is provided a reflector having a reflectivity in the visible region which is substantially as high as possible and a transmission of the radiation above about 7000 A., that is, in the infrared which, also, is substantially as high as possible.

The reflector preferably comprises a coating composed of an odd number of thin optically-dielectric layers. In one embodiment both the layer located adjacent to the support **46** and the outermost layer of the reflecting coating, that is, the layer closest to the filament, comprise or are principally composed of a high-refractive-index material. The reflector can comprise, for example, three, five, seven, nine, etc. layers, the greater number of which are of high refractive index, e.g., comprising a refractory metal oxide, heretofore noted.

While the thicknesses of the layers can be varied, they are, preferably, of a thickness of the order of a quarter wavelength. Moreover, while all of the high-refractive-index layers preferably comprise a given material and all of the low-refractive-index layers preferably comprise another given material, it should be mentioned that more than one material can be utilized in the makeup of th high- or low-index-layers of the reflector. The thickness number, sequence and composition of the layers are readi ly determinable by one skilled in the art, once the reflect ing and transmitting characteristics desired in the reflecto are decided upon.

In one preferred embodiment of the invention the re flector includes a plurality of layers of alternately high and low-refractive-index materials, the high-refractive-in dex dielectric material comprising tantalum pentoxide an the low-refractive-index dielectric material comprising metal fluoride such, for example, as magnesium fluoride o cryolite. It has been found that such a reflector is nc appreciably affected by high operating temperatures or b reactive gases present in the lamp atmosphere.

Attempted deposition of layers of the preferred tanta lum pentoxide by evaporating it in a vacuum and permit ting the vapors produced thereby to condense upon th reflector have often resulted instead in the formation o undesirably colored layers comprising lower tantalun oxides. It has been found, however, that the desired es sentially colorless tantalum pentoxide layers can b achieved by several methods. For example, after the dep osition of an undesirably colored, oxygen-deficient tanta lum oxide layer, such a layer can be converted to tanta lum pentoxide by suitably heating it in an atmosphere con taining oxygen, that is, in air. The production of tantalun pentoxide layers can also be assured by heating the tanta lum oxide deposit during the formation thereof. A suitabl pressure of an oxygen-containing gas is introduced int the system during such coating and heating in order t facilitate the formation of a tantalum pentoxide deposi It is also possible to first deposit all the layers and the heat the composite structure in an oxygen-containing at mosphere to convert any lower tantalum oxides preser therein to the desired tantalum pentoxide form. The abov methods can also be utilized in connection with the forma tion of layers of the other preferred refractory meta oxides, above mentioned.

Since certain changes may be made in the above proc ucts without departing from the scope of the inventio herein involved, it is intended that all matter containe in the above description or shown in the accompanyin drawing shall be interpreted as illustrative and not in limiting sense.

What is claimed is:

1. An incandescent lamp comprising a filament whic comprises tantalum carbide and is adapted to operate a a very high temperature, a concave multilayer reflector i reflecting positional relationship to said filament, a seale bulb having a light-transmitting portion enclosing sai filament and said reflector, and a carbon-containing at mosphere also contained within said bulb and adapted t maintain the tantalum carbide structure of said filamer at said high operating temperature, said reflector bein adapted to reflect light in a direction forwardly throug said light-transmitting bulb portion and transmit infrare radiation in a generally reverse direction and comprisin a curved support, a plurality of layers of alternately high and low-refractive-index substances which are of type highly resistant both to heat radiating from said filamer and to attack by any reactive gases present in said atmos phere, said high-refractive-index substance comprising refractory metal oxide selected from the group consistin of tantalum pentoxide, thorium dioxide, zirconium d oxide and hafnium dioxide.

2. An incandescent lamp according to claim **1** wherei the low-refractive-index substance is selected from th group consisting of the alkali metal and alkaline eart metal fluorides.

3. An incandescent lamp according to claim **1** wherei said carbon-containing atmosphere comprises a hydrocai bon and hydrogen.

4. An incandescent lamp according to claim **1** wherei said carbon-containing atmosphere comprises a hydrocai bon, hydrogen and nitrogen.

5. An incandescent lamp according to claim 1 wherein said carbon-containing atmosphere comprises a halogenated hydrocarbon and hydrogen.

6. An incandescent lamp, as defined in claim 1, wherein said high-refractive-index substance comprises tantalum pentoxide.

7. An incandescent lamp, as defined in claim 6, wherein said low-refractive-index substance is selected from the group consisting of the alkali metal and alkaline earth metal fluorides.

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