Jan. 20, 1942. U. W. DOERING 2,270,276

ELECTRIC GAS AND VAPOR DISCHARGE LAMP FOR LIGHTING PURPOSES

Filed Sept. 21, 1938

Fig. 1

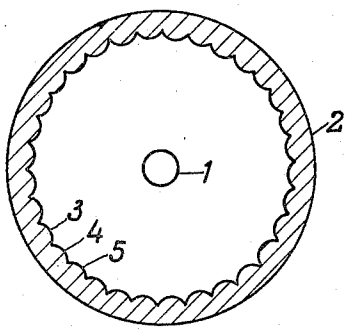


Fig. 3

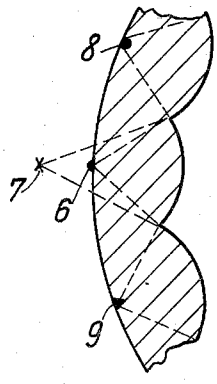


Fig. 2

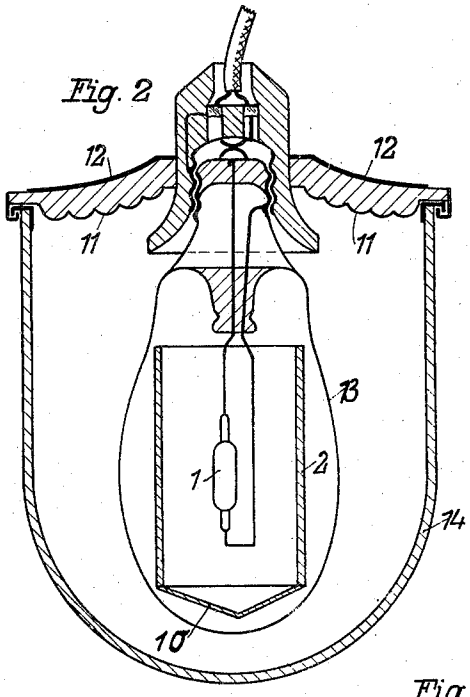


Fig. 4

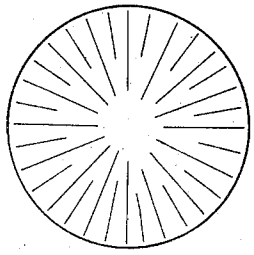


Fig. 5

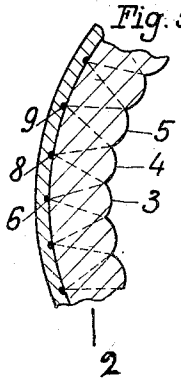


Fig. 6

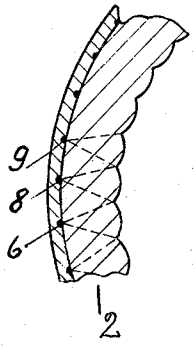
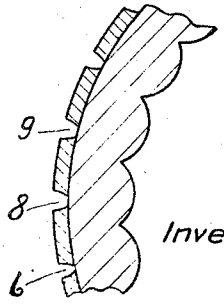


Fig. 7



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ELECTRIC GAS AND VAPOR DISCHARGE LAMP FOR LIGHTING PURPOSES

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5 Claims. (Cl. 176—122)

This invention relates to electric discharge lamps more particularly to those adapted to emit light rays, and having an electric gas or vapor discharge operated therein between suitable electrodes, this discharge forming the primary source of the rays emitted.

Now, in those lamps simultaneously with the emission of the useful light rays, a large portion of the energy is emitted in the form of ultraviolet rays which will not add to the lighting power of the lamp. Furthermore some of the visible rays emitted may be abundant distorting the color impression of the lamp, or of short wave lengths, such as blue or violet, being visible in itself, however, not adding much to the lighting power of the lamp.

Now it has been made known to transform the ultraviolet rays emission or a surplus of violet and blue rays emitted by many types of gas and vapor discharge tubes especially mercury lamps, into visible light by means of fluorescent materials. For this purpose the metal vapor lamp was covered by fluorescent materials, or fluorescent glasses were used, or enclosing containers, envelopes or reflectors were used, which were fluorescent or covered by fluorescent materials.

This known method has not fulfilled the expectations connected therewith, mainly for the reason, that the visible emission emitted by the vapor lamp was absorbed by the way of being reflected from a fluorescent layer or even more by passing such layers. Even fluorescent materials selected with respect to a small absorptive property for visible light, may be able to improve the color of the light to some extent, however, they are unable to improve the total economy of the emission to a useful extent.

It is the object of this invention to eliminate these disadvantages and to combine a suitable primary source of radiation with suitable fluorescent materials in such a manner, that invisible or superfluous rays will be transformed to additional radiation improving the light output and color, without diminishing the primary radiation with respect to its intensity or color distribution. According to the present invention the rays emitted by the gas or vapor lamp will be separated by optical means into a visible and into an invisible fraction. Furthermore, the visible fraction will be emitted and transmitted to the outside directly, and therefore practically without losses, without being diminished by any passage through or reflection from fluorescent layers, and without being altered undesirably with respect to its wave length. On the other hand it will be taken care, that the ultraviolet rays, may be also the blue rays, at any rate all rays determined to be transformed, will be radiated on fluorescent materials exclusively, so that they will be transformed thereby into visible radiation. By doing so, an additional amount of visible radiation will be generated without diminishing the primary visible radiation, and besides an improvement of the color and an absolutely improved total economy will be secured. This process of transformation of the ultraviolet rays into complementing or at any rate additional visible rays is even achieved with a considerably improved output in the absence of visible rays or heat radiation, simultaneously striking the fluorescent surfaces. The separation of the two groups of rays, as emitted by the primary source of radiation, can be reached by various optical means, which have the property of a differing refractive, reflective or dispersive power with respect to varying wave lengths, and which will enable thereby a local separation of the rays, such means being lenses (e. g. spherical or cylindrical lenses) prisms, by making use of the angles of total reflection, different for differing wave lengths or by similar means.

The invention will be more clearly understood by referring to the accompanying drawing representing by the way of example different sectional views of the lamp.

Fig. 1 is a cross-section of the lamp.

Fig. 2 is a section in a plane perpendicular to the first through a similar lamp having a plurality of envelopes.

Fig. 3 is a section through a ray transforming portion of the wall.

Fig. 4 is a projection of a part of the ray transforming envelope.

Figs. 5, 6 and 7 are sections through other ray transforming portions of the wall or envelope.

In Figure 1 reference character 1 represents the gas and vapor discharge tube, a high pressure mercury vapor lamp preferably. With respect to the present invention it is advantageous to apply in such lamps pressures of several atmospheres up to several hundred atmospheres, in order to reduce the electric arc serving as the primary source of light optically to a point-like or filament-like form. Furthermore, at raised pressure the fraction of invisible ultraviolet radiation, which can be transformed according this invention, is increased at the expense of the invisible, however, not transformable, infrared radiation. The lamps may be provided, as has been made known, with mercury elec-

trodes, preferably however with activated incandescent electrodes; metal vapors such as cadmium or zinc may be introduced instead or additional to the mercury. Other types of electrical arcs, condensed discharges having an especially strong ultraviolet radiation as compared with the low development of heat, or spark discharges may be used as well in open air or closed metal vapor lamps, or in lamps containing permanent gases, such as rare gases, hydrogen or nitrogen. The wall of such lamps is made preferably permeable for ultraviolet rays. It may consist e. g. of quartz or glasses containing a high percentage of silica, or of phosphate glasses or boracic glasses, which may be not even weatherproof. The arc lamp is surrounded by an envelope **2**, which is preferably of cylindrical form if to be applied to lamps having elongated arcs therein. Additional envelopes, which may be present are represented by **13** and **14** in Figure 2.

The lamp and the envelope mentioned in the first place have a cross section as shown by Figure 1. The envelope **2** on its surface turned to the primary source of radiation is studded with numerous lenses **3**, **4**, **5**, . . . which are shown by Figure 3 in a magnified order. In the following a construction having a large number of lenses combined to a kind of grating or lattice is described merely as an example. Notwithstanding, the invention may be realized also by singular lenses, not connected to each other, or by other kind of optical means enabling a local separation of the different wave lengths. On account of its larger rate of refraction the short wave radiation hitting any cylindrical lens, e. g. the lens **3** in Figure 3 will be concentrated in the point **6**. Advantageously conditions are chosen so that this point **6** becomes situated in the plane represented by the outer surface of the envelope. The long wave visible radiation will not be concentrated in the point **6**, but transmits the surface plane by a broad area and would not become focussed but in a point **7**, which is situated outside of the envelope.

At the point **6**, which with spherical lenses is a real point, with cylindrical lenses represents a long line, the fluorescent materials are provided in a layer of suitable thickness. They transform the ultraviolet radiation concentrated on them into visible radiation, whereas the transmission of the primary visible radiation is merely slightly prohibited because of their small extension. The fluorescent materials may be deposited on the outer glass wall. They may be filled into small grooves or furrows provided at these places as indicated at **8** and **9**. With the latter embodiment a rather deep but very narrow bore or a corresponding deep and narrow incision is provided within the material of the envelope, which is filled with fluorescent materials. As can be seen the transmission of the visible radiation by the latter arrangement of the fluorescent materials is almost not hindered at all. With elongated forms of the primary source of radiation cylindrical lenses will be employed, arranged in the same direction and provided on an envelope possibly cylindrical as shown. Thereby ultraviolet images of the arc tube will be caused on the outer surface of the cylinder, all of them situated within the same plane. With short point-like arcs spherical lenses are more suitable as may be understood easily. In this case the envelope carrying the lenses should have possibly spherical form, so that the numerous single images of the primary source of radiation will be situated within the plane of the surface of the envelope. The wall of the envelope is chosen so thick corresponding to the refractory power of its material and the distance between primary source and wall of the envelope, that the ultraviolet radiation will be focussed in the right plane, i. e. where the fluorescent material is arranged. A mercury arc lamp of high pressure has a very strong emission between 3000 Å. and 3200 Å. and between 3600 Å. and 3700 Å. As can be seen these wave lengths are much shorter than the neighbouring violet radiation at 4000 Å. and even considerably much shorter than the useful main rays at 5500 Å. and 5800 Å. On account of the strong refraction, the ultraviolet rays will suffer, and the separation is relatively easy to be secured. With mercury lamps or cadmium lamps, for example, it is advisable to concentrate also a large portion of the superfluous violet and blue radiation on the fluorescent materials, whereby the separation from the residual radiation is facilitated even more. It is merely important to provide for the green and yellow rays, with cadmium lamps for the red rays too, to penetrate unhinderede to the outside. However this is easily achieved on account of the small refraction and small convergence which will enable these rays to pass. So, depending on the kind of sources of radiation used, and on the kind of the radiation generated primarily, and on the composition of light to be reached finally, one is able to subject a more or less large portion of the visible radiation to the transforming process. In this case the fluorescent material will be arranged so in the way of the rays having passed the lens, that it is situated within the focus of concentration of e. g. the violet or blue rays. This is achieved, for example, by adapting the thickness of the envelope carrying the lens and the fluorescent material to the distance of said focus. Instead, the effect may be also secured in a somewhat less effective way by increasing the diameter of the spots of fluorescent material. So the light emitted by a mercury vapor lamp can be made a bluish-white, a pure white or even a yellowish-reddish color in a determinable degree.

The fluorescent materials too, will be adapted to the composition of the radiation to be transformed, that is, to the kind of rays emitted by the primary source. For example, the ultraviolet emitted by cadmium vapor differs in its wave length and distribution from that emitted by mercury vapor. The fluorescent materials will be selected so that their ranges of high excitability will correspond to the main emissions of the radiation to be transformed of the primary source. When doing so, it is not necessary any more to care for diminishing absorption of visible rays. So, fluorescent materials, various zinc silicates, especially such consisting of small particles of the size of 1–5 μ, furthermore zinc sulfides, especially such being activated additionally by manganese. Zinc silicate and zinc sulfide combine favorably with arc discharges in cadmium and/or mercury vapor of high pressure. Mercury vapor lamps may be combined for the purpose also of complementing their color with fluorescent materials having a strong red emission such as sulfide of barium activated by copper, sulfide of magnesium activated by manganese, furthermore sulfides, selenides and the like of samarium, praseodymium, erbium or other basic materials. According to this invention even fluorescent materials such as eosine or rhodamine or many dye stuffs fluorescing with

green, yellow or red color can be made use of, which would absorb the yellow and green rays of the primary source. Numerous other suitable fluorescent materials having a good red, orange or panchromatic emission are generally known.

Reference character 2 represents an envelope, which consists preferably of an ultraviolet permeable glass, especially boracic glass, glasses containing phosphates of alumina possibly of highly dispensing property, or of quartz. Organic substances which are permeable for ultraviolet rays, such as suitable kinds of cellon, Cellophane, derivatives of vinyl or the like will suit the purpose too. It is advisable to make the dimensions of the lenses, prisms or the like possibly small, in some cases even not larger than fractions of a millimeter in order to make small the thickness of the wall thereby decreasing the length of the path of the ultraviolet rays within the material of the envelope. If doing so, it will be possible to decrease the thickness of the wall to less than 1 millimeter or fractions thereof and to use ordinary species of glass. Just the same, two concentric envelopes adjusted in their respective positions, may be used, the inner very thin envelope bearing the system or lattice of lenses, the outer envelope, which can serve also as glass-shade, the corresponding system or lattice of fluorescent lines or spots. Discarding with a special envelope the lattice of lenses as well as that formed by the fluorescent materials may be deposited also on the tube or bulb 13 of the lamp (in Figure 2) itself. This one may enclose, as known in the art, the arc tube proper (or the arc itself). With elongated primary sources of radiation the bulb is preferably of the form of a cylinder arranged coaxially to the arc tube. In order to protect the fluorescent materials against effects of the heat, the bulb may be evacuated, however, it may be filled with a rarefied gas too. Omitting a special envelope 13 the lattices of lenses and fluorescent materials in some cases may be provided on an envelope 14 in Figure 2, which may be a part of the ordinary lamp fixture. Preferably it comprises also a reflector 11 functioning advantageously as a separator of the rays' groups and carrying lattices of lenses and fluorescent materials. Covering the fluorescent materials or the respective surface, the reflector has a reflecting metallisation of good reflecting property or a white screen 12. The latter may rest upon directly or at a short distance and form a light permeable intermediate layer. If making use of it, the envelope may be closed at the bottom by a plate or cup 10, being also provided with a lattice of lenses of a form as indicated by Figure 4.

The exact respective position of the numerous lenses which form a lattice of lenses and the grooves containing the materials forming a fluorescent lattice will be secured by blowing, pressing or rolling the glass or other materials into or between forms of corresponding gauge or pattern or between suitable pressing plates or rollers. The cylinder 2 may be made e. g. by rolling a plain plate, cutting it in suitable strips, and finally bending them to a cylinder. The fluorescent materials, after adding suitable binders, will be rubbed or pulverized into the surface, the latter thereafter must be polished so that the materials will exclusively adhere to the grooves or roughened places.

In the following a method may be described by which to provide the fluorescent materials in a simple and suitable manner even in microscopic specks or lines to the right places, and even, if wanted without making use of grooves and the like. In Figure 5 reference character 2 represents the wall of an envelope carrying the lattice of lenses 3, 4, 5 . . . In making the optical system according to this invention, a mixture of materials to form a fluorescent lattice under addition of glue (gelatine) containing chromates, or under an addition of other substances getting tanned or hardened by radiation, being dissolved in water or another kind of solving means, will be deposited on the outer surface of the wall. The plates or finished bulbs or envelopes must be subject thereafter to a strong source of ultraviolet rays under conditions with respect to form, size and distance similar to those under subsequent working conditions, removing the visible light by filters. By this process the ultraviolet radiation will be focussed by the single lenses e. g. in focusses 6, 8, 9 in Figure 5, situated within the plane of the surface of the wall. At these respective points the gelatine becomes hardened and insoluble. The surface thereafter must be washed or brushed mechanically, whereby exclusively the portions hardened by the light and still containing fluorescent materials will be left as points, lines or the like forming a fluorescent lattice. As can be easily understood their localisation corresponds also later on in the finished lamp to the points of highest concentration of the ultraviolet rays, under assumption of the same distance of the lighting source.

A more refined method yielding the fluorescent materials in a pure state without residues of glue is as follows and shown in Figure 6. The first step is to deposit a layer of chromated gelatine on the outer surface of the wall 2 determined to carry the lattice of lenses. Then, by ultraviolet irradiation insoluble portions corresponding to the ultraviolet focusses 6, 8, 9 . . . i. e. a lattice of hardened portions will be generated.

The unhardened gelatine will be removed. The surface thereafter will be covered by a varnish which is chemically or mechanically resistive e. g. hard lacquers or paraffine, thereafter polished, so that the hardened portions of chromate will get uncovered, and treated by acids or alkaline solutions, or if using suitable hard lacquers brushed mechanically. Thereby the chromated portion will be removed, so that the cross-section of the wall is as represented by Figure 7 i. e. showing a lattice of excavated portions. The surface after this, will be covered or rubbed in with the dustlike fluorescent materials, which will settle chiefly at the places 6, 8, 9 . . . which now represent excavated grooves. Thereafter by dissolving means, by burning or evaporating the protective varnish may be removed. So, finally the fluorescent spots will be left arranged in the form of a lattice. Altering somewhat the method the surface may be treated with fluoric acid instead of other acids. This acid will not only macerate away the chromated portions, but will roughen or at prolonged treatment will excavate the respective parts. Then, the whole surface will be cleaned of all traces of lacquer as well as of chromates. It will show thereafter macerated portions according to the former focusses. This lattice of corroded areas may as easily be provided with materials to form a fluorescent lattice.

In an even more simplified manner and without the use of protecting varnishes, one may proceed as follows: The surface may be covered

with a layer of chromates, treated by ultraviolet radiation; a lattice of hardened portions may be created thereby; then, all parts not hardened may be removed; the surface, which has numerous small specks or ridges of chromate, may be soaked in fluoric acid; the surplus may be removed or dried, so that the acid, which will be retained within the portions of gelatine is allowed to develop its macerating action at these places. Afterwards fluorescent materials may be dusted upon or rubbed into the surface and the material which will not adhere to the smooth parts of the surface will be removed therefrom. It is also advisable to add suitable fluorides instead to the gelatine right from the start and to treat thereafter with sulfuric acid which will develop free fluoric acid. The fluorescent lattice, especially if provided on the outer surface may be covered with a highly permeable protective varnish.

What I claim is:

1. An electric gas and vapor discharge lamp for lighting purposes comprising in combination a gas or vapor arc discharge emitting rays of various wave lengths, surrounding refracting optical means, lenses among them, said optical means being adapted to separate and direct ultraviolet rays and visible rays into locally different places, and fluorescent materials capable of transforming ultraviolet rays into visible radiation arranged at the points of highest concentration of the ultraviolet rays.

2. A light emitting electric gas and vapor discharge lamp comprising in combination a mercury arc discharge tube at high vapor pressure, an envelope surrounding said arc discharge, a plurality of lenses provided on the inner surface of said envelope adapted to focus the short wave and ultraviolet radiation at places preferably situated in the plane of its outer surface and different from the focusses of the longer wave, visible radiation therefore unhindered passing by to the outside, and fluorescent materials provided at the places of highest concentration of the short wave and ultraviolet radiation, said materials being adapted to transform the radiation striking them into complementing visible radiation.

3. A light emitting electric gas and vapor discharge lamp comprising in combination a mercury arc discharge tube at high vapor pressure, an envelope of predetermined thickness permeable for light radiation emitted by said discharge tube, said envelope enclosing said discharge tube arranged centrally and axially therein, said envelope being provided with a plurality of lenses arranged on the inner surface thereof in the form of a lattice and adapted to focus the short wave and ultraviolet radiation at places situated in the plane of the outer surface of said envelope and different from the places where the longer wave visible radiation is focussed, and fluorescent materials provided on the outer surface of said envelope at the places of highest concentration of the short wave and ultraviolet radiation for transforming the short wave and ultraviolet radiation into long wave visible light radiation.

4. A light emitting electric gas and vapor discharge lamp comprising in combination a filamentlike mercury arc discharge tube at high vapor pressure, a cylindrical envelope of predetermined thickness permeable for light radiation emitted by said discharge tube, said envelope enclosing said discharge tube arranged centrally and axially therein, said envelope being provided with a plurality of cylindrical lenses arranged in parallel with said discharge tube on the inner surface thereof in the form of a lattice and adapted to focus the short wave and ultraviolet radiation at places situated in the plane of the outer surface of said envelope different from the places where the longer wave visible radiation is focussed, and fluorescent materials provided on the outer surface of said envelope at the places of highest concentration of the short wave and ultraviolet radiation for transforming the short wave and ultraviolet radiation into long wave visible light radiation.

5. A light emitting electric gas and vapor discharge lamp comprising in combination a pointlike mercury arc discharge tube at high vapor pressure, a substantially spherical envelope of predetermined thickness permeable for light radiation emitted by said discharge tube, said envelope enclosing said discharge tube arranged centrally and axially therein, said envelope being provided with a plurality of spherical lenses arranged on the inner surface thereof in the form of a lattice and adapted to focus the short wave and ultraviolet radiation at places situated in the plane of the outer surface of said envelope and different from the places where the longer wave visible radiation is focussed, and fluorescent materials provided on the outer surface of said envelope at the places of highest concentration of the short wave and ultraviolet radiation for transforming the short wave and ultraviolet radiation into long wave visible light radiation.

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