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GROOVED LAMP VAPOR PRESSURE CONTROL

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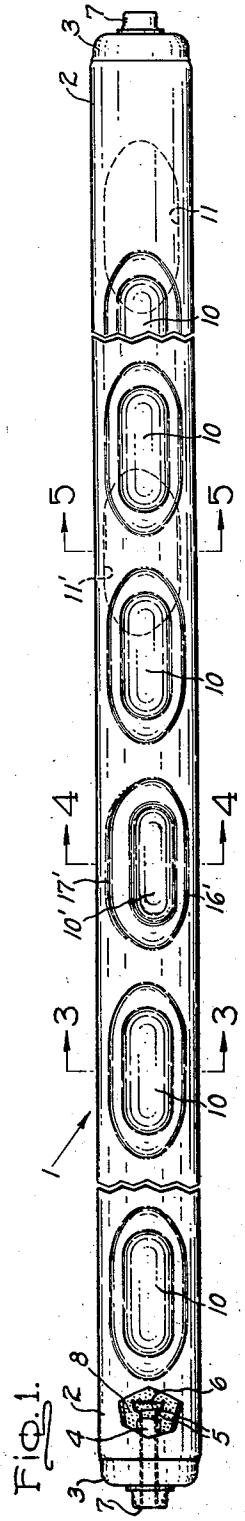


Fig. 1.

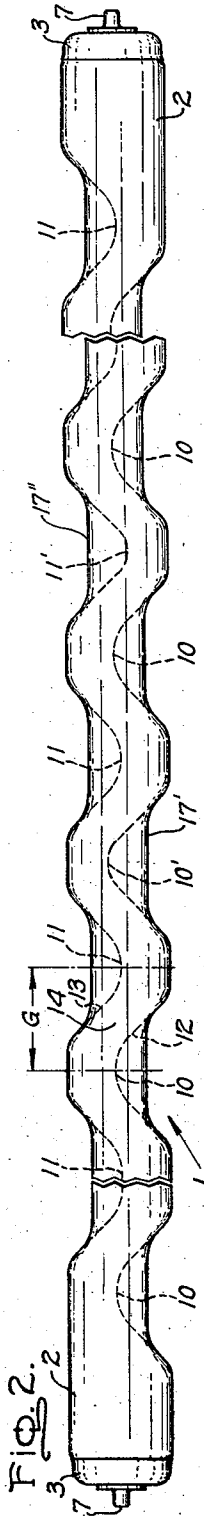


Fig. 2.

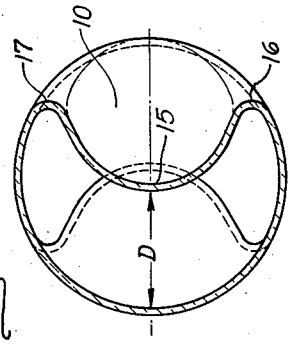


Fig. 3.

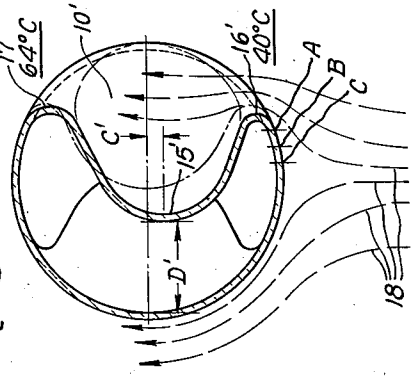


Fig. 4.

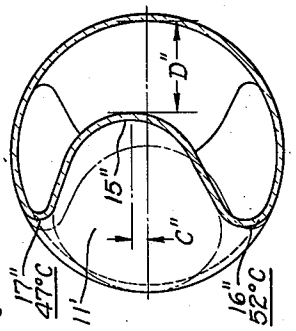


Fig. 5.

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GROOVED LAMP VAPOR PRESSURE CONTROL

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5 Claims. (Cl. 313—109)

This invention relates generally to mercury vapor pressure control in highly loaded low pressure discharge lamps having elongated tubular envelopes. It is particularly adapted to such lamps having a non-circular grooved or kidney-shaped cross section.

In copending application Serial No. 577,017 of Eugene Lemmers, filed April 9, 1956, entitled Tubular Electric Lamps and assigned to the same assignee as the instant invention, now Patent 2,915,664, various forms of re-entrant cross section fluorescent lamps are disclosed. In one form which is sometimes referred to as a double-groove lamp, short sections of groove are provided alternating on opposite sides of the envelope giving it a dimpled or crenelated appearance. The relatively short grooved portions alternating on opposite sides combined with the merging portions in between achieve a high ratio of perimeter to area of the cross section along with a relatively high implosion resistance. This is highly advantageous in resonance radiation lamps, for instance in fluorescent lamps utilizing the resonance radiation of mercury vapor at 2537 A. to excite a phosphor coated internally on the walls of the envelope in order to produce visible light. It permits higher loadings and lumen output per unit axial length at a given efficiency than heretofore possible.

Among the important factors involved in the high efficiency achieved with a grooved contour is the high electron temperature or speed obtained simultaneously with reduced elastic collision losses due to more rapid diffusion of electrons, mercury ions and radiation quanta to the bulb walls. For a given lamp length and wattage, the lamp current is less and the lamp voltage is higher than with a lamp of the same perimeter in a circular cross section, thereby reducing the proportion of both cathode and ballast losses.

An advantageous characteristic of the grooved lamp is its inherent or built-in tendency to regulate the mercury vapor pressure. It is well known of course that departure of mercury vapor pressure from the optimum entails a reduction in efficiency of generation of 2537 A. radiation or in wattage loading capacity at a given current. The drop off is particularly rapid on the low pressure side of the optimum. The optimum partial pressure of mercury vapor is in the range of 1 to 20 microns. The optimum in any given lamp may vary with the kind of starting gas, that is, whether helium, neon, argon, krypton or xenon or mixtures thereof, with the pressure of the starting gas, with the size and shape of discharge cross section, and with the current density. In an envelope of 2⅛" diameter where the starting gas is argon at approximately 3 millimeters pressure, the optimum pressure of mercury vapor for maximum efficiency is about 6 microns corresponding to a temperature of approximately 38° C. to 40° C.

In a grooved lamp, the joining edge walls or rails on either side of the groove are cooler than the remainder of the lamp and their temperature rises more slowly with increase in loading. This effect is due in part to

constriction of the plasma or discharge causing it to draw away from the edge walls or rails as the current is increased, the consequence being proportionately reduced heating, and in part to the configuration which facilitates cooling of the rails. However at very high loadings, for instance loadings in the range of 30 watts per foot and up, even the improved vapor pressure regulating characteristics of grooved discharge lamps may be insufficient to maintain optimum mercury vapor pressure.

The mercury vapor pressure is determined by the coolest point in the lamp. One of the earlier proposals for achieving a cool spot and consisting in blowing cold air at a suitable place on the lamp, has obvious practical disadvantages. Another proposal, consisting in placing heat shields within the lamp behind the cathodes in order to reduce heat radiation and convection flow of heated gas to the ends of the lamp, has the disadvantage that it shortens the effective length of the discharge space and results in unduly long dark ends.

In copending application Serial No. 729,425, filed April 18, 1958, of Eugene Lemmers, entitled Vapor Pressure Control in Discharge Lamps and assigned to the same assignee as the present invention, vapor pressure control centers are achieved by imparting special forms to the envelope walls contiguous to at least one of the grooves and resulting in a constricted zone from which the discharge plasma is substantially excluded. The special form may be an upstanding fin extending upwardly from the bottom wall of a groove and entirely located within the re-entrant groove. Another form consists in a short indentation on one side of the bottom wall of the groove projecting inwardly into the envelope space. Such vapor pressure control centers have the advantage that they avoid projections beyond the general cylindrical configuration of the lamp, thereby facilitating manufacture and reducing the danger of breakage in handling. However further improvements are desirable from the point of view of ease of manufacture, facility of coating with phosphor, and inconspicuousness.

An object of this invention is to provide a double-grooved discharge lamp having a new and improved vapor pressure control feature.

Another object of the invention is to provide a vapor pressure regulating center in a double-groove lamp which is convenient and economical to manufacture, which does not project beyond the general cylindrical configuration of the lamp envelope, and which does not present any special problems or difficulties in the application of the phosphor coating.

Yet another object is to provide a vapor pressure control center in a double-groove lamp which is hardly noticeable except on close inspection.

The invention has occurred in part as a result of the observation of substantial variations in operating characteristics among apparently identical double-groove lamps. Substantial variations have been observed not only from lamp to lamp but even in the same lamp operated with the grooves facing to the sides when rotated 180° on its longitudinal axis. These variations were finally traced to the presence of one or more non-symmetrical grooves accidentally produced during manufacture. A groove offset to one side of the diametral plane through the lamp would result in one of the rails on one side of the groove being narrower than the other. The narrower groove would then operate cooler and this effect would be accentuated if the mounting of the lamp was such as to place the narrower groove lowermost.

These discoveries are utilized in a double-groove lamp in accordance with the invention to provide a mercury vapor pressure control center by means of at least one groove which is asymmetrically located to one side of the diametral plane through the lamp. This results in

a rail portion on one side of the groove which is larger than that on the other side. The discharge plasma then displaced itself towards the larger rail and away from the smaller one. The smaller rail operates at a cooler temperature than the remainder of the envelope and serves as a mercury vapor pressure control center. To achieve the full benefiits of the invention, the lamp is operated with the grooves facing to the sides, that is with the medial plane of the grooves horizontal and the smaller rail located lowermost so as to receive the maximum cooling effect from convection air flow.

In a preferred embodiment, two asymmetric grooves are provided, one on each side of the lamp. These grooves are offset in opposite directions relative to the medial plane with the result that there are two wider rail sections, and likewise two narrower rail portions, on diametrically opposite sides of the lamp. It then becomes immaterial how the lamp is mounted provided the grooves face to the sides; that is the lamp is non-polarized and can be rotated at will 180° in either direction inasmuch as one of the narrower rails is always located lowermost in a position to receive the maximum cooling effect from air convection.

For further objects and advantages, attention is now directed to the following detailed description of an embodiment of the invention and to the accompanying drawing. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

In the drawing:

Fig. 1 is a side elevation view of a discharge lamp embodying a preferred form of the invention, portions of the envelope wall being cut away to shorten the figure.

Fig. 2 is a corresponding plan view of the same lamp.

Fig. 3 is a transverse cross sectional view of the lamp in the plane 3—3 of Fig. 1 but on a larger scale.

Figs. 4 and 5 are transverse sectional views of the lamp in the planes 4—4 and 5—5 respectively of Fig. 1, likewise on a larger scale.

Referring to the drawing and more particularly to Figs. 1 and 2, there is shown a fluorescent lamp of the low-pressure positive column type comprising an elongated vitreous envelope **1**. The envelope is provided with circular or round tube ends **2**, **2** which are annularly reduced or shouldered at their extremities for securing thereto bases **3**, **3**. As shown at the end of the lamp having the cut-away portion, an electrode mount or stem **4** is sealed into each tube end. A pair of lead wires **5** are sealed through the stem and support on their inward projections a filamentary cathode **6** while their outward projections are connected to a pair of contacts located within the projecting boss **7** of the base. The cathode may consist of a coiled coil of tungsten wire provided with an overwind and coated with an activated mixture of alkaline earth oxides, such as the usual mixture comprising barium and strontium oxides.

The lamp contains an ionizable atmosphere including a starting gas or mixture of one or more of the inert rare gases of group 0 of the periodic table at a pressure such as 0.5 to 5 millimeters of mercury for instance argon at approximately 3 millimeters of mercury, or alternatively a mixture of argon and preferably not over 20% neon in this range of pressure. The mercury vapor is provided by a small quantity of mercury exceeding in amount the quantity vaporized during the operation of the lamp wherein the mercury vapor may exert a paritial pressure of approximately 6 microns for optimum generation of mercury resonance radiation at 2537 A. A phosphor coating indicated at **8** on the inside of the envelope converts the 2537 A. radiation into visible light.

The envelope is sometimes described as double-grooved, that is it is provided with spaced indentations or re-entrant portions **10**, **11** on diametrically opposite sides of the generally circular section outer wall giving it a dimpled or crenelated appearance. Otherwise viewed, the indentations **10**, **11** may be considered to be short sections of a longitudinal groove alternating on opposite sides of the envelope. The discharge cross section through the grooved sections of the lamp is in general kidney-shaped as illustrated in Figs. 3 to 5. This configuration has a high implosion resistance and provides in addition good lamp efficiency at high loadings.

The ends **12**, **13** of adjacent grooves alternating on opposite sides of the envelope are sufficiently close to form desirable constricted intermediate zones **14** between them as described in copending application Serial No. 734,551 filed of even date herewith, of Eugene Lemmers and John O. Aicher, entitled "Grooved Discharge Lamp" and assigned to the same assignee as the present invention. The discharge in these zones is restricted or confined in somewhat the same manner as in the kidney-shaped cross section of the groove sections. Thus the discharge operates at a high efficiency even in the intermediate zones and furthermore the arc is lengthened by virtue of the zigzag path which it is constrained to follow. This further increases the percentage of total lamp wattage going into the positive column relative to fixed electrode losses, thereby increasing the efficiency of wattage loading capacity.

In accordance with the invention, at least one of the grooves is offset downwardly from the diametral plane through the lamp as shown at **10'**. Preferably a groove is selected located near the center of the lamp, that is approximately equidistant between the ends. There is a cataphoretic effect in low pressure discharge lamps operated on A.C. and containing argon and mercury vapor, as a result of which the mercury vapor tends to drift longitudinally to the center of the bulb. Accordingly for more rapid attainment of equilibrium it is preferable that the vapor pressure controlling asymmetric groove be located near the center of the bulb. The transport of mercury from the ends to the control center when the lamp is first turned on then occurs more readily, so that equilibrium is attained more quickly.

Fig. 3 illustrates the cross section of the lamp through one of the symmetrical groove sections **10** (or **11**) and Fig. 4 illustrates the cross section through asymmetric groove section **10'**. In Fig. 4, the bottom or inner fold of the asymmetric groove at **15'** is formed to a smaller radius but is pressed in deeper and is displaced downwardly. The bottom is also made slightly shorter so as to compensate for the deeper pressing and maintain approximately the same wall-to-wall spacing in the regions **14**. By way of example, the bottom **15** of the symmetric groove in Fig. 3 may be formed to approximately ⅝″ radius and pressed in so that dimension D is approximately 0.9″ (for the case of a T–17 tube approximately 2⅛ inches in diameter). The asymmetric groove at **10'** on the other hand is formed to approximately ½″ radius at **15'** and is pressed in deeper so that dimension D' is approximately 0.7″. At the same time, the center line of the asymmetric groove is displaced ⅛″ (dimension C') downwardly from the diametral plane of the lamp. This causes the radius of curvature of the narrower rail portion **16'** in Fig. 4 to be approximately the same as that at **16** in Fig. 3, whereas the larger rail portion **17'** in Fig. 4 has a radius of curvature substantially greater than that at **17** in Fig. 3.

The above-described construction wherein one of the rail portions in the asymmetric groove section is made larger while the smaller one remains the same as throughout the rest of the lamp has been found preferable because it does not introduce any difficulties in coating the phosphor on the inside of the envelope. On the other hand, except for the greater difficulty in coating, similar electrical results and temperature control can be achieved by maintaining the radius of the larger rail the same in the asymmetric section and making the radius of the

smaller rail less than throughout the remainder of the lamp.

The grooves, including the asymmetric groove serving as a vapor pressure control center, may be formed by the technique described in copending application Serial No. 578,772 of Eugene Lemmers, et al., filed April 17, 1956, now Patent No. 2,916,645, entitled Tubular Lamp Envelopes, and assigned to the same assignee as the present invention. According to this technique, the lamp envelope is selectively heated in the zones where the groove panels are to be formed until the glass becomes suitably plastic. Then a plunger or pressing bar provided with protuberances or ridges corresponding generally to the grooves required to be formed is pressed down against the envelope. The ridges have the desired radius of curvature of the bottom of the grooves, namely 5/8" in the example given, and contact the glass in the heated zones causing the envelope walls to fold inwardly in those zones and forming the re-entrant cavities or grooves desired. The ridge corresponding to asymmetric groove **10'** is formed to a radius of curvature of approximately ½" for the example given; it projects 0.2" more than the others and is axially shortened to compensate and is displaced ⅛" off the center line of the other ridges. The grooves are formed by what may be described as a free-forming process wherein the glass of the envelope is contacted only in the region of the bottom of the grooves and forms freely in the adjoining regions which merge with the bottoms of the groups to form the side walls and the rails.

It is preferable to have an asymmetric groove on each side of the envelope, both being located near the center. Where the groove length or throw is relatively short, it is preferable to locate the asymmetric grooves three groove positions apart rather than adjacent. In the illustrated embodiment, the groove throw is approximately 2⅛" (axial distance between corresponding points in adjacent grooves on opposite sides of the envelope, dimension G in Fig. 1). This permits a total of 40 grooves or indentations in a 96T–17 lamp of nominal length 8 feet, **20** grooves to a side. Groove **11'** is likewise asymmetrically located and is displaced upwardly a distance D" of ⅛" as more clearly seen in Fig. 5; this makes lower rail **16"** larger while upper rail **17"** remains substantially the same. By locating asymmetric grooves **10'** and **11'** three groove lengths apart, the plasma channel is not caused to weave suddenly from one side of the lamp to the other. Thus the plasma shifts gradually from larger rail **17'** in asymmetric groove **10'** to larger rail **16"** in asymmetric groove **11'** and the displacement is more complete than would be the case if the asymmetric grooves were immediately adjacent.

Considering both Figs. 4 and 5, it is seen that the lamp is provided with two larger radius rail sections, namely **17'** and **16"**, located 180° apart; the comparatively narrower rail sections corresponding to these are likewise located 180° apart. Thus whether the lamp is oriented as shown in Fig. 1 of the drawing, or is turned 180° on its axis, there will always be a narrower rail section of an asymmetric groove located lowermost. The lamp is thus nonpolarized and it is immaterial how it is mounted provided the grooves face horizontally.

Curved lines **18** in Figs. 3 and 4 illustrate convection flow of air around the lamp in operation. Tests of double-grooved lamps in the T–17 size, that is approximately 2⅛" outer diameter operating at a loading of approximately 30 watts per foot in still ambient air at 26° C. showed the approximate temperatures indicated in Figs. 4 and 5 at the rails of the two asymmetric grooves. In both grooves the arc or discharge plasma moves away from the narrower rail towards the larger rail. Irrespective of whether the smaller rail is up or down, it tends to operate cooler. However, where the smaller rail is down, the proportionately reduced heating effect is assisted by the cooling effect of convection flow of air and results in a temperature of approximately 40° C. as against a temperature of 64° C. at the upper rail. On the other hand where the smaller rail is uppermost as in Fig. 5, it operates at a temperature of 47° C. as against a temperature of 52° C. at the larger rail which is here located lowermost. This demonstrates the reason why two asymmetric grooves are required, one on each side of the lamp and with the narrower rails angularly located 180° apart. The narrow rail located lowermost operates at the lowest temperature; thus it serves as the effective mercury vapor pressure control center and governs the partial pressure of mercury vapor throughout the lamp for optimum efficiency.

The exact radius of curvature of the narrower rail is not too important provided it be not so sharp as to affect coating adversely. Tests have shown that typical temperatures at the points A, B and C shown in Fig. 4 may be 39.2, 40.0 and 40.8° C. This demonstrates that the temperature gradient at the curve of the smaller rail is relatively flat so that the exact degree of curvature is not too important. What is important is that there be a substantial difference in dimension of one rail as against the other whereby to cause the plasma to be displaced towards the rail of larger radius.

While a certain specific embodiment of the invention has been illustrated and described in detail, it is intended as illustrative and not as limitative of the invention. The scope of the invention is to be determined by the following claims which are intended to cover any modifications coming within its true spirit and scope.

What we claim as new and desire to secure by Letters Patent of the United States:

1. A low pressure electric discharge lamp comprising an elongated vitreous light transmitting envelope having electrodes sealed into opposite ends and containing an ionizable medium including an inert starting gas and a metal vapor in equilibrium with an excess of non-vaporized metal, said envelope having an outer wall of generally circular section and a plurality of relatively short longitudinally extending grooves alternating on opposite sides of the envelope, most of said grooves being symmetrically located on a diametral plane through the longitudinal axis of the envelope, and at least one of said grooves being asymmetrically located to one side of said diametral plane in order to provide a wider rail portion on one side and a narrower rail portion on the other and cause substantial displacement of the discharge plasma toward said wider rail portion and away from said narrower rail portion.

2. A low pressure electric discharge lamp comprising an elongated vitreous light transmitting envelope having electrodes sealed into opposite ends and containing an ionizable medium including an inert starting gas and mercury vapor in equilibrium with an excess thereof, said envelope having an outer wall of generally circular section and a plurality of relatively short longitudinally extending grooves alternating on opposite sides of the envelope, most of said grooves being symmetrically located on a diametral plane through the longitudinal axis of the envelope, and at least one of said grooves being asymmetrically located to one side of said diametral plane in order to provide a larger radius rail portion on one side and a smaller radius rail portion on the other and cause displacement of the discharge plasma toward said larger rail portion and away from said smaller rail portion, said smaller rail portion thereby operating at a cooler temperature than the remainder of the envelope and serving as a mercury vapor pressure control center.

3. A low pressure electric discharge fluorescent lamp of the double groove type comprising an elongated vitreous light transmitting envelope coated internally with a phosphor and having electrodes sealed into opposite ends and containing an ionizable medium including an inert

starting gas and mercury vapor in equilibrium with an excess thereof, said envelope having an outer wall of generally circular section and a plurality of relatively short longitudinally extending grooves alternating on opposite sides of the envelope, most of said grooves being symmetrically located on a diametral plane through the longitudinal axis of the envelope, at least two of said grooves, one on each side of the envelope, being asymmetrically located with one displaced above and the other displaced below said diametral plane in order to provide in each case a wider rail portion on one side and a narrower rail portion on the other, the discharge plasma in each asymmetric groove portion being thereby displaced toward the wider rail portion and away from the narrower rail portion.

4. A low pressure electric discharge fluorescent lamp of the double groove type comprising an elongated vitreous light transmitting envelope coated internally with a phosphor and having electrodes sealed into opposite ends and containing an ionizable medium including an inert starting gas and mercury vapor in equilibrium with an excess thereof, said envelope having an outer wall of generally circular section and a plurality of relatively short longitudinally extending grooves alternating on opposite sides of the envelope, most of said grooves being symmetrically located on a diametral plane through the longitudinal axis of the envelope, at least two of said grooves, one on each side of the envelope, being asymmetrically located with one displaced above and the other displaced below said diametral plane in order to provide in each case a larger radius rail portion on one side and a smaller radius rail portion on the other, the discharge plasma in each asymmetric groove portion being thereby displaced toward the larger rail portion and away from the smaller rail portion, one of the smaller rail portions being thereby always located lowermost when the lamp is mounted and operated with the grooves facing horizontally so that it is cooled by convection air flow in addition to the effect of the displacement of the plasma, whereby said one smaller rail portion operates at a cooler temperature than the remainder of the envelope and serves as the effective mercury vapor control center regulating the partial pressure of mercury vapor throughout the entire lamp.

5. A lamp as defined in claim 4 wherein there are two asymmetric grooves, one on each side of the envelope, and the two grooves are located longitudinally near the center of the lamp and three groove throws apart.

References Cited in the file of this patent

UNITED STATES PATENTS

2,317,265	Foerste	Apr. 20, 1943
2,213,245	Germer	Sept. 3, 1940