Jan. 24, 1961 M. PENNYBACKER ET AL 2,969,476

MERCURY RESERVOIR FOR DISCHARGE LAMPS

Filed Sept. 19, 1957

FIG. 1

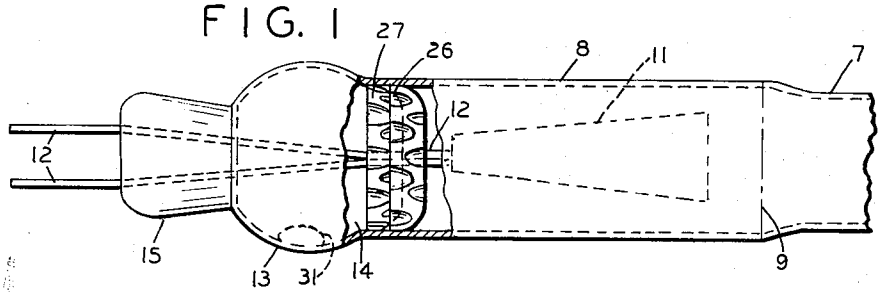


FIG. 2

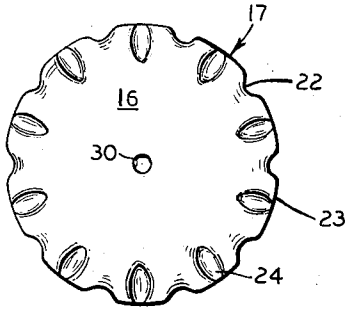


FIG. 6

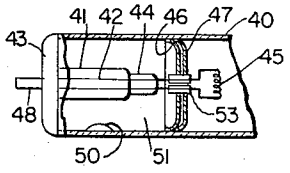


FIG. 4

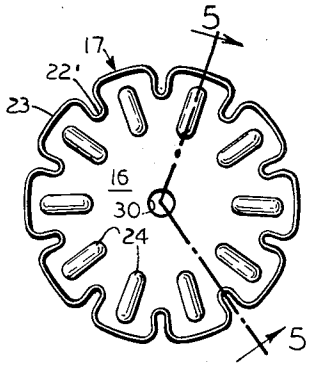


FIG. 3

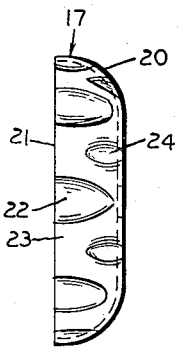


FIG. 5

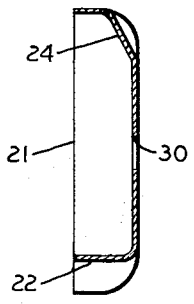
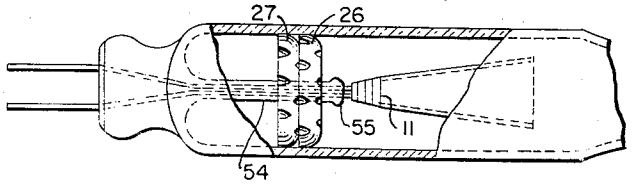


FIG. 7



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MERCURY RESERVOIR FOR DISCHARGE LAMPS

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2 Claims. (Cl. 313—328)

This invention relates to mercury-gas discharge tubes for lighting and for advertising displays and relates more particularly to an improved means for providing a partitioned cavity at the end of such tubes. This application constitutes a continuation-in-part of my co-pending application Serial No. 618,636, filed October 26, 1956.

Discharge tubes of this general character are provided at each end with an electrode. The electrode is usually of the well-known cold cathode type if the tube is intended to carry currents of up to about 200 milliamperes and it is usually of the hot cathode type for higher currents. The design and construction of the partitioned cavity of this invention is very similar for all types of such tubes. It performs one or all of its several functions depending, among other things, upon the current at which the tube operates, and the ambient temperature. For example, if the mercury discharge tube is of the cold cathode type and is operated outdoors in cold weather the cavity serves as a mercury reservoir and prevents the loss of mercury vapor near the ends of the tube with consequent dimming at the ends which might otherwise occur. In this case it tends to increase the mercury vapor pressure. If the tube is a hot cathode or a cold cathode fluorescent lamp operating at relatively high current so that the wall temperature of the bulb in the portion between the electrodes is above that corresponding to optimum mercury vapor pressure for best luminous efficiency, then the partitioned cavity serves to reduce the mercury vapor pressure by virtue of the fact that the insulated cavity is cooler than the rest of the bulb. In a particular lamp the cavity may perform first one of the above functions and then the other. It may provide increased mercury vapor pressure at the end of the lamp if the lamp is operated at a low bulb wall temperature, and it may reduce the pressure of said vapor if the lamp is operated at a relatively high temperature.

In all cases the partition of our invention forms a cavity in which a reserve of liquid mercury may be stored. This is important to a long life of the lamp inasmuch as mercury is used up slowly during normal operation. If this relatively large reserve supply is put into an ordinary lamp not provided with a reservoir it frequently settles in the luminous portion of the lamp. It is then unsightly and reduces efficiency. With the partition of our invention any such excess of liquid mercury that gets into the luminous portion of the lamp during manufacture or later may be moved readily into the cavity of our invention where it is then effectively restrained from returning.

An object of this invention is to provide a partition which may be cheaply formed of metal by a punch press operation, which does not require a seal or special close fit with the glass wall in order to sufficiently restrict the flow of liquid mercury, which is shaped so that the relation of its periphery to the glass wall facilitates the

passage of liquid mercury in one direction and resists such passage in the other direction.

Another object of the invention is to provide a mercury-gas discharge tube with a partitioned cavity wherein the lead-in-wires are insulated from the cavity walls and particularly from the metal partition forming the inner wall of the cavity.

The technique of fabricating and pumping the various types of gas discharge tubes varies somewhat. In the standard hot cathode lamps the filament is typically mounted on support wires which are sealed into the pressed section of a glass stem. This stem is then sealed onto the end of a fluorescent coated glass tube or bulb. The partition of our invention is mounted on the stem prior to the mounting of the filament and with the supports extending through the partition through small holes therein, or through eyelets so that passage of liquid mercury in either direction would be prevented. It is necessary that one of the support wires be provided with a glass bead, a ceramic coating or other insulation so that a low voltage may be applied across the filament without being short circuited by the partition or by the drop of mercury which may be accumulated in the cupped portion if the lamp is vertical. The pumping of the lamp and the insertion of mercury during the pumping operation may then be done in the usual manner.

Whenever the partitioned cavity is used on lamps intended primarily for indoor use, the cavity is needed only at one end of the lamp. This is true because on these lamps the temperature of the main bulb portion is adequate to maintain adequate mercury vapor pressure, and a cooler cavity at one end only is sufficient to reduce the mercury vapor pressure. The introduction of mercury during the pumping operation on such lamps may be done at either end. If the mercury is introduced into the cavity during this operation it will vaporize or distill out in sufficient quantity during the operation of the lamp. If mercury is introduced at the other end, or into the main body of the lamp, it may be forced past the partition and into the cavity by a shaking or tapping operation as described below for sign tubes.

Mercury discharge tubes for outdoor signs, and lamps intended for use at low ambient temperatures, will preferably have the cavity, or mercury reservoir, provided at each end to prevent the end dimming which might otherwise occur. While it is possible to provide tubulations at each end for the introduction of mercury into each cavity separately during the pumping operation, this invention also permits the introduction of mercury without substantially altering the widely used method of introducing mercury directly into the main body of the tube rather than through the electrode.

For example, in sign tube production it is common practice to seal a smaller diameter glass tube, known as the tubulation, at right angles to the sign tube somewhere between the two electrodes. At the proper stage in the processing of the tube the mercury charge, usually consisting of about one or two grams of liquid mercury, is introduced by way of this tubulation. The tubulation is then sealed off with a gas flame. A similar procedure is used with tubes having electrodes of this invention except that a charge of mercury about double the usual size is preferred.

It has previously been proposed to provide a partition back of the electrode consisting of a disc having its periphery sealed to or closely fitting the glass wall with a mercury tight seal. The disc is provided with one or more eyelets spaced at some distance from the periphery, the tubular portion of the eyelet extending into the reservoir. This accomplishes the purpose of maintaining some liquid mercury in the reservoir regardless of ordinary

handling. But it makes extremely difficult, if not impractical, the introduction of mercury from the central portion of the tube by the usual method described above. The introduction of mercury is facilitated by having the passages for mercury along the glass wall of the tube as provided in this invention. After the mercury is introduced from the tubulation as described above it is then positioned on top of the partition adjacent to the tube wall, and hence over the open passages or ports in the partition. The tube is then tapped or shaken to force all or part of the mercury through. Obviously it would be much more difficult to hold the mercury globule over the opening of an eyelet in a flat disc during this operation.

The partition member of the present invention consists of one or a plurality of dished or cup-like structures preferably having a scalloped contour around their periphery. Whereas one such cup gives good results it is preferred to employ at least two of the cups in nested relation, the openings between the cup and the glass wall being small enough to prevent the free flow of mercury should small particles get into the openings. A considerable restraining force, however, comes from the cup-like shape of the partition, the concave side of the cup facing the adjacent closed end of the tube. If one end of the tube is placed downwardly and then inverted the mercury will flow due to gravity but the cup simply scoops up the globule of mercury. Even with the heavy vibration sometimes encountered in shipment or handling of the tube at least some of the liquid mercury stays in the reservoir. It is this residue, however, small, which is important to the maintenance of brilliance in cold weather. Any excess mercury which goes into the main portion of the tube is of little importance. Mercury vapor, however, can readily pass through the openings. The partition of the present invention is thus essentially a one-way or check valve since it denies travel of the liquid mercury in one direction while permitting its passage in the opposite direction and it accomplishes these results without any moving parts.

In the drawing:

Fig. 1 is a broken side elevation, partially in section, of an electrode positioned at one end of a tubular envelope for a mercury lamp embodying the present invention.

Fig. 2 is an elevation of the inner or convex end of one of the cup-shaped partitions.

Fig. 3 is a side elevation thereof.

Fig. 4 is a broken plan view of the outer or concave end of the partition and showing a modified construction.

Fig. 5 is a section taken on line 5—5 of Fig. 4.

Fig. 6 is a broken side elevation of a hot cathode type of mercury lamp where the electrode is not a separately formed element and the partitions are located just outside the filament.

Fig. 7 is an electrode similar in construction to that of Fig. 1 except that an insulating sleeve surrounds the two wires to insulate the cups from the metallic circuit.

The tubular glass envelope is shown at **7** and it may have an internal coating of fluorescent material which converts invisible ultra-violet rays from the mercury discharge into useful visible radiation. One end only of the tube is shown as fitted with an electrode structure including a tubular element fused to the end of the envelope at **9**. A cone-shaped electrode shell is shown at **11** and plural lead-in wires **12** connected therewith pass through a slightly enlarged bulbous section **13** whose inner area forms the closed chamber or reservoir **14** for the mercury, and thence through a flat press seal **15**.

The valve-like arrangement which forms the inner wall of the cavity includes one or more cup-shaped partitions, each having a relatively flat wall section **16** and an annular flange **17** which is curved in cross section as shown at **20** (Fig. 3). The peripheral edge or rim **21** of this flange is of scalloped contour and has a plurality of spaced, inwardly extending recesses **22** which are generally U-shaped in cross section as noted in Fig. 2. When viewed from the side these recesses leave land portions **23** forming arcs of a circle of approximately the same diameter as the inner diameter of the tube.

Each land portion has a recess or dimple **24** on the curved portion **23** of the flange, the dimple being located substantially centrally of the land portion and extends to and partially into the flat section of wall **16**. When a plurality of these cups are used, which is preferred in order to prevent any substantial leakage of liquid mercury from chamber **14** into the central body of the tube, they are arranged in nested relation with the U-shaped recesses **22** of the inner cup, shown at **26**, positioned in the dimples **24** of the outermost cup shown at **27**.

The base wall is formed with a central opening **30** through which wires **12** pass and if desired the wires may be secured therein by fastening means or they may be sealed therein.

A globule of mercury is shown at **31** in chamber **14** and if the tube **7** is rotated clockwise 90° from the position of Fig. 1 the mercury travels down the now inclined wall of the chamber and is, in effect, scooped up by the first cup **27**. A small particle of mercury may pass through a recess **22** but it becomes entrapped in the second cup since the land portion thereof lies in line with the recess in the first cup through which the mercury travels. Thus the land portion of the second cup simply scoops up the droplet and deposits it in the second cup. If the tube is returned to the position of Fig. 1 and tilted somewhat farther so that the left-hand end is lower than the opposite end, the tube may be tapped and the droplet will return to chamber **14**. The curved face of the partition **26** thus forms, together with the wall of the tube, the elements of the larger end of a funnel and when the electrode is so tapped the mercury moves through the small channels and into the reservoir. The opposite ends of the channels leading into the reservoir thus correspond to the small end of a funnel and return flow of the mercury to the area containing electrode shell **11** is largely prevented. This is due in some degree to the small openings at these opposite ends of the channels. If a small particle of mercury does pass through the channel of partition **27** it is generally scooped up into the cup of partition **26** as earlier referred to.

Th dimples **24** serve largely as useful indexing means for lining up the recesses **22** of one cup with the land portions **23** of the next cup during assembly. They also serve the purpose of preventing relative rotation between the cups.

In the modified cup shown in Figs. 4 and 5 the recesses **22'** are deeper than those shown in Fig. 2 but the other elements are the same.

Fig. 6 shows the application of the invention as applied to a hot cathode mercury lamp wherein the electrode is incorporated into the terminal of the tubular envelope **40**. A glass stem **41** having lead-in wires **42** is mounted at the end of the tube and a cap **43** is secured in place. The wires pass through a pressed glass seal **44**. The filament is shown at **45** and the partitions are shown at **46** and **47**. An external contact **48** is connected with the wires.

The cup-like structures which form the partition shown in this Fig. 6 does not have the scalloped periphery. If the inside diameter of the glass wall is only slightly larger than that of the cup, for example, only about $\frac{1}{32}$ inch larger, then the bulk of the mercury will still be retained in the cavity during ordinary handling. Also any excess mercury which may get into the body of the lamp may be returned to the cavity by a tapping operation as described above. In other words, this cup shape having a smooth circular periphery will function to provide greater resistance to the flow of mercury in one direction than in the other, even though it does not have certain additional advantages provided by the cup with

the scalloped periphery. It should be noted that it is advisable to fasten this smooth type of partition on the wires by means of a ceramic cement or otherwise, inasmuch as the smooth periphery is not as well suited to a friction fit with a range of glass diameters as is the scalloped periphery. A globule is shown at **50** in the cavity **51**. Insulation for the wires passing through the partitions is shown at **53**.

A thin wall small diameter insulating tube of glass is shown at **54** in Fig. 7. This glass tube surrounds the wires and serves to effectively insulate them from the metal cups **26** and **27**. The insulating tube is slightly enlarged or flared at the end **55** to prevent the metal cup **26** from making contact with the metal electrode shell **11**. This glass insulating tube prevents any part of the gas discharge current from taking place on the surface of the cups, as can happen under certain circumstances if they are part of the metallic circuit. Such discharge from the cups may not only produce unsightly sputter of the metal but may also tend to cause excess heating of the cups and too rapid evaporation of the mercury from the cavity.

It will be apparent that for certain lamps it may be desired to provide a better insulated or cooler cavity in order to maintain a more nearly optimum temperature therein for the mercury vapor. One way by which this can be accomplished is by moving the electrode shell or the filament, both of which generate heat, farther from the end of the tube. The farther the filament or the electrode shell is from the partition the less heat will be transferred to the cavity, which reduces the vapor pressure of the mercury. Using a multiplicity of the partitions of this invention is another way of improving the insulation and reducing the temperature of the cavity.

The term electrode is used herein and in the appended claims to designate both the separately fabricated terminal structure which may be fused to the end of a tube as shown in Fig. 1, and also to refer to the entire terminal assembly of a hot cathode lamp where the filament is mounted on a stem and the stem sealed into a tube or bulb as shown in Fig. 6.

In either case there is provided a reservoir for the liquid mercury which is defined at its inner end by the partition of the present invention. The metallic terminal or cathode from which the electrical current flows into the gas in the tubular envelope lies outside the reservoir. This terminal is the cone **11** of Fig. 1 and the filament of Fig. 6.

While there have been described herein what are at present considered preferred embodiments of the invention, it will be obvious to those skilled in the art that many modifications and changes may be made therein without departing from the essence of the invention. It is therefore to be understood that the exemplary embodiments are illustrative and not restrictive of the invention, the scope of which is defined in the appended claims, and that all modifications that come within the meaning and range of equivalency of the claims are intended to be included therein.

What we claim is:

1. An electrode for a mercury discharge tube which is provided with a seal at its outer end and lead-in wires passing through the seal, said electrode comprising a tubular envelope which is generally circular in cross section and which has a cavity for liquid mercury at said sealed end, and a partition mounted in the tubular envelope with a friction fit defining the other end of the said cavity, said partition comprising a cup-shaped member with a base and a resilient rim and having said rim facing the cavity, the outer periphery of the rim having a plurality of inwardly extending recesses forming channels between the partition and the envelope and increasing the resilience of the rim, said channels being large enough to permit passage therethrough of liquid mercury past the corner sections formed at the juncture of the base and the rim, and into the cavity, and small enough to cause substantially all liquid mercury traveling in the opposite direction to roll over the rim and pass into the cup-shaped interior of the partition.

2. An electrode for a mercury discharge tube which is provided with a seal at its outer end and lead-in wires passing through the seal, said electrode comprising a tubular envelope which is generally circular in cross section and which has a cavity for liquid mercury at said sealed end, and a partition defining the other end of said cavity, said partition comprising a plurality of cup-shaped members, each provided with a base and rim and having said rim facing the cavity, the outer periphery of the rim being of such diameter as to resiliently engage the envelope and having a plurality of inwardly extending recesses forming channels between the member and the envelope, said cup-shaped member being arranged in nested relation with the recesses in one offset from the recesses in the other, said channels being large enough to permit passage therethrough of liquid mercury past the corner sections formed at the juncture of the base and the corner sections formed at the juncture of the base and the rim, and into the cavity, and small enough to cause substantially all liquid mercury traveling in the opposite direction to roll over the rim and pass into the cup-shaped interiors of said cup-shaped members.

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