

Oct. 21, 1969

J. W. VOLLMER

3,474,280

LAMPS USING SPHERICAL CATHODES

Filed Sept. 14, 1967

Fig. 1.

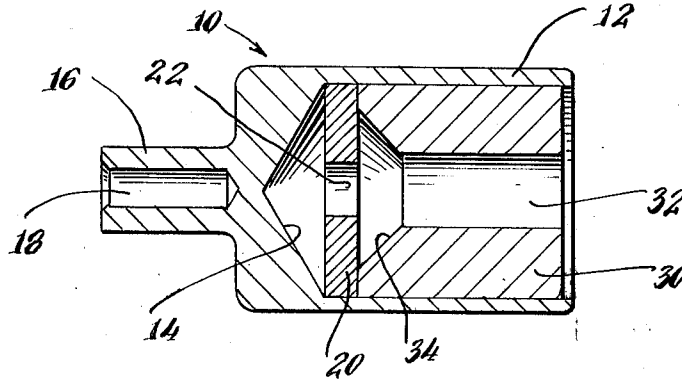


Fig. 2.

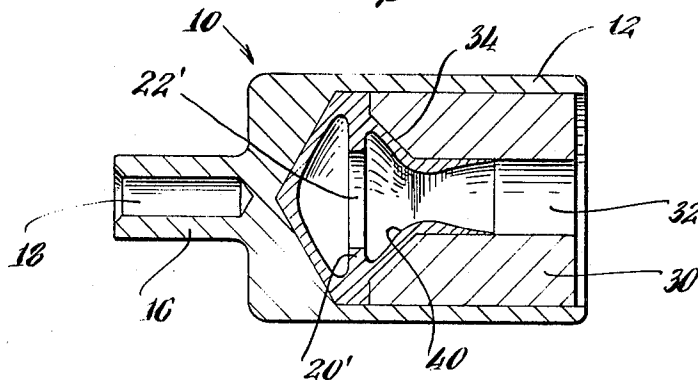
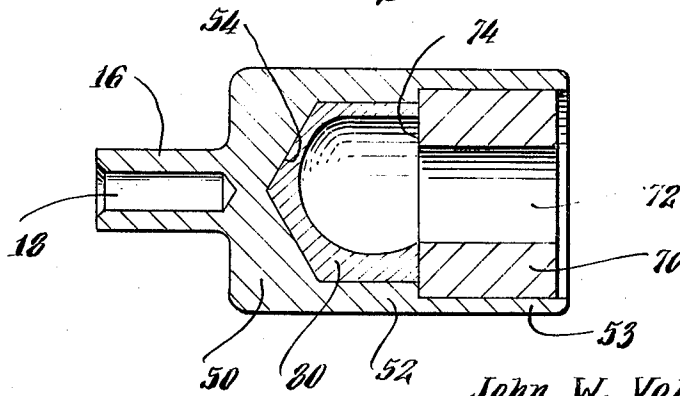


Fig. 3.



John W. Vollmer

BY

Daniel R. Levinson

ATTORNEY.

1

3,474,280

LAMPS USING SPHERICAL CATHODES

John W. Vollmer, Norwalk, Conn., assignor to The Perkin-Elmer Corporation, Norwalk, Conn., a corporation of New York

Filed Sept. 14, 1967, Ser. No. 667,814

Int. Cl. H01j 1/14, 1/38, 19/06

U.S. Cl. 313—310

8 Claims

ABSTRACT OF THE DISCLOSURE

A technique for forming a coating of (a relatively rare) desired metal on the recessed interior surface of a cup-shaped hollow cathode (of the type used in spectral radiation lamps) includes: introducing an apertured disc or discs of the desired metal to a position near but spaced from the closed "bottom" of the hollow cathode; and inserting a countersunk, similarly apertured tubular sleeve (e.g., of the same metal as the hollow cathode holder itself) into the open end of the hollow cathode so as to partly restrict its opening. A breaking-in usage will cause the desired metal in the discs to sputter and coat the cavity formed by the bottom and lower surfaces of the hollow cathode and the confronting countersunk portion of the sleeve. By suitably shaping the original bottom of the hollow cathode and the confronting surface of the sleeve, the coated emitting cavity can be made to approximate a partially spherical surface, which shape is particularly efficient for the desired emission.

This invention relates to a technique for forming a spectrally emitting coating on the interior of a hollow cathode of a lamp. In particular the technique of the invention forms a relatively thin coating of a desired metal in a cavity adjacent the "bottom" (i.e., the interior surface of the closed end) of the hollow cathode. The inventive technique allows a relatively extensive (in area) coating to be formed with a very small amount of the desired metal, and additionally is capable of forming a substantially (partial) spherical coated cavity in the lower (closed) part of the hollow cathode, without requiring complicated and expensive mechanical operation (such as machining a re-entrant portion).

An object of the invention is the formation of a hollow cathode for use in a spectral emission lamp, in which a relatively thin but extensive coating is formed on the more remote interior surfaces of the cathode in a simple and material-conserving manner.

A further object of the invention is the provision of such a coated remotely interior surface of a hollow cathode, which surface at least approximates a partially spherical cavity.

Other objects, features and advantages of the invention will become obvious to one skilled in the art upon reading the following detailed description in conjunction with the accompanying drawing, in which:

FIG. 1 is a central section through one form of the invention prior to its being run in;

FIG. 2 is a similar central section of the same hollow cathode assembly as FIG. 1, as it will appear after run-in and some use in an otherwise conventional hollow cathode lamp;

FIG. 3 is a somewhat different form of a hollow cathode according to the invention, which is particularly useful for lower melting point metals.

FIG. 1 shows one form of a hollow cathode assembly according to the invention, which assembly although containing all of the mechanical parts, has not yet been run in so as to form the coating of the desired metal on the interior surfaces of the cathode generally adjacent to the

2

closed end thereof. FIG. 2 shows the same cathode subsequent to running in and some usage, in which the desired metal has formed such a coating, shown generally at 40. In FIG. 1 an otherwise conventional hollow cathode cup or holder 10 is either initially formed or else subsequently machined (e.g., drilled) to have a relatively thin side wall 12. Additionally the bottom wall defining the open interior of cathode 10 has been formed (as by countersinking) so as to have a generally concave shape as indicated at 14 in FIG. 1. The cathode holder 10 has a conventional narrow portion 16, which may be apertured as at 18 to receive the cathode pin of an otherwise conventional hollow cathode lamp (see for example applicant's U.S. Patent Application Ser. No. 591,748, filed Nov. 3, 1966, now U.S. Patent 3,361,925 assigned to the same assignee as the present application). One or more washer-like apertured discs 20, constituting the metallic material for which spectral radiation is desired to be obtained, is positioned as indicated at 20 just above the point at which the interior of the cathode holder 10 joins the concave or angled bottom portion 14. The outside diameter of the apertured disc (or discs) 20 will obviously match the interior diameter of the cathode holder 10 (i.e., the distance between the opposite interior surfaces of wall 12), and may be for example $\frac{3}{8}$ of an inch. The internal diameter of aperture 22 in discs 20 may be, for example, $\frac{1}{8}$ of an inch; and the total thickness of these discs (i.e., the vertical dimension in FIG. 1) may be as little as about 0.03 ($\frac{3}{100}$) of an inch.

It has been found convenient to form the disc 20 from a plurality of very thin (e.g., 0.01 inch thick) stacked washers, but apertured disc 20 may of course be a single somewhat thicker washer. After placing disc 20 adjacent the bottom (i.e., 14) of the inside of the cathode 10, an apertured sleeve 30 is positioned inside the hollow cathode. Sleeve 30 (which may be of the same material as the cathode holder 10) will have an exterior diameter substantially identical to the interior diameter of the holder 10 (as defined by wall portion 12). A central longitudinal channel or aperture 32 extends the entire length (i.e., the horizontal direction in FIG. 1) of element 30; in addition the lower end of sleeve 30 is given the general concave shape as indicated at 34 (e.g., so that longitudinal channel 32 and concave surface 34 resemble a hole formed for a countersunk screw). Although the lower surface 14 of holder 10 and the facing surface 34 of sleeve 30 are illustrated in FIG. 1 as angled, relatively flat surfaces (as would be formed by a conventional countersink), they may instead be curved, so as to present truly concave facing surfaces (e.g., surfaces 14 and 34 may be similar or different concave spherical or other curved surfaces). The diameter of aperture 32 in sleeve 30 will be approximately equal (e.g., $\frac{1}{8}$ of an inch) to the diameter of aperture 22 in disc 20.

The assembly of FIG. 1 will be incorporated in a well-known manner (see, for example, applicant's previously referred-to U.S. patent application Ser. No. 591,748) in an otherwise conventional hollow cathode lamp. During run-in and early stages of use of the lamp, a substantial part of the desired metal of disc 20 will sputter away from the disc so as to reduce the disc to a somewhat thinner disc 20' having an enlarged aperture 22', as may be seen in FIG. 2. Most of the sputtered material will not escape from the cathode assembly (through longitudinal channel 32) but rather will form a substantially continuous coating 40 over the adjacent surfaces (14 and 34 in FIG. 1) of the cathode and sleeve (10 and 30, respectively). Since both the cathode holder and the sleeve will be of material having a larger work function (so that they do not appreciably sputter under operating lamp conditions), they will not be substantially deformed during use.

The sputtered coating 40 of the metallic material for which the spectral radiation is desired will form a substantially spherical coating 40 on the surfaces, as indicated in FIG. 2. Thus after only a relatively short time, the cathode assembly will comprise a substantially spherical internal cavity having the continuous coating 40 on its entire surface. The actively emissive part of the hollow cathode assembly will therefore assume this highly efficient shape, effectively shielded or restricted by the sleeve 30, so as to present a relatively narrow discharge channel to the anode through elongated aperture 32. Thus the technique of the invention allows the formation of a cathode assembly having the desirable substantially spherical coated interior cavity and relatively narrowly restricted channel, without requiring any difficult internal machining operations. Additionally the technique of the invention is particularly useful for this purpose when the "active" desired material (i.e., the material of disc 20, 20' and the coating 40) is extremely expensive and/or difficult to obtain.

A hollow cathode assembly, generally conforming to FIGS. 1 and 2, has been made and successfully used in otherwise conventional hollow cathode lamps in which yttrium was the desired emitting metal, by using a copper cathode holder (10) and copper sleeve (30), conforming generally to those shown in these figures and of the exemplary dimensions previously mentioned. Specifically the yttrium was initially introduced (i.e., as in FIG. 1) as three 0.010 inch thick discs which were stacked so as to form an 0.030 inch thick disc (20). This cathode assembly was successfully tested in an otherwise conventional hollow cathode lamp, using neon as the low-pressure fill gas. Similar lamps in which the disc 20 is composed of substantially pure uranium, homium, samarium, ytterbium, erbium, gadolinium, dysprosium, terbium, neodymium, ruthenium, praseodymium have been constructed and at least partially tested with successful results.

FIG. 3 illustrates a modified form of cathode assembly, especially suitable when the spectrally emitting metal has a melting point near or somewhat below the temperature of the cathode during operation of the lamp. In FIG. 3 the cathode cup or holder 50 may be made from the same original cathode as that (at 10) in FIGS. 1 and 2; and may have the same narrow portion 16 and cathode pin-receiving aperture 18. As in the FIGS. 1 and 2 forms, the bottom of the interior of cathode 50 is made somewhat concave in shape, as indicated at 54. The side wall portion 52 of the holder 50 is preferably recessed on its interior surface adjacent the open end of the cathode so as to form a thin wall portion 53. A generally tubular sleeve 70, having a longitudinal aperture or channel 72 may then be received (as by press fit) within the larger internal diameter portion of cathode 50 defined by the thin walls 53. Either before or after such insertion of sleeve 70 into the open end of the cathode 50, a moderate amount of the metallic material for which spectral emission is desired would be introduced into the interior of the cathode (using small pieces, of course) if the sleeve is already in the cathode. By heating the entire cathode assembly (or merely operating the lamp after the cathode assembly has been incorporated therein) to a temperature somewhat in excess of the melting point of this desired emitting metallic substance, it may be rendered molten and caused to form a substantially continuous coating as at 80 by rotating the cathode (or the entire lamp into which it has been incorporated) about the longitudinal axis of the cathode (i.e., the central axis running along the length of apertures 18, 72). Preferably the material of the cathode 50 should be chosen so it is easily "wetted" by, but does not readily alloy with, the particularly actively emitting metallic material (at 80). For example, when the active emitting material is lead or tin, the cathode holder 50 may be made of iron or titanium, respectively. Sleeve 70 may be of any suitable material which does not substantially sputter or spectrally interfere with the desired

active metal (at 80). In general it may (but need not) be made of the same material as the cathode holder 50. After the coating 80 has been initially formed, it will in general maintain the form shown in FIG. 3 (being somewhat heavier at the bottom than in its upper portions because of gravity) for a fixed position of the lamp containing the cathode assembly, even though the material of coating 80 will normally melt during lamp use and be solidified between uses.

As stated above in regard to the FIGS. 1 and 2 embodiment of the invention, the exact shape of the generally concave bottom surface 54 of the cathode 50 and the confronting surface 74 at the adjacent end of sleeve 70 need not be angled and flat as indicated in FIG. 3; rather various curved forms (e.g., approximating parts of a sphere) may be used, especially for surface 54. In the FIG. 3 form the exact shape of the surface 74 at the interior end of sleeve 70 may be varied so as to insure no substantial loss of the material at 80 during lamp use (when it may be completely, or at least partially molten). As indicated in FIG. 3, the channel 72 in sleeve 70 is preferably somewhat smaller than the effective diameter of the coated cavity, thereby obtaining a relatively large emitting (coated) surface while restricting the amount of material lost per unit of time during lamp operation. The approximately (partial) spherical shape of the emitting cavity formed by coating 80 also enhances the efficiency and therefore the brightness of the spectral radiation, as previously noted. The FIG. 3 form also has the same general advantages as the FIGS. 1 and 2 forms concerning ease of manufacture, and to some extent relative economy in the quantity of the spectrally emitting material (at 80) required.

Although two specific exemplary embodiments of the invention have been described in detail, various changes may be made including not only variations actually mentioned in the previous description, but also changes which will be obvious to those skilled in the art from the previous description.

What is claimed is:

1. The method of forming an improved hollow cathode assembly for a spectrally emitting lamp comprising: providing a hollow cathode holder having tubular side walls and a closed bottom portion, thereby being generally cup-shaped, forming a generally concave interior surface on said cathode bottom, introducing into said cathode holder in an area at least adjacent said bottom portion a solid metallic material for which the spectral radiation is desired, partially plugging the open end of said cathode holder so as to leave a reduced diameter open channel in communication with the lower part of said cathode holder, and causing said metallic material to coat at least a substantial part of the interior surfaces of said bottom position and the immediately adjacent part of said side walls, thereby forming substantially a partially spherical emitting cavity lined with a coating of the material for which spectral emission is desired.
2. The method of forming a hollow cathode assembly according to claim 1, in which: said partial plugging is accomplished by introducing into the open end of said cathode holder a hollow tubular sleeve having an exterior surface which generally conforms to the interior surface of the said side walls of said hollow cathode holder, said tubular sleeve having an end surface which, after introduction into said cathode, faces but is spaced from the interior surface of said cathode bottom portion, said metallic material therefore ultimately coating said end surface of said hollow sleeve.
3. The method of forming a hollow cathode assembly according to claim 1, in which; said solid metallic material is initially introduced into

5

the hollow cathode holder in the form of at least one thin washer-like apertured disc;
 and said metallic material is caused to coat the lower interior parts of said cathode by it sputtering from said apertured disc by operation of said hollow cathode assembly in a substantially completed lamp during a run-in period,
 whereby the relatively small amount of metallic material contained in said apertured disc will ultimately form a thin coating over substantially all of the adjacent interior surfaces of said hollow cathode assembly.

4. The method of forming a hollow cathode assembly according to claim 1, in which:
 said metallic material has a melting point at least somewhat below the normal operating temperature of said hollow cathode assembly during normal operation of the lamp;
 and said metallic material is caused to coat the interior lower surfaces of said cathode by raising the temperature of said cathode assembly to a temperature above the melting point of said solid material and rotating said cathode assembly generally about its longitudinal axis, causing said metallic material to wet said interior surfaces.

5. A hollow cathode assembly for spectrally emitting lamp, comprising:
 a metallic hollow cathode holder having tubular side walls and a bottom portion having an interior surface which is generally concave toward the hollow center of said cathode;
 a coating of the metallic material for which spectral radiation is desired substantially covering the interior surfaces of at least said bottom wall portion and the immediately adjacent side wall portion of said cathode;
 and means restricting the interior of the open part of said cathode so as to form a longitudinal channel of reduced diameter,
 whereby said hollow cathode assembly includes at least partially generally spherical emitting cavity of said desired spectrally emitting metallic material and a restriction to avoid undesirable loss of said material.

6

6. A hollow cathode assembly according to claim 5, in which:
 said restricting means comprises a generally tubular hollow sleeve, having an exterior surface substantially conforming to and engaging the interior surface of said substantially tubular side walls of said hollow cathode holder,
 said hollow sleeve extending from the vicinity of the open end of said cathode into the hollow interior of said cathode to a point generally near but substantially spaced from said interior surface of said bottom wall of said cathode,
 whereby the longitudinal internal aperture of said hollow sleeve forms the reduced-diameter longitudinal channel of said cathode assembly, and the end surface of said sleeve facing said bottom wall of the cathode defines part of said spherical emitting cavity.

7. A hollow cathode assembly according to claim 5, in which:
 said coating comprises a metallic material having a melting point at least somewhat below the normal operating temperature of said hollow cathode assembly during lamp use,
 whereby said restricting means also inhibits loss of said coating by liquid flow during lamp use.

8. A hollow cathode assembly according to claim 5, in which:
 said tubular side walls of said cathode holder are substantially cylindrical.

References Cited

UNITED STATES PATENTS

3,361,925	1/1968	Vollmer	313—310
3,390,297	6/1968	Vollmer	313—346 X
3,422,301	1/1969	Sebens et al.	313—311

JOHN W. HUCKERT, Primary Examiner

R. F. POLISSACK, Assistant Examiner

U.S. Cl. X.R.

29—25.17, 25.18, 460; 312—311, 346