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DISCHARGE TUBE SEAL

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Fig. 1.

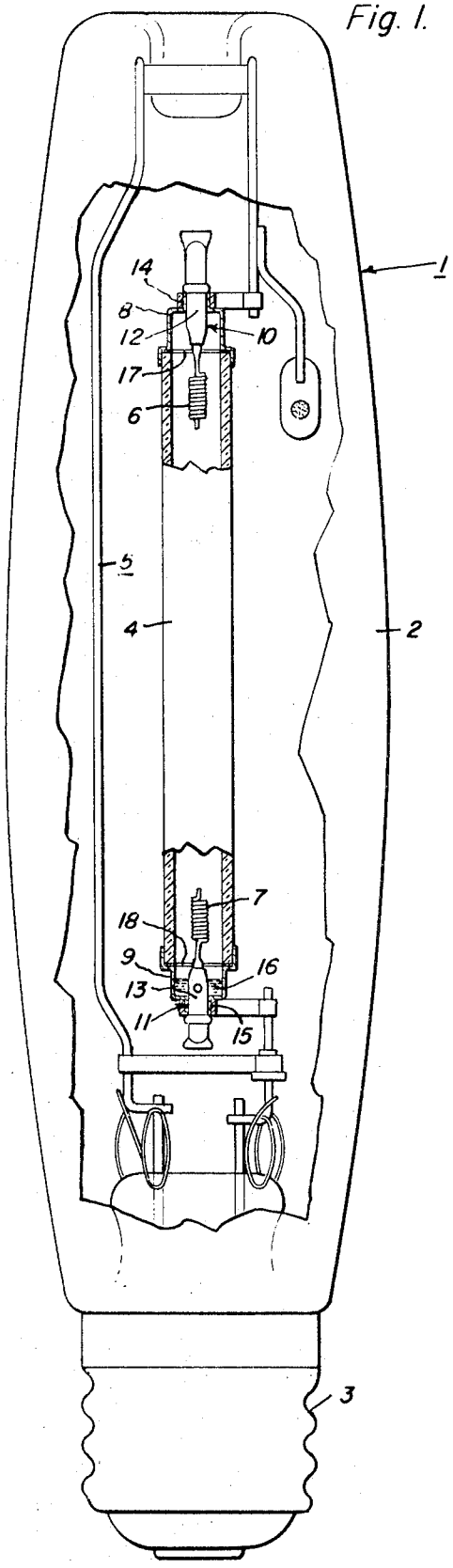
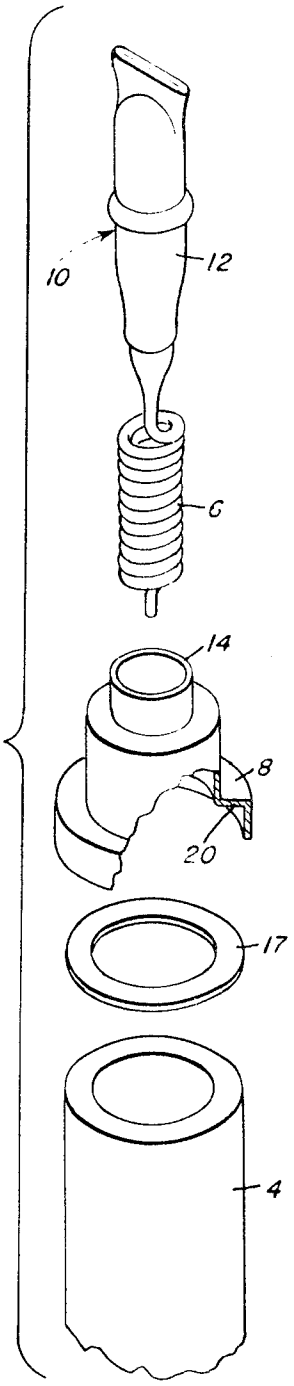


Fig. 2.



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DISCHARGE TUBE SEAL

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ABSTRACT OF THE DISCLOSURE

In high-pressure sodium vapor lamps utilizing an alumina ceramic arc tube, the interior of the arc tube is isolated from the interior of the outer glass envelope by means of end caps made of niobium which are sealed to the ends of the alumina tube. This seal is accomplished by means of a shim or washer of titanium which is first bonded to the end cap by solid state diffusion or by a molten bond and then pressed against the end of the alumina tube at a temperature above 1200° C. to produce a titanium-alumina bond.

CROSS REFERENCES TO RELATED APPLICATIONS

Ser. No. 616,538, filed Feb. 16, 1967 by Rodney E. Hanneman; Paul J. Jorgensen and Richard J. Charles (RDCD–633), "High-Pressure Sodium Vapor Lamp," same assignee.

BACKGROUND OF THE INVENTION

The invention relates to high pressure sodium vapor lamps utilizing alumina ceramic for the arc tube and, more particularly, with the provision of seals or joints between the end caps of the arc tube which isolate the interior of the arc tube from the interior of the outer glass envelope of the lamp.

The high pressure sodium vapor lamp with which the invention is more particularly concenred generally comprises an outer vitreous envelope or jacket within which is mounted a slender tubular arc tube of high density polycrystalline alumina. The basic lamp type is described and claimed in U.S. Pat. No. 3,248,590, issued Apr. 26, 1966 to Kurt Schmidt. The arc tube encloses a charge of sodium, preferably a filling of sodium-mercury amalgam, and an inert gas such as xenon. It operates with sodium vapor pressure sufficient to cause appreciable broadening and self-reversal of the resonance lines, the range from 30 to 500 torr being preferred. A large percentage of the total radiation is emitted on either side of the yellow resonance D lines of sodium at 5890 and 5896 Angstroms resulting in a golden white light having a relatively large amount of energy in the red. The xenon is a starter gas for the lamp and the mercury is a buffer gas producing the proper temperature distribution in the plasma and at the envelope walls. The presence of the mercury increases the voltage gradient of the arc, resulting in a lamp operating at a higher voltage and lower current for a given wattage and this make for a more efficient lamp and permits savings in ballast costs. Even though the partial pressure of mercury in the lamp may be several times greater than that of sodium, little radiation of mercury lines is apparent in the visible spectrum and it is essentially only the sodium atoms that are excited to produce light.

In the manufacture of these lamps, the arc tube has been provided at each end with metallic end caps which are sealed to the ends of the tube and serve to isolate the interior of the tube from the interior of the surrounding lamp envelope. The arc tube is preferably made of a sintered, high density, polycrystalline alumina ceramic

of a high degree of transparency such as is disclosed and claimed in U.S. Pat. No. 3,026,210, Coble, "Transparent Alumina and Method of Preparation" and assigned to the present assignee. Previously, this has been accomplished by means of a ceramic seal. This seal has proven to be quite effective, however, occasional failure of these seals has been experienced and, because of the nature of the seal, the upper limit of the operating temperature has been limited which has an effect upon the color of the emitted light. It would be desirable to provide a more durable seal which would permit the use of higher operating temperatures.

It is therefore a principal object of this invention to provide an improved end cap and arc tube structure characterized by a non-ceramic joint therebetween which seals the interior of the tube from its surrounding environment.

A yet further object of the invention is the utilization of a sealing joint between the nibium end caps and the arc tube ends comprised of an interlayer of titanium which is diffusion bonded to the niobium at the niobium-titanium interface and which is bonded to the alumina ceramic arc tube by a solid state reaction bond at the titanium-alumina interface. Other and specifically different objects of the invention will become apparent to those skilled in the art from the following description.

SUMMARY OF THE INVENTION

Briefly stated, in accordance with one aspect of the invention, it has been found that a seal may be formed between the niobium end caps and the ends of the alumina ceramic arc tube of the subject sodium vapor lamps by utilizin ga titanium shim or washer and a two-step bonding process. Essentially, the titanium shim is diffusion bonded to the niobium end cap by placing the titanium shim against the niobium surface and heating under a protective atomsphere or in a vacuum while pressing the two members together. If the temperature is raised to just below the melting point of the titanium for a brief period of time, a solid state diffusion bond is formed at the interface. It will be appreciated that a molten bond may be produced if desired, by heating briefly above the incipient melting point. The so bonded end cap and shim assembly is then assembled with the alumina ceramic tube and pressed thereagainst while heated under a protective atmosphere or vacuum for a few minutes at a temperature sufficient to cause the titanium to react with the alumina to produce a titanium-alumina bond.

Those skilled in the art will gain a better understanding of the invention from the detailed description set forth below in conjunction with the drawings which form a part of this disclosure, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational veiw of a high pressure sodium vapor lamp embodying this invention in a preferred form with parts broken away for clarity; and

FIG. 2 is an exploded view of the components used to seal one of the end caps to one end of the arc tube.

As shown in FIG. 1, high pressure sodium vapor lamp **1** comprises an outer, transparent vitreous envelope **2** provided with a conventional screw base **3**. Arc tube **4** is supported within the envelope by the structural elements collectively shown as **5**, the structural elements **5** also providing electrical connections for tungsten electrodes **6** and **7** which in turn are supported in position at the upper and lower ends of arc tube **4** by end cap members **8** and **9** which are hermetically sealed to the alumina arc tube. The shanks **10** and **11** of electrodes **6** and **7** are preferably formed of niobium and are supported from the niobium end caps **8** and **9** by the cylindrical portions **12** and **13**, respectively, which project through tubular portions **14**

and **15** of the end caps and are hermetically sealed thereto. Each electrode consists of a double wound tungsten wire coil with interstices filled with an electron emitting material such as, for example, barium oxide. As shown, the lower end cap **9** provides a reservoir for the sodium-mercury amalgam **16**, otherwise the end cap, electrode and arc tube assembly is substantially identical for each end of the arc tube.

The structural relationship of the upper end cap **8**, upper electrode **6**, the upper end of arc tube **4** and the titianium washer or shim **17** is shown in FIG. 2 as an exploded view. It will be appreciated that the lower end cap **9**, lower electrode **7**, the lower end of arc tube **4** and a similar titanium washer **18** have an exactly analagous structural relationship.

In forming the sealed joint between for example, the niobium end cap **8** and arc tube **4**, the titanium shim **17** is pressed into engagement with the inner shoulder **20** of end cap **8** and heated in either a vacuum or under an inert atmosphere such as argon, for example, to a temperature of about 1550° to 1700° C. while maintaining the parts under compression. After holding the parts at temperature for a brief time, about 100 to 1000 seconds for example, a solid state diffusion bond is formed between the niobium end cap and the titanium shim, whereupon the bonded assembly is cooled and removed from the treatment chamber. It will of course be apparent that a molten bond may be formed if desired instead of the solid state diffusion bond by merely briefly heating to a temperature above the incipient melting point, all other conditions and procedural steps being the same.

The end cap and washer assembly is then placed over the end of the alumina ceramic arc tube **4** and the bonded titanium shim pressed against the end of the tube. While maintaining the pressure, the assembly is heated under either a vacuum or an inert atmosphere for a few minutes at a temperature which is effective to achieve the titanium-alumina reaction bond. For example, a temperature of about 1200° C. for about **15** minutes is satisfactory. It should be noted that temperatures significantly higher than about 1500° C. should be avoided during the formation of the titanium-alumina bond because the reaction will be too extensive, producing an inferior bond. It is desirable that only a thin layer of the titanium shim react with the alumina. It is for this reason that the formation of the end cap-tube seal is accomplished in two separate bonding steps. The complete seal may then be accomplished by inserting the cylindrical portion **12** of shank **10** of electrode **6** into the tubular portion **14** of end cap **8** and brazed or welded in place to form a hermetic seal. Care should be exercised that the temperature of the titanium-alumina bond should not exceed its formation temperature. It will of course be understood that both ends of the arc-tube are sealed in the same manner. It will also be obvious that the electrode and end cap may be secured together either before the titanium shim is bonded to the end cap or before the end cap is bonded to the arc tube, if desired.

The shank portion **10** of electrode **6** and the end cap **8** are both fabricated from either substantially pure niobium or a niobium rich alloy such as, for example Nb+1 percent zirconium alloy. Under the operating condition for the lamp, these materials are permeable to oxygen and the interior of shank **10** of the electrode is provided with a material which combines with any oxygen present. Furthermore, niobium or the disclosed niobium rich alloy form a continuous series of solid solutions with titanium and no brittle second phases or intermetallic compounds which would weaken the joint are formed during the bonding operation or during operation of the lamp.

The details of construction of the preferred embodiment which have been illustrated and described are intended as exemplary and not in order to limit the invention except as set forth in the accompanying claims.

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

1. A method for bonding a niobium body to an alumina ceramic body comprising the steps of pressing a titanium body against the surface of said niobium body, excluding reactive gases from the space surrounding said bodies, heating said bodies under compression to a temperature in the range of about 1550° C. to about 1700° C. for a period of time sufficient to form a bond at the titanium-niobium interface, cooling said bonded composite body to a temperature below 1200° C., biassing the alumina ceramic body against the unbonded surface of the titanium layer of said composite body, heating the bodies under compression to a temperature of from about slightly above 1200° C. up to about 1500° C. for a period of time sufficient to form a titanium-alumina bond while excluding reactive gases from the space surrounding said bodies, and cooling said bonded composite body.

2. The method set forth in claim **1** wherein said alumina ceramic body is tubular in shape and is composed of sintered, high density polycrystalline ceramic having a high degree of transparency.

3. The method set forth in claim **2** wherein said niobium body comprises an end closure for said tubular alumina ceramic body and includes an electrode which extends into the interior of said alumina ceramic body.

4. As an article of manufacture, the product of the process recited in claim **1**.

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