United States Patent [19]

Lake et al.

[11] **3,868,528**

[45] **Feb. 25, 1975**

[54] **QUARTZ PINCHES CONTAINING SEALANT GLASS**

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[73] Assignee: **General Electric Company**, Schenectady, N.Y.

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[21] Appl. No.: **433,045**

[52] **U.S. Cl.** **313/220**, 29/25.13, 174/50.64, 174/50.61, 316/17, 117/128, 65/59, 313/182

[51] **Int. Cl.** **H01j 61/36**

[58] **Field of Search** 313/220, 315, 182; 29/25.11, 25.13; 316/17; 117/128; 174/50.61, 50.64

[56] **References Cited**

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[57] **ABSTRACT**

In quartz envelopes for high pressure metal vapor lamps, improved pinch seals contain a glass sealant filling voids between the quartz and the tungsten electrode shank extending into the envelope. Prior to pinching, the tungsten shank is coated with a thin layer of substantially alkali-free glass having a coefficient of expansion intermediate that of tungsten and quartz. During pinching, the glass coating flows and fills the cavity which forms about the shank and extends from the sealing foil into the discharge space. Advantages include reduced shaling of quartz about the shank, less devitrification of quartz between main and starter electrode, and reduced attack of the shank by the metal halide.

10 Claims, 7 Drawing Figures

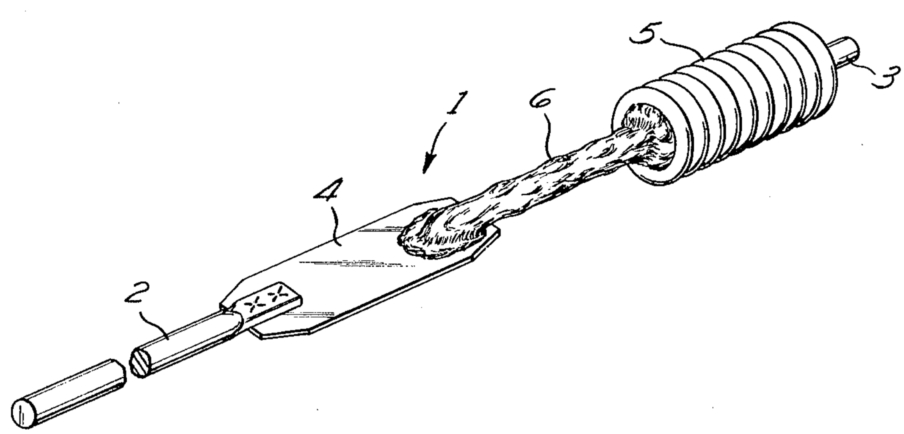

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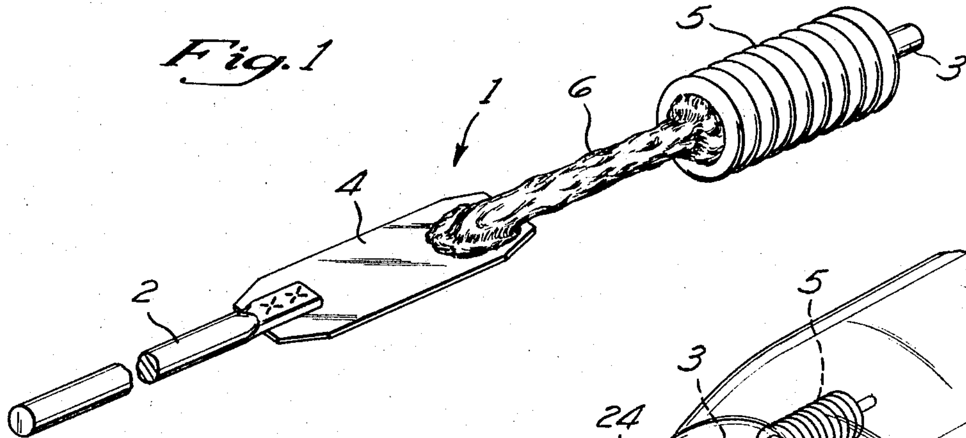
Fig. 1



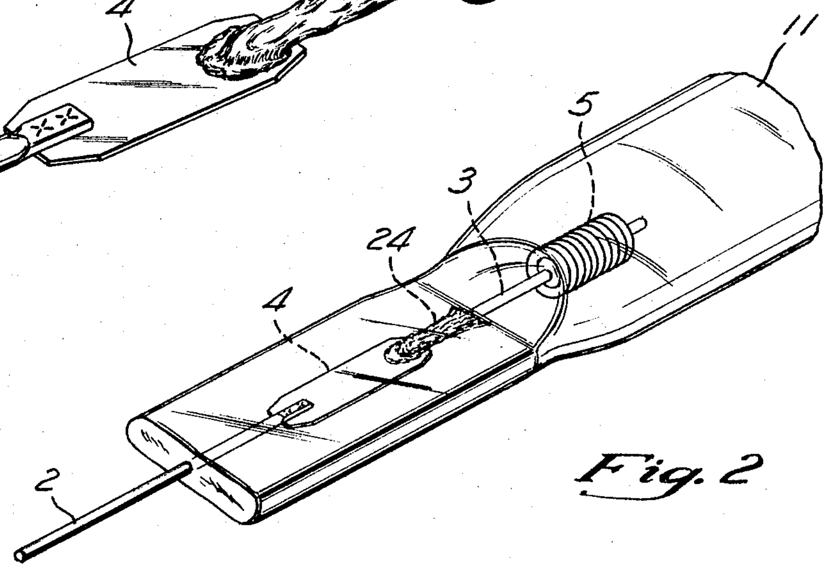
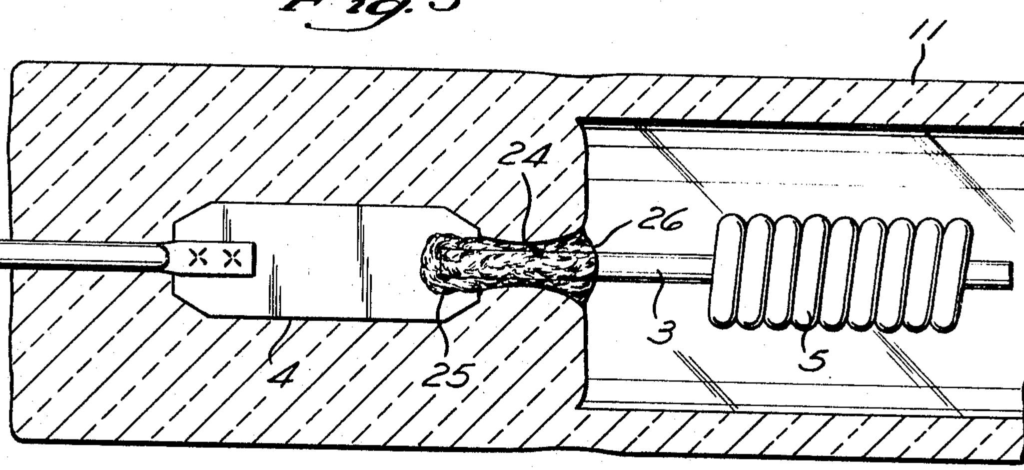


Fig. 2

Fig. 3



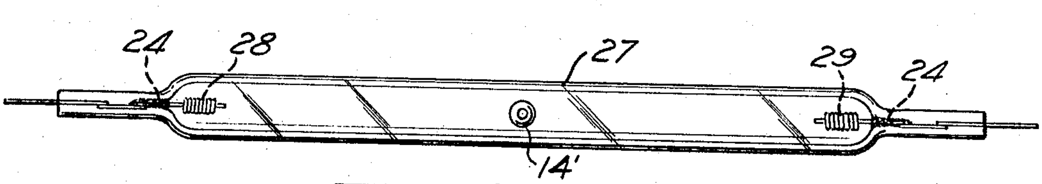


Fig. 4

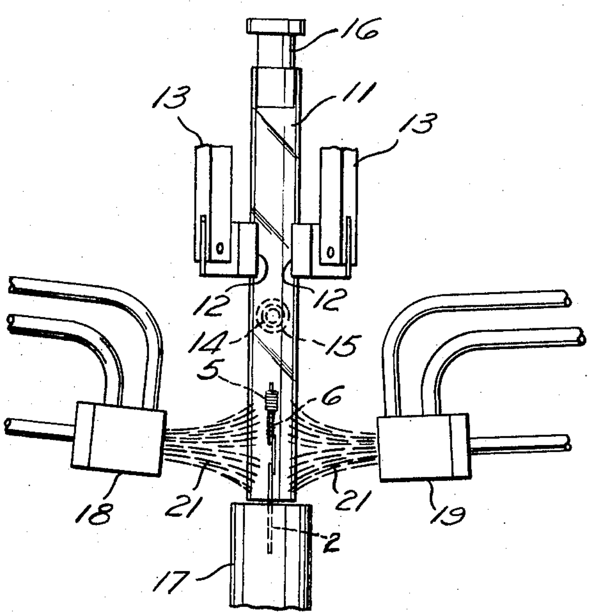


Fig. 5

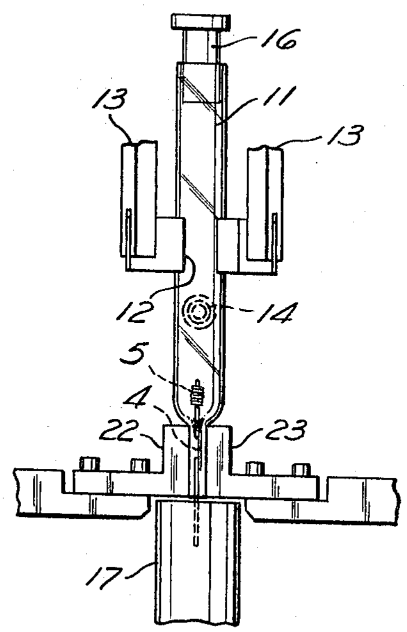


Fig. 6

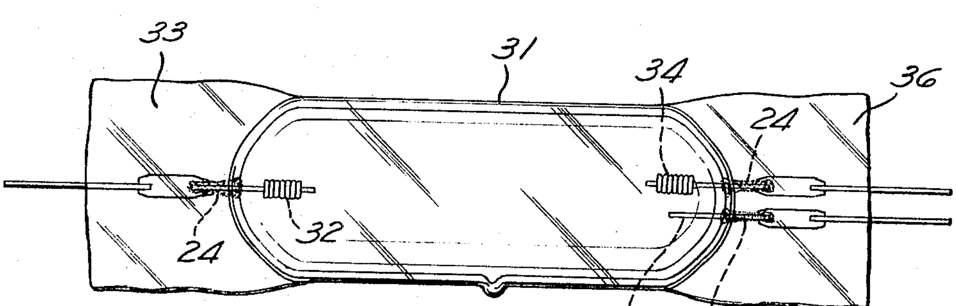


Fig. 7

QUARTZ PINCHES CONTAINING SEALANT GLASS

BACKGROUND OF THE INVENTION

The invention relates to electric lamps of the type comprising a tubular quartz or fused silica envelope closed at each end by pinches or press seals through which extend refractory metal inleads. The invention is especially applicable to high intensity discharge lamps of this kind having a metallic halide fill and is also concerned with the manufacture of the lamps.

Such lamps generally comprise tungsten electrodes supported on the inner ends of foliated inlead assemblies extending through pinches or press seals in the ends of the envelope. These seals are made by pinching the ends of a quartz tube while in a heat-softened condition between a pair of opposed jaws to press the quartz about an intermediate foil portion of the electrode assembly and thereby achieve a hermetic seal. The lamps contain a filling which may but need not necessarily include mercury and comprises one or more metal halides plus a small quantity of inert gas to facilitate starting. In lamps intended for general lighting, the filling usually includes mercury and either sodium, thallium, and indium iodides, or sodium and scandium iodides, and the arc tube is enclosed within an outer glass envelope or jacket provided with a screw base at one end. Metal halide lamps intended for other uses such as reprographic and photochemical applications frequently utilize a long slender quartz tube without any outer envelope, and such lamps are sometimes known as linear metal halide lamps.

During normal operation of metal halide lamps, the arc tube walls attain a temperature of about 900°C except for the end portions in the vicinity of the pinches which remain at lower temperatures from 700° to 800°C. Metal halide lamps usually contain an excess of the metal halides beyond what is vaporized in normal operation, and the excess, for instance liquid sodium iodide, tends to collect in the cooler regions in the vicinity of the pinches. It is well-known that the presence of liquid sodium iodide next to a main and adjacent auxiliary starting electrode results in devitrification of the quartz and rapid failure of the seals where a potential is permitted to exist between the inleads. One solution to this problem which has been widely adopted is provided by U.S. Pat. No. 3,226,597 — Green, and consists in a thermal switch which short-circuits the auxiliary electrode to the adjacent main electrode after the lamp has heated up. However a thermal switch means added cost and, if it should fail to operate, the lamp may fail prematurely.

It has also been observed that a reaction may take place directly upon the inlead assembly which causes the tungsten shank to become detached from the molybdenum foil. British Pat. No. 1,240,253 published July 21st, 1971 proposed as remedy to seal a fine quartz tube into the pinch so as to extend into the envelope and form a sleeve surrounding the electrode shank.

In copending application Ser. No. 390,768, filed Aug. 23, 1973 by William H. Lake, entitled "Selective Spectral Output Metal Halide Lamp," and similarly assigned, a linear metal halide lamp is described and claimed wherein the filling comprises zinc, lithium, thallium, and gallium iodides and optionally a small quantity of mercury. In this lamp attack of the tungsten electrode shank is particularly severe. Attempts to protect the electrode shanks by applying quartz sleeves produced variable results depending upon how closely the sleeves fitted the shanks. If they were too tight, they cracked and broke away while if too loose they failed to reduce the chemical attack sufficiently.

SUMMARY OF THE INVENTION

The object of our invention is to provide an improved solution to the problems of seal devitrification or shaling and electrode lead attack considered above.

The inlead assembly which extends through the pinch generally comprises a molybdenum outer lead serving as a current terminal, an intermediate molybdenum sealing foil, and a tungsten inner lead or shank on whose distal end the electrode proper comprising one or more layers of wound tunsten wire is mounted. Outer and inner leads are welded to the foil and the hermetic seal is made where the quartz has wetted and become bonded to the molybdenum foil during pinching. During lamp operation, excess metal halide tends to creep up any crack or crevice between the tungsten shank and the quartz. Since the coefficient of expansion of tungsten is much greater than that of quartz, there cannot be a bond between the tungsten shank and the quartz and such crevices will inevitably form into which metal halide will creep.

In accordance with our invention, we provide an improved pinch seal containing a glass sealant filling any voids between the quartz and the tungsten electrode shank extending into the envelope. The sealant glass is one which is substantially alkali-free and has a coefficient of expansion close to that of tungsten. The coefficient of expansion of the sealing glass should preferably be intermediate that of tungsten and quartz so that the glass is in a state of compression following fusing.

In a preferred process for making such improved pinch seals, the tungsten shank of the inlead assembly is coated with a thin layer of glass. During pinching, the inlead assembly is supported vertically with the electrode uppermost within the quartz tube as the fires heat it. At jaw closure, the glass coating flows and fills the cavity which forms about the shank where it emerges into the envelope.

Advantages of our invention are reduced shaling of quartz about the shank and reduced electrolysis and devitrification of the seals in lamps having main and starter electrodes. Loss of metal such as sodium by electrolysis is reduced. In lamps where the metal halides tend to attack the tungsten electrode shank or the shank to foil weld region such attack is apppreciably reduced.

DESCRIPTION OF DRAWINGS

FIG. 1 is an enlarged pictorial view of an electrode assembly including a glass-coated tungsten shank.

FIG. 2 is an enlarged pictorial view of a sealed lamp end according to the invention.

FIG. 3 is an enlarged fragmentary cross section of a pinched lamp end according to the invention and showing the glass sealant about the electrode shank.

FIG. 4 illustrates a linear metal halide lamp embodying the invention.

FIG. 5 is a fragmentary front elevation of apparatus used in pinch-sealing a quartz tube by the method of the invention.

FIG. 6 shows the apparatus of FIG. 5 at the instant of jaw closure.

FIG. 7 illustrates the arc tube of a general lighting metal halide lamp embodying the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1, the illustrated electrode inlead assembly 1 comprises an outer molybdenum wire conductor 2 and an inner tungsten wire conductor or shank 3 spot-welded to opposite ends of a thin molybdenum sealing foil 4. The tungsten conductor 3 sometimes known as the electrode shank has its distal end overlaid by a double wound coil 5 of tungsten wire serving as the electrode proper. Some metal halide lamps rely upon the metal halides included in the envelope as the ionizable filling for electrode activation, whereas others include a quantity of electron emissive activating material which may be retained within the electrode coil in known manner, for instance in the interstices between the two layers of the coil.

To make a pinch seal containing glass sealant, we start by providing a glass sheath around the tungsten wire conductor or electrode shank 3. The sheath may take the form of a glass tube which may be slipped over the shank before it is welded to the foil. However we prefer to apply a glass coating 6 which is fired on as indicated in FIG. 1. The coating extends from the near end of the coil 5 and overlaps the spot weld of the shank to the sealing foil 4. The coating may conveniently be applied by painting a slurry of the glass suspended in an organic binder and then firing first under conditions adequate to remove the binder, for instance about 450°C in a suitable atmosphere, and then in nitrogen at a temperature sufficient to melt the glass, for instance from 1,100° to 1,250°C. Coatings of better quality in respect of freedom from bubbles and pinholes caused by broken gas bubbles may be obtained by vacuum firing rather than nitrogen atmosphere firing. By way of example, in an electrode inlead assembly corresponding to that illustrated in FIG. 1, the tungsten shank diameter was 0.029 inch, the foil thickness 0.001 inch, and the thickness of the glass coating was about 0.0025 inch. The illustrated inlead assembly is intended for a 3 to 4 ampere lamp and typically has an overall length of 30 to 40 millimeters.

The glass-coated electrode inlead assemblies 1 may be pinched into the ends of a quartz tube 11 by the use of generally conventional press sealing apparatus as illustrated in FIGS. 5 and 6. The quartz tube is held vertically in jaws 12 on the lower ends of pivotable arms 13 which are part of a sliding head which may be lowered into station. A side tubulation or exhaust tube 14 extends horizontally out from quartz tube 11 to the rear and a flexible tube 15 supplies an inactive gas such as nitrogen to it. When the first pinch seal is being made on an arc tube, the open top of quartz tube 11 is closed by a suitable temperature resistant plug 16; no plug is needed when the second pinch seal is being made. The nitrogen prevents oxidation of the leads and electrodes during heating and pinching. The electrode inlead assembly is supported by accommodating outer molybdenum wire 2 in a suitable hole in spindle 17 and the arc tube is supported with its lower edge just clearing the face of the spindle.

The lower end of the quartz tube is heated by two pairs of opposed burners; only one pair 18, 19 is illustrated in FIG. 5 but another complementary pair is located at right angles. The burners emit mixed jets of hydrogen and oxygen and the oxy-hydrogen flames 21 completely envelop the lower end of the quartz tube as illustrated in FIG. 5 and heat it to plasticity. The heating time may be regulated by a timer or by a temperature sensing device.

At the conclusion of the heating cycle at which time the lower end of the quartz tube is white hot at a temperature of about 2,000°C., a fast-acting mechanism withdraws the burners clear of the arc tube and closes a pair of pinching jaws 22, 23 upon the lower end as shown in FIG. 6. The tube end is flattened and the quartz pressed into engagement with the molybdenum sealing foil 4 which it wets and to which it bonds. When the white hot quartz comes into contact with the glass coating 6 on the tungsten shank, the glass is suddenly heated to a temperature where it begins to flow readily. The pinching jaws are then withdrawn and the quartz is again heated by the oxyhydrogen flames to anneal the seal and complete the formation of the glass sealant. During the pinching and annealing, the glass runs down the shank and fills the cavity or crevice which forms about it as illustrated in FIGS. 2 and 3. Apparatus adaptable to commercial production of quartz lamps in accordance with our process is disclosed U.S. Pat. No. 2,857,712 — Yoder, et al., Quartz Lamp Sealing Machine.

The pinch at the other end of the arc tube may be made in the same fashion by inverting the tube in its holder. The manufacture of the arc tube is then completed in conventional fashion which involves exhaust of the sealed arc tube, introduction of metal halides, mercury if desired, and inert starting gas such as argon into the tube, and finally tipping off the exhaust tube as indicated at 14′.

Referring to FIGS. 2 and 3, the sealing glass which has run down into the pinch may be seen at 24 filling the voids which are usually left in the seal area. One concentration of glass occurs at 25 where tungsten shank 3 is welded to molybdenum foil 4, and the other concentration at 26 occurs where the shank emerges from the pressed quartz into the discharge space. The presence of the glass during pinching causes enlargement of the crevice which normally forms about the tungsten shank and more glass is accommodated as a result.

We have found that the presence of glass bonded to the tungsten shank in the seal area in the manner described greatly reduces shaling. This indicates a considerable lessening of stress concentration by comparison with that existing in normal pinches as previously made. The presence of the seal glass produces a better stress distribution in the seal area.

The requirements for a suitable sealant glass are as follows. It should be substantially alkali-free (less than 0.05 wt. % sodium). It should have a coefficient of expansion intermediate that of quartz at 5.5×10^{-7} per degree C. and that of tungsten at 46×10^{-7} per degree C. but should be chosen closer to that of tungsten. It should have a softening point temperature from 900° to 1,200°C. By way of example, one glass which we have found suitable is identified as GE 177 and comprises SiO_2 62.3%, Al_2O_3 17.2, BaO 18.8%, CaO 1.7%, and includes less than 0.05% alkali; its coefficient of expansion is 40.5×10^{-7} per degree C.

A specific form of electric discharge lamp embodying the invention and known as a linear metal halide lamp is illustrated at 27 in FIG. **4**. The electrodes **28, 29** are pinch-sealed into the ends with sealing glass present in the crevice extending along the tungsten electrode shank in the manner previously described. The lamp is intended for reprographic applications and provides radiation concentrated in blue, green and red bands as described in copending application Ser. No. 390,768, filed Aug. 23, 1973, by William H. Lake, titled "Selective Spectral Output Metal Halide Lamp" and assigned like the present application. The ionizable filling comprises a limited quantity of ZnI_2 serving as a buffer species, LiI, TlI and GaI_3 serving as emitter species and a small quantity of Hg serving as a secondary buffer. In this lamp, chemical attack of the molybdenum foil-tungsten shank weld region is particularly strong and causes the development of high local stress concentrations which may cause a pinch or press seal to be split in half. By providing sealant glass to fill the voids in the pinch in accordance with the invention, chemical attack of the foil-shank is substantially eliminated or at least greatly reduced.

Another specific form of electric discharge lamp embodying the invention is illustrated at **31** in FIG. **7**. It has a single electrode **32** pinch-sealed into one end **33** and a main electrode **34** along with an auxiliary starting electrode **35** pinch-sealed into the other end **36**. All the electrodes desirably include sealant glass present in the crevice extending along the tungsten shank from the sealing foil into the discharge cavity. The ionizable filling of this lamp may comprise mercury, sodium, thallium and indium iodides and argon for the inert starting gas. A common problem with this lamp prior to our invention was penetration of sodium iodide into the cavities of the pinch sealing in the main and auxiliary starting electrode. The high sodium concentration in the quartz between the inleads of electrodes **33** and **34** accelerates the electrolysis process particularly when a potential exists between the inleads. By filling the voids or crevices by sealing glass in accordance with our invention, sodium migration into the pinch region is eliminated or substantially reduced. The need for a thermal shorting switch in accordance with U.S. Pat. No. 3,226,597 — Green, is thereby greatly reduced. Alternatively, in the event that a switch is still used but fails to operate, premature failure of the lamp is avoided.

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

1. An electric lamp comprising:

a quartz tube envelope having refractory metal inleads pinch-sealed into its ends of the kind comprising an outer terminal lead, an intermediate sealing foil, and an inner lead extending into said envelope, said inner and outer leads being connected to opposite ends of said foil,

and a sealing glass bonded to said inner lead and filling the crevice in the quartz around said inner lead extending from said foil into said envelope, said sealing glass being substantially alkali-free and having a coefficient of expansion intermediate that of quartz and that of said inner lead.

2. An electric lamp as in claim **1** wherein the inner lead extending into the envelope is tungsten, and said sealing glass has a coefficient of expansion close to that of tungsten.

3. An electric lamp as in claim **2** wherein the sealing glass has a softening point temperature in the range from 900° to 1,200°C.

4. An electric discharge arc tube comprising:

a quartz tube envelope having inleads pinch-sealed into its ends of the kind comprising an outer terminal lead, an intermediate molybdenum sealing foil, and an inner tungsten lead extending into said envelope, said inner and outer leads being connected to opposite ends of said foil and said inner lead having an electrode at its distal end,

a sealing glass bonded to said inner lead and filling the crevice in the quartz around said inner lead extending from said foil into said envelope, said sealing glass being substantially alkali-free and having a coefficient of expansion intermediate that of quartz and tungsten,

and an ionizable filling in an envelope including an excess of vaporizable metal.

5. An arc tube as in claim **4** wherein said sealing glass has a softening point temperature in the range from 900° to 1,200°C.

6. An arc tube as in claim **5** wherein said ionizable filling includes sodium iodide in excess of the quantity vaporized in operation and said arc tube has an additional inlead pinch-sealed into one end which terminates in an auxiliary starting electrode.

7. An arc tube as in claim **5** wherein said ionizable filling comprises ZnI_2, LiI, TlI and GaI_3.

8. The method of pinch-sealing a quartz arc tube which includes:

making a refractory metal inlead-foil-shank assembly comprising an outer terminal lead, an intermediate sealing foil and an inner shank,

applying to said inner shank a sheath of substantially alkali-free sealing glass having a coefficient of expansion intermediate that of quartz and that of said inner lead,

standing said assembly upright with the glass-sheathed shank uppermost and surrounding it by the lower end of a quartz tube,

heating the lower end of said quartz tube to plasticity while filled with inactive gas,

and quickly compressing the tube end to collapse it and hermetically unite the quartz to said intermediate sealing foil while causing said sealing glass to flow and fill a crevice in the quartz around the inner shank.

9. The method of claim **8** wherein said glass sheath is applied to said inner shank as a thin fired-on layer of glass.

10. The method of claim **8** wherein after compressing, the tube end is heated to anneal it.

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