April 18, 1950 | A. GREINER | 2,504,521

QUARTZ-TO-METAL SEAL

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Fig. 1.

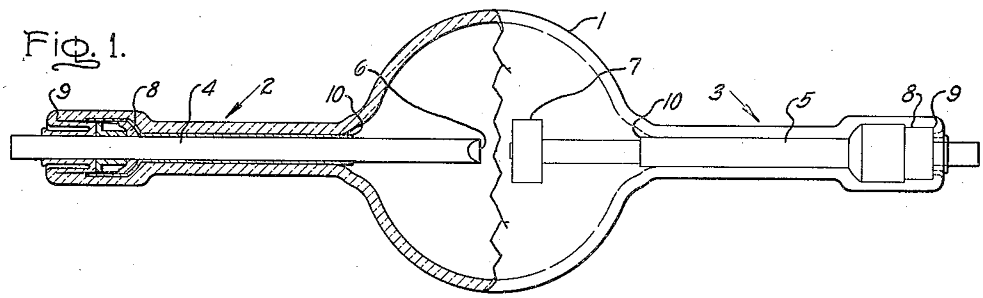


Fig. 2.

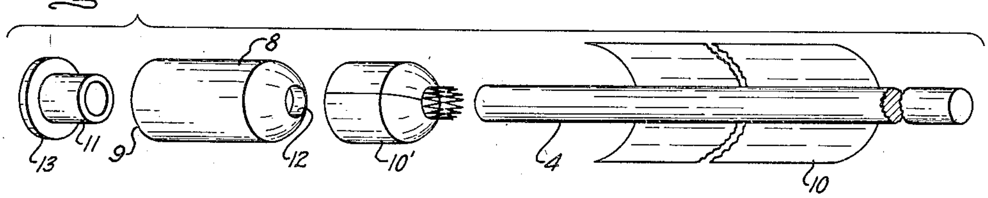


Fig. 3.

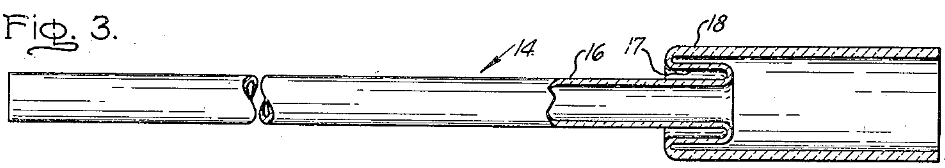


Fig. 4.

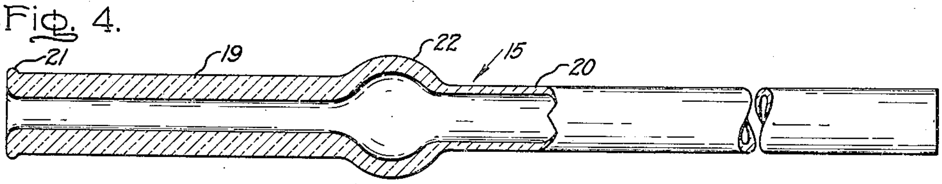
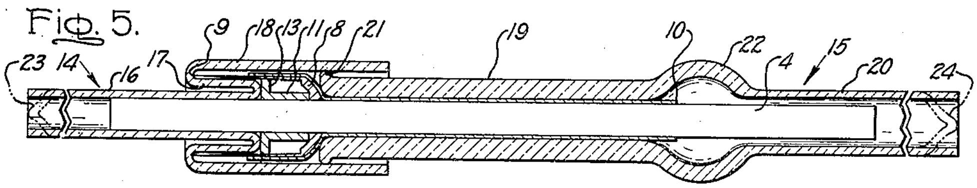


Fig. 5.



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QUARTZ-TO-METAL SEAL

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12 Claims. (Cl. 250—27.5)

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My invention relates to quartz-to-metal seals for high pressure discharge devices, such as high pressure mercury vapor discharge lamps.

Lamps of this kind are high intensity light sources and may operate with a power consumption in the order of several kilowatts and a vapor pressure of many atmospheres. One type of such lamp comprises a spherical quartz envelope having seals in the form of protruding stems supporting the electrodes and including leading-in conductors in the form of multiple molybdenum foils connected in parallel to carry the heavy discharge current and fused into the quartz body of the stem. The foils are extremely thin and therefore require careful and skilled handling in making the stem.

An object of my invention is to provide a quartz-to-metal seal in the form of a stem which is of simple structure. Another object of my invention is to provide a method of making such a stem. A further object of my invention is to provide a method of making a quartz-to-metal seal. Other objects and advantages of the invention will appear from the following description of species thereof taken in conjunction with the accompanying drawing in which Fig. 1 is an elevational view, partly in section, of a lamp having stems embodying my invention; Fig. 2 is an exploded view of the metal parts of the stem shown in section in Fig. 1; Fig. 3 is a sectional elevational view of a vitreous tube constituting part of the stem; Fig. 4 is a similar view of another quartz tube also constituting part of the stem; and Fig. 5 is a similar view of the stem elements of Figs. 2 to 4 assembled for fusion together.

The lamp shown in Fig. 1 of the drawing is of the high vapor pressure electric discharge type having a spherical quartz envelope 1 provided with quartz-to-metal seals in the form of aligned stems 2 and 3 protruding from diametrically opposed portions thereof. The stems 2 and 3 are identical in structure and have lead-in conductors including tungsten rods 4 and 5 extending through quartz stem tubes and carrying electrodes 6 and 7 at their inner ends. Rods 4 and 5 are exposed at their outer ends for connection to the terminals of a power source for the lamp.

The electrodes 6 and 7 are closely spaced in the center of the quartz envelope 1 which contains an ionizable gaseous atmosphere including a starting gas, such as argon, and mercury in an amount sufficient to produce on the power input for which the lamp is designed an unsaturated vapor atmosphere having a pressure

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of the order of atmospheres. A vapor pressure of the order of 300 pounds per square inch or 20 atmospheres may be produced in such a lamp having a power consumption of about 10 kilowatts.

In order to carry such large currents, the tungsten rods 4 and 5 must be of such large diameter that quartz cannot be fused directly thereto to make a fused joint which will be gas-tight under the conditions of operation.

To provide such a joint I utilize thimbles 8 of refractory metal, such as molybdenum or tungsten, positioned in the stem tubes and around the rods 4 and 5. The thimbles 8 are hermetically united with the rods 4 and 5 and have a feathered sealing edge 9. The quartz of the stems 2 and 3 is fused to both the inner and outer surfaces of the edge 9, as described below, to make a mechanically strong and temperature-resistant quartz-to-metal seal. The quartz parts of the stems surrounding the thimbles and the rods provide good support therefor to hold the electrodes 6 and 7 in proper position in the envelope 1.

As best shown in Figs. 2 and 5, the outer surface of the thimble 8 back from the portion to which the quartz is fused and the portion of the rod 4 extending from the thimble 8 toward the electrode 6 are sheathed with molybdenum foil 10 which acts as a cushion between the quartz tube and the parts of the rod and the thimble covered by the foil. This foil covering, the thickness of which is greatly exaggerated in the drawing, prevents the quartz from adhering to these thick metal parts during fabrication of the stem and avoids cracking of the quartz when these metal parts expand and contract in response to changes in temperature.

A metal spacer 11 inside the thimble 8 serves the same purpose by preventing the quartz from going so far into the thimble during fabrication that it would fuse not only to the inner surface of the feathered sealing edge 9 of the thimble 8 but also to other thicker portions of the inner surface of the thimble.

Thus, the only portion of the conductor, including the rod 4 and the metal thimble 8, to which the quartz is hermetically fused is the annular, tapered, feathered sealing edge 9 which is of such thin wall section that the quartz adheres to both the inner and outer surfaces thereof without cracking during fabrication and use of the stem.

In making the stem, the thimble 8 is cut and ground to shape from bar or flat molybdenum stock. As best shown in Fig. 2 of the drawing, it has a domed-shaped closed end having an opening 12 for the rod 4. A specific embodiment of a thimble which has given good results has its annular side wall 7/8 of an inch in depth with an inner diameter of 5/8 of an inch and tapers from the closed end to the feathered sealing edge 9 which is between 0.0006 to 0.001 of an inch in thickness at its end. About 1/4 inch back from the end of the edge 9 the wall thickness is between .0016 and .002 of an inch. I have demonstrated that these upper limits are critical; the quartz will break away from the metal surface or crack and the seal will leak if the upper limit is exceeded.

The flanged spacer 11 inside the thimble 8 is also made of molybdenum. It is 3/8 of an inch long, the cylindrical part thereof is 3/8 of an inch in outside diameter and the flange part 13 slightly less than 5/8 of an inch in diameter so that there is small clearance between it and the inner surface of the annular thimble wall. The tungsten rod 4 passing through the opening 12 in the thimble 8 and through the spacer 11 is approximately 1/4 of an inch in diameter and the openings in the spacer 11 and in thimble 8 are made just large enough to accommodate the rod 4. The spacer 11 holds the rod and the thimble in alignment during the brazing operation by which these three members are joined together after they are assembled as shown in Figs. 1 and 5.

I prefer to use platinum as the brazing material to bond the three metal members together. This metal withstands the high temperatures existing thereat during fabrication and use of the stem and forms a hermetic joint between the tungsten rod 4 and the molybdenum thimble 8.

After the rod 4, the thimble 8, and the spacer 11 have been joined together they are thoroughly cleaned and the metal sheath 10 is applied. The sheath consists of two sheets of molybdenum foil approximately .0006 of an inch thick wrapped around the parts of the rod 4 and the thimble 8 to be covered. One of the sheets is shaped in the form of a collar 10′ wrapped around the domed end of the thimble 8, the part of the rod emerging from the closed end of the thimble and the part of the annular wall of the thimble adjacent the domed bottom. The foil collar 10′ covers the brazed joint between the rod and the thimble and extends to within 3/16 of an inch of the feathered edge 9 of the thimble 8. The collar 10′ is preferably shaped from a foil strip approximately 7/8 of an inch wide and 2 1/8 inches long. One long edge of the strip is serrated to a depth of approximately 3/8 of an inch with a distance 1/4 of an inch between serrations which overlap when the strip is wrapped around the thimble and the rod to form the collar. The tab is welded to the surface of the strip after the collar is formed. In Fig. 2 the collar is shown removed from the thimble for purposes of illustration.

The foil sheet 10 wrapped around the rod 4 may overlap the end of the collar slightly and is made of a sheet approximately 1 1/8 inches wide and 1 3/8 inches long.

This assembly of the metal members is inserted in the two quartz tubes 14 and 15 shown separately in Figs. 3 and 4, respectively. The complete assembly before fusing the various elements of the stem together is shown in Fig. 5.

The quartz tube 14 surrounding the thimble 8 and the outer end of the rod 4 is made up of three overlapping coaxial tubes 16, 17, and 18, the tube 16 of smallest diameter being 3/8 of an inch in outside diameter, 6 1/2 inches long and 1/16 of an

inch thick, the tube of largest diameter 18 being 7/8 of an inch in outer diameter, 23/32 of an inch in inner diameter and 2 5/32 inches long, and the intermediate tube 17 being slightly larger than 5/8 of an inch in outer diameter and 1/16 of an inch thick. The ends of the tubes 16, 17, and 18 are fused together as shown in Fig. 3. The tubes 17 and 18 form a longitudinally extending annular recess opening into the interior of the tube 14 and which accommodates the feathered edge 9 of the thimble 8 with the said edge 9 touching or in close proximity to the fused joint between the tubes 17 and 18 and the flange 13 on the spacer 11 resting against the fused joint between the tubes 16 and 17 as shown in Fig. 5.

The quartz tube 15 surrounding the inner end of the rod 4 has a thick wall portion 19 approximately 3 1/4 inches long which surrounds the rod 4 in the completed stem and a thinner wall portion 20 approximately 5 1/2 inches long. The thicker wall portion 19 has an outer diameter of 5/8 of an inch, an inner diameter slightly greater than 1/4 inch to accommodate the rod 4 and the sheath 10, a flare 21 about 11/16 of an inch in diameter at the end thereof to be inserted in the end tube 18 of the quartz tube 14 and a bulge or bulbous portion 22 of about 15/16 of an inch outside diameter at the end joining the thin wall portion 20 thereof.

In the assembly including all the elements shown in Fig. 5 the portion 18 of the tube 14 overlaps the end of portion 19 of tube 15 with the flare 21 on the latter making a close mechanical fit with the inner surface of the tube portion 18. The two quartz tubes 14 and 15 then form a chamber for the metal parts. In completing the stem a non-oxidizing gas, such as nitrogen or forming gas which is a mixture of hydrogen and nitrogen, is first caused to flow into the chamber through the open end of each of the tubes 14 and 15. This gas fills the chamber to prevent oxidation of the metal parts therein during heating of the quartz parts. It flows out of the chamber between flare 21 and tube portion 18. The flare 21 prevents too rapid escape of the gas from the chamber formed by the tubes 14 and 15 before these are fused together.

With the gas flowing as described above, heating flames are applied to the tube portion 18 surrounding flare 21 and overlapping the tube portion 19. During this heating step and before the overlap of tube 18 collapses onto the flare 21 to seal the opening between them, the stream of gas passing between the flare 21 and the inner surface of tube portion 18 prevents products of combustion from the heating flame entering the chamber and affecting the metal parts. When the heated quartz becomes plastic and closes the space between the flare 21 and the tube portion 18, the pressure of the gas in the chamber is immediately reduced to only slightly above atmospheric pressure to avoid blowing out the plastic quartz as the overlapping portions of the tubes 14 and 15 are being fused together.

After the tubes 14 and 15 have been spliced together in the above manner the assembly is allowed to cool to room temperature with the gas still flowing through the chamber. The chamber is then exhausted to a high vacuum and, while the vacuum is maintained, the metal parts are heated by a high frequency oscillator to remove any gas which may have formed on these parts during the splicing of the tubes 14 and 15. The assembly is again allowed to cool until it may be sealed off from the vacuum system with the chamber in a highly evacuated condition. As shown in dotted lines at 23 and 24 of Fig. 5, both ends of the chamber formed by the quartz tubes 14 and 15 are sealed.

A heating flame is then applied at the juncture of tubes 17 and 18 surrounding the feathered sealing edge 9 of the thimble 8 to soften and collapse these tubes simultaneously onto both sides of the edge 9 of the thimble and to make a fused hermetic joint between the quartz and the thimble. During this heating step care must be exercised to heat both of these tubes 17 and 18 at the same rate so that their opposing portions collapse simultaneously back from their juncture and into contact with the inner and outer surfaces of the feathered sealing edge 9. If these walls collapse at different rates, the thin wall of the thimble will either be split if the inner tube 17 collapses into engagement therewith first, or will wrinkle if the outer tube 18 does so first.

The foil sheath on the outside of the thimble 8 and the flange 13 on the spacer 11 prevent the tubes 17 and 18 from fusing with the thicker portions of the thimble wall. The hermetic seal between the quartz and the thimble edge 9 is approximately 3/16 of an inch long on the outside and about 3/8 of an inch long on the inside of the thimble wall measured back from the end of edge 9 so that the seal has an overall length of approximately 11/16 inches and is of large area.

After the hermetic seal has been formed the quartz tubing surrounding the foil covered portion of the thimble and the tungsten rod is heated, starting from the thimble, to collapse the quartz onto the sheath 10 to give good mechanical support to the metal parts of the stem. Due to the sheath 10 the quartz does not adhere to the rod 4 or the covered portion of the thimble. The assembly is again allowed to cool and the surplus quartz tubing is severed and removed at about the maximum diameter of the bulge 22 and at a point approximately ½ inch from the opposite end of the rod 4 to complete the stem. One end of the rod 4 is thus exposed for connection to a power source when mounted in a lamp and the other end, which is the inner or electrode end of the rod, extends an appreciable distance beyond the remaining part of the bulge and into the lamp envelope when the remaining bulge part, which constitutes a sealing flange for fusion with the quartz envelope of the lamp, is joined to the lamp envelope as shown in Fig. 1.

The cathode 6 of the high pressure lamp is constituted by the inner end of rod 4 which is shaped in the form of a wedge and preferably impregnated with material having high electron emissivity characteristics, such as thorium. The anode 7 is constituted by a block of tungsten welded to the end of rod 5. In making the lamp, the electrodes 6 and 7 are inserted into the quartz envelope 1 through diametrically opposed openings and the flanges on the stems are fused into said openings to close them and to support the electrodes in proper spaced apart positions in the lamp. The lamp is completed by steps well known in the art, including evacuation and introduction of the gas filling and mercury.

In the co-pending application of Leo R. Peters, Serial No. 24,522, of even filing date herewith and assigned to the assignee of the present application, the method of brazing the tungsten and molybdenum parts of the conductor together and the article produced by the method are disclosed and claimed.

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

1. The method of making a stem for a vitreous envelope which comprises forming a vitreous tube with a longitudinally extending annular recess opening into its interior, forming a metal conductor including a rod and a thimble around said rod and hermetically united therewith, said thimble having a feathered sealing edge, covering the portion of said rod extending outward from the closed end of the thimble and said thimble, other than the feathered sealing edge of the latter, with a metal foil, positioning said conductor in said tube with the feathered sealing edge in said recess, positioning a second vitreous tube around the foil-covered portion of the rod and fusing it to said first-named tube to form a composite tube, reducing the pressure in said composite tube below atmospheric, heating the wall of the recess on both sides of said edge to collapse said wall on both of said sides simultaneously to fuse said wall to said edge without deforming the latter and then heating the portion of the composite tube surrounding the foil covered portion of said thimble and said rod to collapse said portion onto said metal foil so that said composite tube tightly fits said thimble and said rod and provides mechanical support for said conductor in said composite tube.

2. The method of making a mechanically strong, electrically conducting gas-tight seal for high capacity, high pressure discharge quartz lamps which comprises hermetically joining a molybdenum thimble having a feathered sealing edge around a tungsten rod passing through the thimble, forming a quartz tube with a longitudinally extending annular recess opening into its interior, positioning the thimble in said tube with its feathered edge in said recess and the rod extending along the tube and exposed beyond one end thereof, positioning a second quartz tube around the exposed end of the rod and telescoped within said first-named tube, filling said tubes with a non-oxidizing atmosphere, fusing the telescoped tube portions together to form a chamber, evacuating the said chamber, heating the wall of the recess on both sides of the feathered edge of the thimble to collapse said wall onto both of said sides simultaneously to fuse said wall to said edge without deforming the latter and then heating the wall of said chamber surrounding the remainder of said thimble and said rod to collapse said wall so that it tightly fits said thimble and said rod to provide mechanical support therefor.

3. A high-pressure-resistant stem for electric devices comprising an elongated vitreous stem tube, a lead-in conductor extending along said tube and beyond each of its ends and a thimble wholly within said tube and hermetically joined to and disposed around said conductor with its closed end toward the inner end of the conductor, said thimble having a feathered sealing edge embedded in and making a fused joint with the wall of the stem tube said tube tightly fitting the exterior of said thimble and at least the portion of said conductor extending outward from the closed end of the thimble to provide mechanical support therefor.

4. A high-pressure-resistant stem for electric devices comprising an elongated vitreous stem tube, a lead-in conductor extending along said tube and beyond each of its ends and a thimble wholly within said tube and hermetically joined to and disposed around said conductor with its

closed end toward the inner end of the conductor and with the ends of the conductor extending beyond the thimble ends, said thimble having a feathered sealing edge embedded in and making a fused joint with the wall of the stem tube, said tube tightly fitting the portions of said conductor extending from said thimble and said thimble to provide mechanical support therefor.

5. A high-pressure-resistant stem for electric devices comprising a vitreous stem tube, a lead-in conductor extending along said tube and a thimble wholly within said tube and hermetically joined to and disposed around said conductor with its closed end toward the inner end of the conductor, said thimble having a feathered sealing edge embedded in and making a fused joint with the wall of the stem tube, said stem tube wall extending into said thimble, and a cylindrical member around said conductor and butting against the tube wall in said thimble and the closed end of the thimble to reinforce the latter.

6. A high-pressure-resistant stem for electric devices comprising a vitreous stem tube, a lead-in conductor extending along said tube and a thimble wholly within said tube and hermetically joined to and disposed around said conductor with its closed end toward the inner end of the conductor, said thimble having a feathered sealing edge embedded in and making a fused joint with the wall of the stem tube, said tube wall closely surrounding said conductor and said thimble to provide mechanical support therefor, and a loose metal foil covering portions of said conductor and said thimble to prevent said tube adhering to said portions.

7. A high-pressure-resistant stem of high capacity for electric discharge quartz devices comprising an elongated quartz stem tube, a tungsten rod extending along said tube and beyond its ends and a molybdenum thimble wholly within said tube and hermetically joined to and disposed around said rod with its closed end toward the inner end of the rod, said thimble having a feathered sealing edge embedded in and making a fused joint with the wall of the stem tube said tube tightly fitting the exterior of said thimble and at least the portion of said rod extending from the closed end of the thimble to provide mechanical support therefor.

8. A high-pressure-resistant stem of high capacity for electric discharge quartz devices comprising an elongated quartz stem tube, a tungsten rod extending along said tube and beyond its ends and a molybdenum thimble wholly within said tube and hermetically joined to and disposed around said rod with its closed end toward the inner end of the rod, said thimble having a feathered sealing edge embedded in and making a fused joint with the wall of the stem tube, and a molybdenum foil sheath extending from the fused joint and covering the exterior of said thimble and the portion of said rod extending inward of the stem tube from the closed end of the thimble, said stem tube tightly fitting the sheathed portions of said thimble and said rod to provide mechanical support therefor.

9. In a high pressure resistant stem for electric devices, a conductor rod, a metal thimble around said rod and a cylindrical metal spacer also around said rod and butting against the inner surface of the thimble, said rod and said thimble being rigidly bonded together with a gas-tight joint therebetween.

10. In a high pressure resistant stem for electric devices, a tungsten rod, a molybdenum thimble around said rod and a molybdenum spacer also around said rod and butting against the inner surface of the thimble, said rod and said thimble being rigidly bonded together with a gas-tight joint therebetween.

11. A high-pressure-resistant stem of high capacity for electric discharge quartz devices comprising an elongated quartz stem tube having a flared end for fusion with the envelope of said device, a tungsten rod extending along said tube and beyond each of its ends and a molybdenum thimble wholly within said tube and hermetically joined to and disposed around said rod with its closed end toward the flared end of the stem tube and with the ends of the rod extending beyond the ends of the thimble, said thimble having a feathered sealing edge embedded in and making a fused hermetic joint with the wall of the stem tube, a molybdenum foil collar around said thimble and extending from the fused joint to the said rod and a molybdenum foil sheath around said rod and extending from said thimble to adjacent the flared end of said stem tube, said stem tube tightly fitting the sheathed portion of said thimble and both ends of said rod to provide mechanical support for said rod and said thimble in said stem tube.

12. A high-pressure-resistant stem of high capacity for electric discharge quartz devices comprising an elongated quartz stem tube having a flared end for fusion with the envelope of said device, a tungsten rod extending along said tube and beyond each of its ends and a molybdenum thimble wholly within said tube and hermetically joined to and disposed around said rod with its closed end toward the flared end of the stem tube and with the ends of the rod extending beyond the ends of the thimble, a molybdenum spacer around said rod and in said thimble and butting against said rod and said thimble, said thimble having a feathered sealing edge embedded in and making a fused hermetic joint with the wall of the stem tube, a molybdenum foil collar around said thimble and extending from the fused joint to the said rod and a molybdenum foil sheath around said rod and extending from said thimble to adjacent the flared end of said stem tube, said stem tube tightly fitting the sheathed portion of said thimble and both ends of said rod to provide mechanical support for said rod and said thimble in said stem tube.

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