

Dec. 20, 1960

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2,965,698

QUARTZ TUBE PINCH SEAL

Filed Aug. 30, 1956

2 Sheets-Sheet 1

FIG. 1.

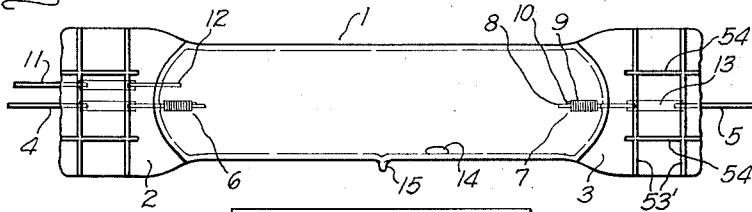
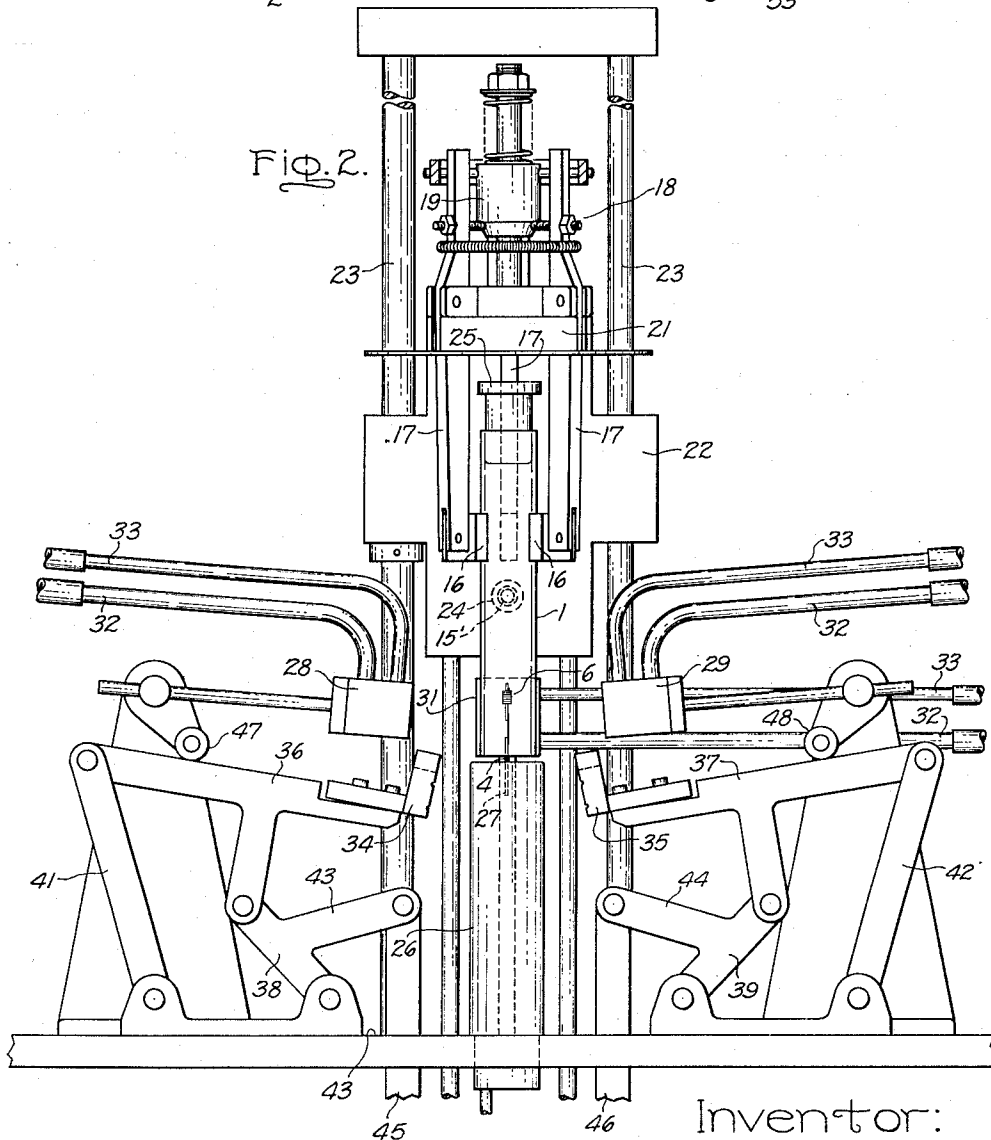


FIG. 2.



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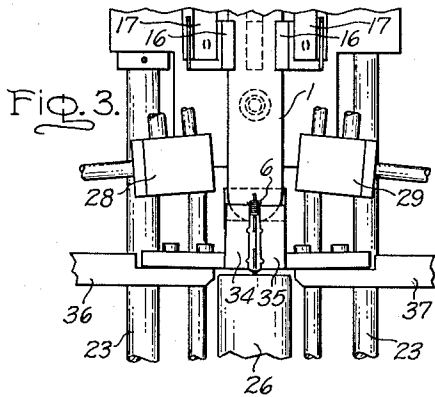
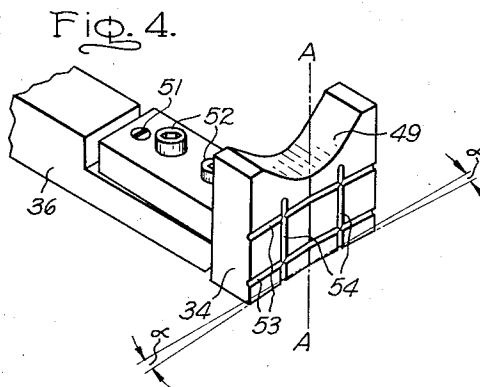


FIG. 5.

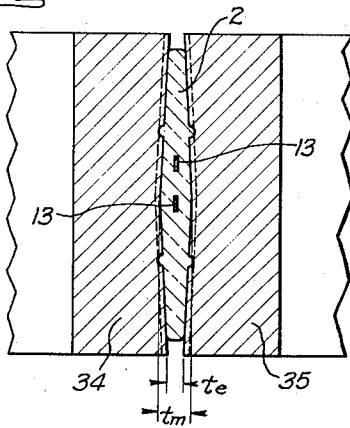


FIG. 6.

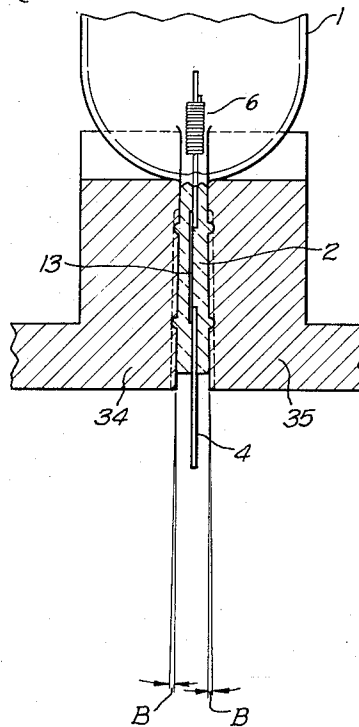
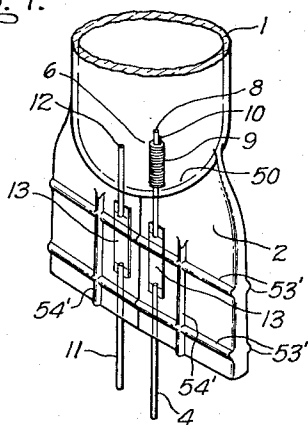


FIG. 7.



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2,965,698

QUARTZ TUBE PINCH SEAL

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Filed Aug. 30, 1956, Ser. No. 607,005

5 Claims. (Cl. 174—50.64)

This invention relates to quartz-to-metal seals for evacuated electric devices. It is more particularly concerned with pinch seals for quartz arc tubes and the manufacture thereof, as used in high pressure mercury vapor discharge lamps.

The quartz arc tube enclosed within the outer glass jacket or envelope of high-pressure mercury vapor discharge lamps contains a quantity of mercury which is vaporized during operation of the lamp, along with a starting gas such as argon at a low pressure to facilitate starting and warm-up of the tube. The electrodes within the arc tube are supported on the inner ends of lead-in wires of refractory metal such as tungsten or molybdenum wire having a foliated or foil-like central portion which is hermetically sealed through the quartz. The arc tube is closed by pressing its ends in a heat-softened condition between a pair of opposed jaws which are moved in a direction substantially perpendicular to the plane of the foliated sections of the lead-in wires to press or pinch the quartz flat about them.

A serious difficulty encountered in the manufacture of pinch seals in which the lead-in wire includes a thin foliated or foil section is the splitting or rupture of the foil section when the hot plastic quartz is squeezed onto it by the opposed jaws. Generally the foil sections rupture by being pulled apart by the flow of quartz under the jaw faces during the pinching operation. Another common difficulty is the occurrence of cavities at the inner end of the pinch seal and opening into the arc tube. Such cavities, which may be thin wedge-shaped openings between the pressed quartz walls of the tube forming the pinch seal, are objectionable because mercury vapor condenses therein during operation of the lamp due to the lower temperature at the seals. Consequently, the lamp fails to develop the mercury vapor pressure for which it has been designed and is defective.

Whereas the difficulties outlined above have been serious even with arc tubes of relatively small diameter, that is tubes having an outer diameter of 10 mm. or less, they have been well nigh insuperable with large diameter arc tubes, for instance tubes having an outer diameter substantially in excess of 10 mm. and wherein the walls are relatively thin, the wall thickness being in general not more than 10% of the outer diameter. Thus for arc tubes having outer diameters of 15, 22, and 27 mm. and the usual wall thickness of $1 \text{ mm} \pm 20\%$, as far as applicant is aware, there has been no commercially acceptable process or means for pinch sealing such tubes across their full diameter. Up to the present, such tubes have been sealed by first reducing the diameter of the ends to about 10 mm. or less. This is generally done by necking down the ends of the arc tube, having a diameter for instance of 22 mm., to about 10 mm. and then splicing on short pieces of 10 mm. quartz tubing which are subsequently pinch sealed with the lead wires inside. The necking down and splicing, which must be done in a glass lathe under fire, is a relatively expensive operation

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and increases the overall manufacturing cost of lamps of this type.

The principal object of this invention is to provide a new and improved full diameter pinch seal incorporating foliated lead-in wires and applicable to relatively large diameter quartz tubing.

Another object of the invention is to provide a suitable apparatus and process for making metal-to-quartz full diameter pinch seals.

In accordance with the invention, a pinch seal is provided which is generally flat and extends the full diameter of the tube, the width of the seal being at least as great as the diameter of the tube and not more than $\pi/2$ times the diameter. Such a seal with foliated lead-ins embedded therein is made feasible by observing certain critical slight departures from parallelism in the generally flat walls of the seal. In the case of quartz tubes having outer diameters greater than 10 mm. and generally in the range from 15 to 27 mm., it has been determined that the seal must be tapered with a thickness decreasing from the medial line, that is from the line corresponding to the axis of the tube, to the lateral edges providing a differential in thickness falling in the range of .03 to .08 inch. In order to avoid cavities at the inner end of the seal where it merges into the body of the tube, there is provided a taper or increase in thickness from the curved inner end to the outer end of the seal and resulting in a differential of thickness in the range of .006 to .02 inch. The first mentioned taper in a transverse direction, that is at right angles to the axis of the tube, is quite critical whereas the taper in the axial direction is less so.

The critical dimensions of the seal are achieved by shaping or positioning in a corresponding fashion the operative faces of the opposed pinching jaws which are used to pinch or press together the heat-softened walls of the quartz tube. Preferably the jaws are also provided with a network of fine transverse and axial grooves which minimize flow of the hot plastic quartz during the pinching operation. These grooves in the jaw faces result in a corresponding network of fine ridges in the opposed faces of the pinch seals.

For further objects and advantages and for a detailed description of the invention, attention is now directed to the following description and accompanying drawings illustrating a preferred embodiment of the invention and the apparatus used in making it. The features of the invention believed to be novel will be more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is a front view of a quartz arc tube for a high-pressure mercury vapor lamp provided with full diameter pinch seals in accordance with the invention.

Fig. 2 illustrates a pinch sealing mechanism which may be used to manufacture the seals illustrated in Fig. 1, the jaws being shown in their retracted position.

Fig. 3 is a detail of the mechanism showing the jaws in their advanced positions closed about the pinch seal.

Fig. 4 is a pictorial view of one of the pinching jaws.

Figs. 5 and 6 are transverse and axial sections respectively on an enlarged scale through the pinch seal with the jaws closed thereon.

Fig. 7 is a pictorial view showing details of a pinch seal.

Referring to Fig. 1, there is shown a quartz arc tube 1 suitable for mounting in the outer vitreous envelope or jacket of a high-pressure mercury vapor lamp of the kind illustrated for instance in co-pending application Serial No. 607,004, of Ernest C. Martt et al., filed of even date herewith, entitled "Arc Tube Mount," and assigned to the same assignee as the present invention, now

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Patent 2,887,825. The ends of the tube are sealed by full diameter pinch seals 2, 3 through which pass respectively inleads 4, 5 supporting on their inner ends main discharge electrodes 6, 7. Each main electrode comprises a core portion 8 which may be a prolongation of the inner end of the inlead made of a suitable refractory metal such as tungsten or molybdenum, and surrounded by a tungsten wire helix 9 (Fig. 7). A small elongated piece or sliver 10 of thorium metal inserted between the core and the helix serves to reduce the cathode drop at the electrodes during operation. An extra inlead 11 at one end of the arc tube adjacent inlead 4 has its inner end serving as an auxiliary starting electrode 12. When the arc tube is made into a lamp, inlead 11 is connected through a current limiting resistor to inlead 5 of main electrode 7 at the opposite end of the arc tube.

Current inleads 4, 5 and 11 as illustrated each comprise a central molybdenum foil section 13 which is bonded to the quartz in the pinch seal, to which are welded a molybdenum wire section projecting outwardly of the seal, and a tungsten wire section projecting inwardly into the arc tube. The foil section may have a thickness of approximately .0008 inch, and, for a 400 watt arc tube, a width of approximately .12 inch, or less in the case of auxiliary electrode inlead 11. Alternatively, the current inleads may be made of a single piece of molybdenum wire having a foliated central portion in accordance with the teachings of Patent 2,667,595, Noel et al., "Ribbon Lead Construction," issued January 26, 1954, to the assignee of this application. The arc tube has a filling of an ionizable medium consisting of a supply of mercury, illustrated as a droplet 14, in sufficient quantity to be completely vaporized with a pressure of the order of one-half to several atmospheres during operation of the lamp, and an inert gas such as argon at a low pressure, for instance approximately 30 mm. pressure, to facilitate starting and warm-up of the tube. The tube is evacuated and the ionizable filling is thereafter introduced into it through a side exhaust tube which is then tipped off at 15.

In accordance with the invention, the pinched end portions or seals 2, 3 of the arc tube extend the full diameter of the tube even for tubes in the range of outer diameters of approximately 15 to 27 mm. In other words, the pinch seal is made by flattening or compressing the ends of the arc tube without prior necking down to a smaller diameter and splicing of a smaller diameter vitreous piece, as has generally been the practice heretofore. The width of the pinch seal is then at least as great as the diameter of the arc tube; in theory, the width would be $\pi/2$ times the diameter of the arc tube but in practice it is less than the figure thus obtained due to slight necking down of the quartz end by surface tension while heated to a plastic temperature during the sealing operation. Thus in the arc tube illustrated which is intended for a 400-watt lamp designated H-400-E1, having an outside diameter of approximately 22 mm. and an inside diameter of approximately 20 mm., the pinch width may be from 25 to 30 mm.

The pinch seals may be formed on the arc tube by using the apparatus illustrated in Fig. 2. The arc tube 1 is held vertically in jaws 16 on the lower ends of pivotable arms 17 of a chuck or holder 18; the arms are spring loaded and actuated by a slidable cone-faced member 19. The holder assembly or chuck 18 is mounted on a water-cooled bracket plate 21 fastened to a sliding head 22 which may be raised or lowered on vertical guide rods 23. The sliding head 22 also carries a tube 24 for supplying nitrogen to a side exhaust tube 15' extending at right angles to the axis of the arc tube. The nitrogen is fed into the arc tube during the pinch sealing operation in order to protect the lead wires from oxidation. When the first pinch seal is being made on an arc tube, the open end of the tube is closed by a suitable stopper such as a transite plug 25. To form the second pinch

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seal, the tube is inverted in the holder assembly, and, of course, the stopper is removed.

The lead wires are accommodated in a lead wire holder or spindle 26 which holds them in place within the arc tube at the proper elevation for sealing into the pinch seal. As illustrated, lead-in conductor 4 has its outwardly projecting wire section received in an aperture 27 in the face of the spindle. The arc tube is supported with its lower edge just clearing the face of the spindle. The lower end of the arc tube is heated by two pairs of opposed burners 28, 29 and 31 and a burner conjugate thereto not shown in the drawing in order to avoid obstructing the view of the arc tube and lead-in conductor. The burners feed mixed jets of hydrogen and oxygen supplied to them through tubes 32, 33; the oxy-hydrogen flames completely envelop the lower end of the quartz tube and heat it to plasticity.

A suitable timer is provided to automatically regulate the heating time by relation to the intensity and heat capacity of the flames for a given size of tube. At the conclusion of such a heating time or cycle, when the lower end of the quartz tube is white-hot and in a plastic condition such that it is beginning to neck down by surface tension in the quartz, the pinching jaws 34, 35 are actuated. The jaws are fastened to the facing ends of the cross arms of T-shaped levers 36, 37 supported on links 38, 39 and 41, 42 pivotally mounted with respect to a bed plate 43. Links 38, 39 have rigidly fastened thereto lateral arms 43, 44 to the ends of which are connected vertical actuating rods 45, 46. Rods 45, 46 for both jaws may be actuated by a hydraulic or air cylinder in order to insure that the pinching operation is effected with the same speed and pressure on the jaws each time.

The initial downward movement of the actuating rods causes the pinching jaws to pivot up into substantially horizontal positions level with the lower end of the arc tube. At the same time, burners 28, 29 which are located directly over the T-shaped levers are pivoted upward by engagement of the rollers 47, 48 and out of the way of the pinching jaws. Continued downward movement of the actuating rods then causes the T-shaped levers to move horizontally together, the jaws thereupon engaging the lower end of the arc tube and flattening or pinching it to the desired shape, as illustrated in Fig. 3. The jaws are then immediately withdrawn and the burners shut off to allow the arc tube to cool. As soon as the lead-in conductors have cooled below the point of red heat, the arc tube may be removed and inverted in the holder or chuck and the pinch at the other end made in the same fashion as has been described.

The structural details of pinch seals in accordance with the invention and the corresponding configuration of the jaws used in making them are illustrated in Figs. 4 to 7. Referring to Fig. 4, the upper edge 49 of the jaw 34 is curved in a concave manner towards the arc tube. Both jaws 34 and 35 are identical and only the former is illustrated. The curved upper edges of the jaws result in a convex and generally hemispherical closure 50 to the end of the arc tube, as illustrated in Fig. 7, thereby avoiding formation of angular corners in which mercury vapor would condense and collect.

In accordance with the invention, the cross-section of the seal is tapered providing a decreasing thickness from the medial line A-A of the seal to the lateral edges. As illustrated most clearly in Fig. 5, such taper is achieved, in the illustrated embodiment, by forming the seal with flat surfaces on either side of the medial line which are inclined to the central plane of the generally flat seal. Thus the jaw surfaces are inclined at an angle α to the plane of the seal; for an arc tube having an outer diameter of 22 mm., α may be between 1.5° and 4° and preferably about 3°. The resulting cross section of the seal is in the nature of a flattened diamond or double wedge and the differential in thickness $\Delta t = t_m - t_e$, where the

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thickness t_m is at the medial line and t_e is the thickness at the lateral edges, as shown in Fig. 5, is in the range of .03 to .08 inch, the actual differential being approximately .06 inch where α is approximately 3° .

The following table gives, for three relatively large sizes of quartz tubing, critical limits for making full diameter pinch seals in accordance with the invention. These are the limits of the inclination of the jaw surfaces on either side of the medial plane, and the limits of the differential in thickness Δt as between the thickness at the medial line and that at the lateral edges. The width of the jaw face is also given, and it is assumed that the pinch seal extends the full width of the jaw face, though in practice it is slightly less, the exact amount depending upon the length of time the quartz tube end is heated to a plastic temperature and the extent of necking down occurring during such time.

Outer Diameter, mm.	Jaw Width, inches	α Inclination, deg.	Δt Differential
15	1.00	2	.035
		5	.087
22	1.25	1.5	.033
		4	.087
27	1.5	1	.026
		3	.079

The table illustrates the unexpected requirement that the limits of the inclination α must shift, as between the various sizes of tubing, to the extent necessary to maintain the limits of the differential in thickness Δt approximately constant. The preferred differential in thickness Δt in each case is about the middle of the range, that is approximately .06 inch, and the preferred inclinations α are approximately 3.5° , 3° and 2° for 15, 22 and 27 mm. tubing respectively.

In the illustrated embodiment, the pinch seal is in the form of a flattened diamond with four plane surfaces providing a decreasing thickness from the medial line to the lateral edges. However it is not essential that the surfaces be plane, and the desired results can also be achieved with curved surfaces. For instance, the jaw faces may be made to a gentle arc providing the same differential in thickness between the medial line and the lateral edges. However, by reason of machine shop practices, it is easier to machine the jaws with plane surfaces than with curved surfaces, and for that reason it is preferred to use inclined plane surfaces as illustrated.

In accordance with the invention and particularly for the purpose of effecting a closure of the arc tube which is free of cavities at the inner end of the seal, the seal is tapered to a wedge shape in axial section providing a thickness increasing from the curved inner edge next to the arc tube to the outer edge, as clearly shown in Fig. 6. The desired result is realized most readily by tipping the jaws 34, 35 relative to the T-levers 36, 37. This may be accomplished by the use of a shim, or a set screw 51 at the rear end of the horizontal portion of the jaw, as illustrated in Fig. 4, which serves to hold the rear end of the horizontal portion up while the two screws 52 fasten it down on the T-lever. The jaws are tipped so that their faces make an angle β with respect to the plane of the seal, or to the plane of the quartz confining enclosure which they form, as shown in Fig. 6. For a 22 mm. arc tube, β is preferably approximately 0.5° ; the resulting increase in thickness along the medial line of the seal from the curved inner edge next to the arc tube to the outer edge due to the taper of both faces of the seal is approximately .012 inch. The increase in thickness should be in the range of .006 to .020 inch for the three sizes of tubing considered. Since the seal length is

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maintained approximately in proportion to the seal width, it follows that the tilt angle of the jaws is increased for the 15 mm. tubing and reduced for the 27 mm. tubing.

As illustrated in Fig. 4, the front face of the pinching jaw is provided with transverse grooves 53 and axial grooves 54 which may be rectangular in section and approximately $\frac{1}{32}$ " deep by $\frac{1}{32}$ " wide. The purpose of these grooves is to minimize flow of the hot plastic quartz under the jaw faces during the pinching or pressing operation. The presence of the grooves in the jaw faces results in the formation of corresponding ridges 53', 54' in the seal which serve to key or lock the quartz in place, thereby reducing the tendency of the quartz to flow and to rupture or split the foil sections of the inleads which are embedded therein. It is possible to make full diameter pinch seals in accordance with the invention without the keying ridges which have been described, but superior and more consistent results are obtained when the keying ridges are used. In this respect the transverse ridges 53' are more important than the axial ridges 54'.

While the present invention has been described with particular reference to a specific preferred embodiment of same, the details of construction described are intended as exemplary and not in order to limit the invention thereto, except in so far as included in the accompanying claims.

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

1. A full diameter quartz-to-metal pinch seal comprising a quartz tube having an outer diameter substantially in excess of 10 mm. and a wall thickness not exceeding approximately 10% of said outer diameter, said tube having one end closed by a pinch seal consisting of the tube walls collapsed and pressed substantially flat and fused together in a plane including the axis of the tube, a refractory metal conductor extending through the seal having an intermediate foil portion hermetically united with the seal substantially in said plane, said seal having a width at least as great as the outer diameter of the tube and being formed with a concave curve at its inner end to provide a generally hemispherical closure to the tube, said seal being tapered with a thickness decreasing from the medial line to the lateral edges thereof through a differential in the range of .03 to .08 inch.

2. A full diameter quartz-to-metal pinch seal comprising a quartz tube having an outer diameter in the range of approximately 15 to 27 mm. and a wall thickness of approximately 1 mm., said tube having one end closed by a pinch seal consisting of the tube walls pressed substantially flat and fused together in a plane including the axis of the tube, a refractory metal conductor extending through the seal having an intermediate foil portion hermetically united with the seal substantially in said plane, said seal having a width at least as great as the outer diameter of the tube and a thickness corresponding approximately to twice the wall thickness of the tube, said seal being formed with a concave curve at its inner end to provide a generally hemispherical closure to said tube, said seal being tapered with a thickness decreasing from the medial line to the lateral edges thereof through a differential in the range of .03 to .08 inch and increasing from the curved inner end to the outer end thereof through a differential in the range of .006 to .02 inch.

3. A full diameter quartz-to-metal pinch seal according to claim 2 provided with transverse and axial ridges in the generally flat surfaces thereof for minimizing flow of plastic quartz during pinching of the seal.

4. A full diameter quartz-to-metal pinch seal comprising a quartz tube having an outer diameter of approximately 22 mm. and a wall thickness of approximately 1 mm., said tube having one end closed by a pinch seal consisting of the tube walls pressed substantially flat and fused together in a plane including the axis of the tube, a refractory metal conductor extending through the seal and having an intermediate foil portion hermetically united with the seal substantially in said plane, said seal

being approximately 25 to 30 mm. wide and approximately 2 mm. thick and having a concave curve at its inner end to provide a generally hemispherical end to said tube, said seal being tapered with a thickness decreasing from the medial line to the lateral edges thereof through a differential of approximately .06 inch and increasing from the curved inner end to the outer end thereof with a differential in thickness of approximately .012 inch, and transverse and axial ridges in the surfaces of said seal for minimizing flow of plastic quartz during pinching of the seal.

5. A full diameter quartz-to-metal pinch seal comprising a quartz tube having an outer diameter in the range of approximately 15 to 27 mm. and a wall thickness of approximately 1 mm., said tube having one end closed by a pinch seal consisting of the tube walls pressed substantially flat and fused together in a plane including the axis of the tube, a refractory metal conductor extending through the seal and having an intermediate foil portion hermetically united with the seal substantially in said plane, said seal having a width at least as great as the outer diameter of the tube and a thickness of approximately 2 mm. and a concave curve at its inner end to provide a generally hemispherical closure to the

tube, said seal being formed with a flattened diamond shape in a transverse section with a thickness decreasing from the medial line to the lateral edges thereof through a differential in the range of approximately .03 to .08 inch, and with a wedge shape in an axial section with a thickness increasing from the curved inner end to the outer end thereof through a differential in the range of .006 to .02 inch, and transverse and axial ridges in the surfaces of said seal for minimizing flow of plastic quartz during pinching of the seal.

References Cited in the file of this patent

UNITED STATES PATENTS

2,020,729	Knoeppel	Nov. 12, 1935
2,312,245	Flaws	Feb. 23, 1943
2,452,061	Krim	Oct. 26, 1948
2,568,459	Noel	Sept. 18, 1951
2,632,033	Krefft	Mar. 17, 1953
2,675,496	Unglert et al.	Apr. 13, 1954
2,676,435	Gillman	Apr. 27, 1954
2,682,009	Fraser	June 22, 1954
2,705,310	Hodge	Mar. 29, 1955
2,775,070	Burroughs	Dec. 25, 1956
2,844,919	Power	July 29, 1958