

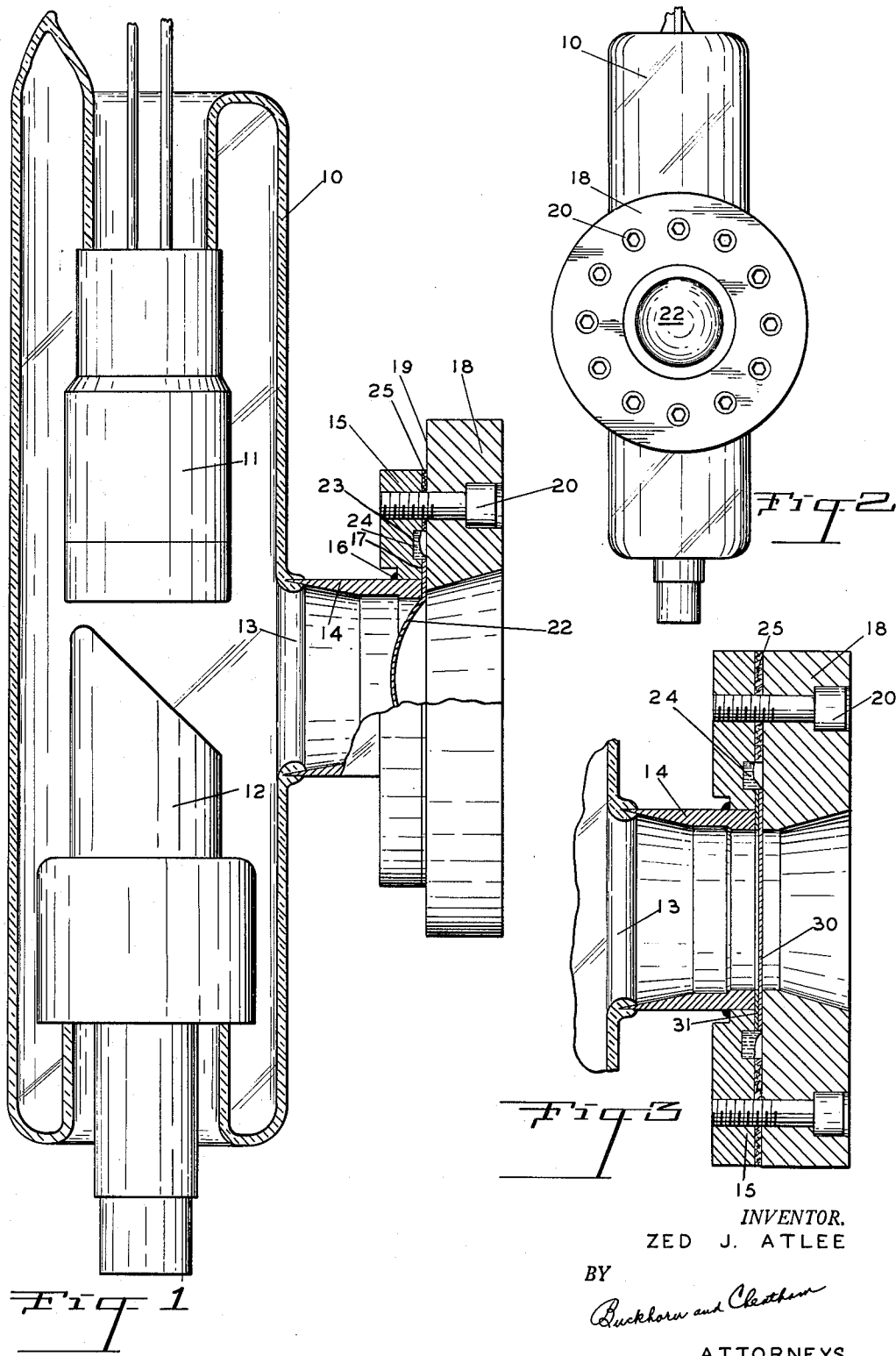
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X-RAY TUBES WITH LOW-ABSORPTION WINDOWS

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1

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X-RAY TUBES WITH LOW-ABSORPTION WINDOWS

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The present invention relates to X-ray generators and more particularly to new and improved mounting arrangements for high X-ray permeability windows in the walls of X-ray tubes.

Materials generally satisfactory for the construction of the envelope of an X-ray tube have a relatively high absorption coefficient for X-rays so that there is a high loss in the X-rays generated by the tube. This is especially true for the so-called "soft" X-rays of relatively long wave length which have less penetrating power than "hard" X-rays of short wave length. To alleviate this problem, considerable effort has been employed to devise a window of high X-ray permeability in the envelope of an X-ray tube in the path of the X-rays emanating from the anode. In a typical installation as heretofore provided, a metal ring has been secured about an opening in the envelope of the tube and a high permeability metal disc has been soldered across the end of the ring. However, the metals which are suitable for forming windows, that is, those metals having a low coefficient of absorption for X-rays, are difficult to solder to obtain a vacuum-tight seal, especially in the thinner foils of such materials. Very thin foils of beryllium, for example, which is an excellent X-ray transmitting material, are practically impossible to successfully solder because they either crack or impurities burn out, making them porous. Consequently, the use of beryllium for such purposes has been restricted to relatively thick foils, thereby reducing the efficiency of the X-ray tube. Aluminum, a metal having fair X-ray transmitting properties and considerably cheaper than beryllium, is also extremely difficult to solder; so difficult, in fact, that its use as window material has heretofore been practically precluded.

It is a primary object of the present invention, therefore, to provide a relatively simple and inexpensive mounting arrangement for a high X-ray permeability window in the envelope of an X-ray tube.

It is a further object of the present invention to provide a new and improved means for mounting a thin foil of high X-ray permeability material across an opening in the envelope of an X-ray tube.

More particularly, it is an object of the present invention to provide a new and improved means for mechanically clamping a high X-ray permeability window in a vacuum-tight seal across an X-ray opening provided in the envelope of an X-ray tube.

In accordance with an illustrated embodiment of the invention, I have provided an X-ray generator including a sealed envelope provided with an opening in the path of the generated X-rays across which is mechanically clamped in vacuum-tight relation a thin disc of high X-ray permeability, gaseous impermeable material. To more effectively seal the clamped joint, a high temperature resistant sealing compound is employed in the clamped mounting.

Other objects and advantages of the present invention will be more readily ascertained from an inspection of the following specification taken in connection with the

2

accompanying drawings wherein like numerals refer to like parts throughout, while the features of novelty will be more distinctly pointed out in the appended claims.

In the drawings,

Fig. 1 is a side elevation of an X-ray tube having my invention incorporated therein, portions being broken away to show certain details of the invention;

Fig. 2 is a front elevation of the tube shown in Fig. 1; and

Fig. 3 is a fragmentary cross-sectional view of a further embodiment of my invention.

Referring now to the drawings, an X-ray generator is shown comprising an evacuated glass envelope 10, but which may be of metal, containing a cathode unit 11 and an anode unit 12 and having an opening 13 positioned in the path of X-rays emanating from the anode 12. Sealed to the envelope 10 about the opening 13 by a conventional glass-to-metal seal is a window mounting ring such as the cylindrical, tubular metal member 14 provided at its outer end with a radially extending peripheral flange 15 having a substantially planar face 17. The flange 15 is preferably formed separately and welded or soldered as at 16 to member 14. A clamping ring 18, having a planar face 19, is clamped against the flange 15 as by a plurality of screws 20 extending through the clamping ring and cooperatively threaded into flange 15, or by other suitable well-known clamping means. Disposed across the outer end of the member 14 is a thin disc of aluminum foil 22, the peripheral marginal portion of the disc extending between the inner edges of the flange 15 and the ring 18, the latter element clamping the margin of the disc tightly against the face 17 of the flange 15. The disc 22 is shown as in an evacuated tube, the external air pressure causing the disc to be depressed inwardly of the mounting as shown.

To assure a vacuum-tight seal between the flange face and the disc, I employ a high temperature resistant semi-fluid having a viscosity of the order of that possessed by greases and having a relatively low volatility. Materials of this nature which I have found to be particularly suitable are represented by the silicone greases. Such a grease will effectively seal the joint between the window disc and the flange if the abutting surfaces thereof are coated with the grease prior to the assembly of the tube. However, this is not a satisfactory arrangement inasmuch as some of the grease may migrate into the tube and evaporate on evacuation of the tube. Though small in amount, the grease will condense on the anode when the tube cools to form a coating on the anode target, perhaps only a few molecules thick, but sufficient to impair the efficient operation of the tube. I have found, however, that if the grease is disposed sufficiently outwardly from the inner edge of the face of the flange that the amount of grease which migrates to the interior of the tube, if any, is inconsequential and does not impair the efficiency of the tube operation. In the preferred arrangement illustrated in Fig. 1, the face 17 of flange 15 is provided with an annular grease retaining groove 23 spaced an appreciable distance outwardly from the opening in the tubular member 14. In this groove is placed, before assembly of the clamping ring 18 upon the flange 15, the gasketing material 24 which, as stated before, may be a silicone grease of low volatility. Though the foil disc 22 may be of such diameter as to extend across the groove 23, I have found that the most effective arrangement is that shown in the drawing wherein the diameter of the disc 22 corresponds substantially to the inner diameter of the groove 23. Should any leaks occur between the disc 22 and the flange face 17 during the evacuation of the tube, the silicone grease flows or migrates to cover the peripheral edge of the foil disc 22 to plug the leak without itself being drawn through. To retain the silicone

grease within the groove 23 and prevent its loss an annular washer 25 of a fibrous material such as fiber or asbestos may be provided outwardly of the annular groove 23.

Referring now to Fig. 3, a beryllium foil disc 30 is shown sealed in vacuum-tight relation across the opening 13. In this instance, the flange 15 and the clamping ring 18 are constructed as in the previous embodiment, but an annular washer 31 of a soft metal, such as, for example, aluminum, is provided between the surface 17 of the flange 15 and the beryllium foil disc 30. It has been found that a more satisfactory seal is formed in this manner than if the beryllium disc 30 is clamped directly against the face 17 of the flange 15, since the washer 31 more readily deforms to meet any irregularities in the surface of the flange. The silicone grease disposed within the groove 23, as previously described, migrates sufficiently to effectively seal the juncture between the flange face 17, washer 31, and the beryllium disc 30. The abutting or clamping surfaces in both the present modification and the embodiment of the invention previously described should be very highly finished to present as few deformities as possible therebetween.

By the practice of the present invention, aluminum window discs having a thickness of about 0.0015 inch have been successfully secured in vacuum-tight relation across the opening in the envelopes of X-ray tubes. It would be practically impossible, of course, to successfully solder an aluminum window of such thinness. Admittedly the use of aluminum rather than beryllium as the window material would decrease the efficiency of an X-ray tube. However, aluminum foils are relatively inexpensive as compared with the cost of thin beryllium discs, and the economic saving in the use of aluminum may in many instances justify its use. In this connection it should be noted that with an aluminum window of the thinness it is possible to provide in accordance with the present invention, an X-ray tube will have a reasonably high efficiency.

Heretofore beryllium windows have of necessity been from about 0.040 inch to 0.060 inch or more in thickness, for the aforementioned reason that windows of lesser thickness cannot be successfully soldered without causing cracks in the beryllium or developing leaks by burning out impurities. By the method of the present invention, however, tubes have been formed having beryllium windows of thicknesses ranging from 0.010 inch to 0.030 inch, making possible the construction of a tube having extremely high efficiency. In addition to being more efficient, tubes having the thinner windows are of greater usefulness in that a greater proportion of the X-rays of longer wave length will be transmitted through the foil. Furthermore, the fabrication of X-ray tubes in accordance with the present invention is accomplished at a much lower cost than was possible heretofore.

It should be apparent that the choice of window material is not limited to beryllium and aluminum. Other materials such as nylon or Teflon, a fluorinated hydrocarbon, could be used, except that in windows of this type a conducting layer would have to be coated on the vacuum side of the foil.

Having illustrated and described a preferred embodiment of the present invention, it should be apparent to those skilled in the art that the invention permits of modification in arrangement and detail. I claim as my invention all such modifications as come within the true spirit and scope of the appended claims.

I claim:

1. An X-ray generator comprising a sealed envelope, anode and cathode means within said envelope, said envelope having an opening opposite said anode means, a round tubular metal member sealed to said envelope about said opening having a radially extending, peripheral flange about its outer end, said flange having a substantially planar face, a metal clamp ring having a sub-

stantially planar face, a thin disc of aluminum foil extending across the outer end of said member and having its peripheral marginal portion extending between said flange and ring, the planar face of said flange having an annular groove therein spaced slightly outwardly from the edge of said disc, a silicone grease of relatively low volatility within said groove and covering the joint between the edge of said foil and the face of said flange, and means operatively connected to said ring and said flange for tightly clamping the face of said ring to the face of said flange with said foil therebetween.

2. An X-ray generator comprising a sealed envelope, anode and cathode means within said envelope, said envelope having an opening opposite said anode means, a round tubular metal member sealed to said envelope about said opening having a radially extending, peripheral flange about its outer end, said flange having a substantially planar face, a metal clamp ring having a substantially planar face, a thin foil disc of X-ray permeable, gaseous impermeable material extending across the outer end of said member having its peripheral marginal portion extending between said flange and ring, at least one of said faces having an annular groove therein spaced slightly outwardly from the periphery of said disc, a silicone grease of relatively low volatility within said groove and covering the joint between the edge of said foil and the face of said flange, and fastening means connected to said ring and said flange for tightly clamping the face of said ring to the face of said flange with said foil therebetween.

3. An X-ray generator comprising a sealed envelope, anode and cathode means within said envelope, said envelope having an opening opposite said anode means, a tubular metal member sealed to said envelope about said opening and having a radially extending, peripheral flange about its outer end, said flange having a substantially planar face, a metal clamp ring having a substantially planar face, a thin disc of X-ray permeable, gaseous impermeable material extending across the outer end of said member with the peripheral marginal portion thereof extending between said flange and ring, a silicone grease of relatively low volatility distributed between said faces adjacent the edge of said disc, and fastening means extending between said flange and ring for tightly clamping said disc between the planar faces of said flange and said ring.

4. In an X-ray generator including a sealed envelope having an opening in the envelope in the path of the generated X-rays, the invention comprising a tubular metal member sealed to said envelope about said opening and having an outwardly extending peripheral flange about its outer end, said flange having a planar face, a metallic clamping ring having a planar face, a thin foil disc of X-ray permeable, gaseous impermeable material extending across the outer end of said member and having its peripheral marginal portion clamped between the inner edges of said flange and ring, a material of greaselike consistency and of relatively low volatility distributed about the edge of said disc at its point of contact with the face of said flange, and fastening means extending between said flange and said ring for tightly clamping said marginal portion of said disc between said planar faces.

5. In an X-ray generator comprising a sealed envelope having an opening in the path of generated X-rays, a tubular metal member sealed to said envelope about said opening, a radially extending peripheral flange about the outer end of said member, said flange having a substantially planar face, said face having an annular groove therein spaced an appreciable distance outwardly from the opening in said member, a silicone grease of low volatility within said groove, a locking ring having a substantially planar face, a thin foil of an X-ray permeable, gaseous impermeable metal extending across the outer end of said member, the peripheral marginal portion of said foil extending between said flange and said ring, and means associated with said ring and said flange for tightly clamp-

5

ing said marginal portion of said foil between said faces.

6. In an X-ray generator comprising a sealed envelope having an opening in the path of generated X-rays, a tubular metal member sealed to said envelope about said opening, a radially extending peripheral flange about the outer end of said member, said flange having a planar face, said face having an annular groove therein concentric with and spaced an appreciable distance outwardly from the opening in said member, a greaselike material of low volatility within said groove, a locking ring having a substantially planar face, a thin foil disc of an X-ray permeable, gaseous impermeable material extending across the opening in said member, and means associated with said ring and said flange for tightly clamping the peripheral marginal portion of said disc between said faces.

7. In an X-ray generator comprising a sealed envelope having an opening in the path of generated X-rays, a tubular metal member sealed to said envelope about said opening, a radially extending peripheral flange about the outer end of said member, a clamping ring, a thin beryllium disc extending across the outer end of said member, the peripheral marginal portion of said disc extending between said flange and said ring, an annular washer of aluminum interposed between said flange and said disc, a silicone grease of relatively low volatility distributed about the edge of said disc at the point of contact thereof with said washer, and about the edge of said washer at the point of contact thereof with said flange, and fastening means associated with said ring and said flange for tightly clamping said disc and said washer therebetween in a vacuum-tight relation.

8. An X-ray generator comprising a sealed envelope, anode and cathode means within said envelope, said envelope having an opening opposite said anode means, a tubular cylindrical metal member sealed to said envelope about said opening and having an outwardly extending, peripheral flange about its outer end, said flange having a substantially planar face, a metal clamp ring having a substantially planar face, a thin disc of beryllium foil extending entirely across the outer end of said sleeve and between the inner edges of said flange and ring, an annular aluminum washer interposed between the face of said flange and said disc, at least one of said faces having an annular groove therein spaced slightly outwardly from the edge of said disc, a silicone grease of relatively low volatility within said groove and covering the joints between the outer peripheral edges of said disc, washer and the face of said flange, and fastening means extending between said member and said ring securing said disc and washer in a vacuum-tight relation therebetween.

9. An X-ray generator comprising a sealed envelope,

6

anode and cathode means within said envelope, an opening in said envelope opposite said anode means, a tubular metal member sealed to said envelope about said opening, a thin foil of X-ray permeable, gaseous impermeable material extending across the outer end of said member, a clamping ring, fastening means cooperatively arranged between said ring and said member for tightly clamping the peripheral margin of said foil between said member and said ring in vacuum-tight relation, and a semifluid of relatively low volatility distributed about the peripheral edge of said foil which lies adjacent said member.

10. An X-ray generator including an anode unit and a cathode unit sealed within a glass envelope having an opening positioned in the path of X-rays emanating from said anode, and means forming an X-ray permeable, vacuum-tight seal over said opening comprising a metal mounting ring sealed to said envelope about said opening, a clamping ring, a foil of an X-ray permeable, gaseous impermeable material disposed over the end of said mounting ring with the peripheral marginal portion thereof clamped in a vacuum-tight relation between said clamping ring and said mounting ring, and a semifluid material having a greaselike consistency and of relatively low vapor pressure dispersed about the outer peripheral joint between said mounting ring and said foil.

11. In an X-ray generator comprising a sealed envelope having an opening in the path of generated X-rays, a tubular metal member sealed to said envelope about said opening, a radially extending peripheral flange about the outer end of said member, a clamping ring, a thin beryllium disc extending across the outer end of said member, the peripheral marginal portion of said disc extending between said flange and said ring, an annular washer of soft metal interposed between said flange and said disc, a silicone grease of relatively low volatility distributed about the edge of said disc at the point of contact thereof with said washer, and about the edge of said washer at the point of contact thereof with said flange, and fastening means associated with said ring and said flange for tightly clamping said disc and said washer therebetween in a vacuum-tight relation.

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