Feb. 9, 1943. Z. J. ATLEE ET AL 2,310,567

X-RAY APPARATUS AND METHOD OF CONSTRUCTION

Filed Jan. 8, 1941

Fig. 1

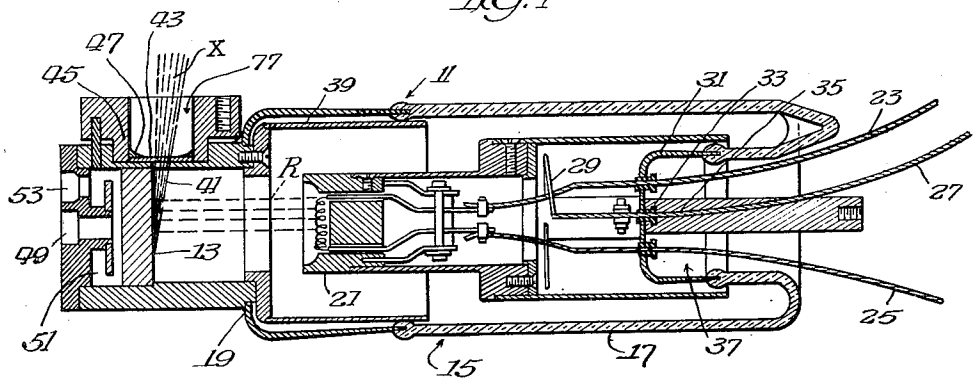


Fig. 2

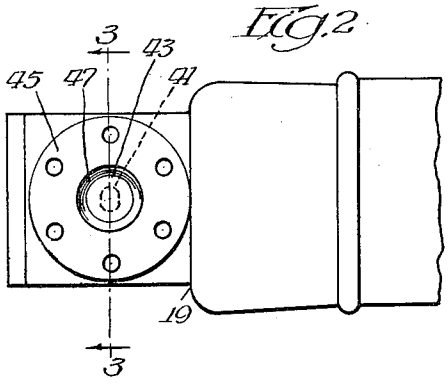
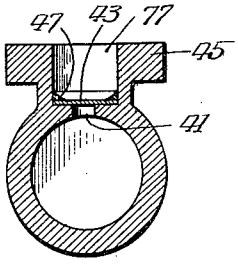


Fig. 3



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X-RAY APPARATUS AND METHOD OF CONSTRUCTION

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10 Claims. (Cl. 250—147)

This invention relates to a new and improved type of X-ray apparatus and to a new and improved method for the construction of such an apparatus.

An important object of the invention is to produce a new and improved type of evacuated tube, more particularly an X-ray generator, in which the outer casing of the tube is constructed in such a manner as to permit the maximum passage of X-rays therethrough.

Another object of the invention is to provide a new and improved type of X-ray generator which is particularly well suited for making X-ray diffraction patterns of chemical substances, or other material.

Another object of the invention is to provide a new and improved type of evacuated tube, more particularly an X-ray generator, in which the window through which the X-rays pass is constructed of beryllium and is disposed in the outer casing of the tube.

Another important object of the invention is to provide a new and improved method for brazing or soldering beryllium to other metals.

Still another important object of the invention is to provide a new and improved method for producing a vacuum-tight joint between beryllium and another metal in an evacuated tube such as an X-ray generator, whereby the X-rays generated may be passed directly through the beryllium window without passing through any intermediate material which might tend to absorb them.

Still a further object of the invention is to produce an X-ray tube especially suitable for making X-ray diffraction patterns and characterized particularly by the fact that greater intensity and concentration of the X-ray on the substance to be examined can be obtained.

Still an additional object of the invention is to provide a new and improved type of X-ray generator having a window constructed of beryllium with a minimum amount of absorption of X-rays of the K-alpha line.

Another important object of the invention is to provide a means for forming a vacuum-tight joint between beryllium and another metal in the outer casing of an evacuated envelope by employing a solder or brazing composition comprising a combination of a metal which has a tendency to go into solution with beryllium very rapidly with another metal that goes into solution with beryllium very slowly.

These and numerous other important objects, advantages, and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawing, discloses a preferred embodiment of the invention.

Referring to the drawing:

Figure 1 represents a sectional view taken through an X-ray generator of a type constructed in accordance with the present invention;

Figure 2 is a plan view of one end of the X-ray generator of Figure 1 with which the present invention is especially concerned; and

Figure 3 is an enlarged cross-sectional view taken along the line 3—3 of Figure 2.

As shown by the drawing, the present invention may be illustrated by an X-ray generator 11 comprising an anode or target 13 made of copper or other suitable material, such as iron, molybdenum, cobalt, chromium, or nickel cast in copper, and supported within a sealed envelope 15 comprising a hard glass portion 17 and a metal portion 19 constructed of cold rolled steel or other suitable material.

Any suitable means may be employed for generating the cathode ray utilized in bombarding the target 13. Thus, in the particular embodiment shown, a line focus cathode 21 is employed, which is furnished with a source of electrical energy through conductors 23 and 25. A conductor 27 is provided in order to supply electrical energy to a getter wire 29. All conductors are introduced into the evacuated portion of the envelope through vacuum-tight joints, such as shown by the joints 31, 33 and 35. Since the tube is immersed in an oil bath, the oil circulating through the area 37 serves to cool the cathode portion of the tube. As shown, the cathode 21 is surrounded by a shield 39.

The cathode rays "R," impinging on the target 13, generate the X-rays "X," which pass through a small port 41 and then through a vacuum-tight beryllium window pane or plate which is brazed or soldered to the surrounding metal 45 by means of a special type of alloy indicated at 47. The useful beam of the X-ray, passing through port 41 and beryllium window pane or plate 43, is preferably taken off at an angle of about four to eight degrees relative to the target 13 As shown in Figure 2, the port 41 is preferably oblong or elliptical in cross-sectional shape. The target 13 is cooled by a direct connection to tap water or other suitable source of water or other cooling fluid, which is introduced through a conduit 49 circulated through

the anode cooling chamber 51 and removed through the outlet conduit 53

The invention herein described is particularly concerned with the beryllium window 43 and the means for attaching it to member 45 in order to produce a vacuum-tight beryllium window joint. It has been found, in accordance with this invention, that an alloy of a metal which has a tendency to form solutions with beryllium rapidly, and a metal which has a tendency to form solutions with beryllium very slowly, can be employed in order to solder or form a vacuum-tight joint between beryllium and other metals, as, for example, cold rolled steel.

In accordance with a preferred embodiment of the invention, we have found that a special alloy, containing about 50% silver and about 50% copper, will form a vacuum-tight joint between a beryllium plate and a steel bushing when the brazing is done in a hydrogen furnace and calcium chloride is used as a flux. This particular alloy, which represents a preferred embodiment of the invention, has the necessary properties of wetting the beryllium but yet not going into full solution with it before a satisfactory joint is formed. In order that an alloy may flow evenly over the surface of the beryllium to form a joint, it must be in a highly molten state. But the higher the temperature, the faster is the rate at which beryllium will go into solution with metals or alloys with which it has any tendency at all to form solutions. For example, pure copper, in the molten state, goes into solution very rapidly with beryllium. On the other hand, pure silver, in the molten state, goes into solution with beryllium very slowly. Alloys of copper and silver have intermediate rates of solution. Moreover, all alloys of copper and silver have melting points lower than that of pure copper. All alloys having less than about 15% of copper have melting points lower than that of pure silver. Therefore, alloys of copper and silver have the added advantage that they can be used at lower temperatures, which possibility adds further to the control of the rate of solution with beryllium. For the purpose of the present invention it is preferable that the relative amounts of copper present in the alloy of copper and silver be greater than the relative amount of copper present in its eutectic composition. The eutectic composition consists of 72% silver and 28% copper.

In actual practice, the vacuum-tight joints which are obtained with the alloy containing 50% silver and 50% copper go into solution over the welded or soldered portions of the surface of the beryllium plate to a depth of only a few thousandths of an inch.

The thickness of the beryllium plate 43 may vary, but good results have been obtained by employing a plate having a thickness from about $\frac{1}{32}$ to about $\frac{1}{8}$ of an inch. It will be understood, of course, that the invention is not limited specifically to the use of alloys of silver and copper containing 50% of each ingredient, nor is it specifically limited to silver or copper alloys, although it is preferable, for the purpose of the present invention, that the alloy be one which is molten at a temperature within the range from 700° C. to 900° C.

In making vacuum tubes, and particularly in making X-ray generators, the use of alloys for brazing which have a melting point greater than about 900° C. is undesirable because of the possibility of cracking or checking parts of the tube, and also because the higher the temperature, the greater is the possibility of the alloy going into solution with the beryllium. If this occurs, the window of the X-ray tube would no longer be substantially pure beryllium, consequently it would absorb a greater amount of the X-rays generated and one of the advantages of the invention would be lost. Furthermore, if higher temperatures are employed in the brazing operation, the temperature more nearly approaches the melting point of beryllium, which is around 1283° C.

In the practice of the invention, we have also employed as the brazing alloy, an alloy containing 80% copper, 15% nickel, and 5% iron. This alloy, although relatively high melting (melting point around 1200° C.), gives a satisfactory joint between the beryllium and another metal, for example, cold rolled steel.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. An X-ray generator comprising an evacuated casing having a portion formed with a window opening, means for generating X-rays within said casing for transmission therefrom through said opening, means forming a sleeve on and extending outwardly of said casing and forming, thereon, an outwardly opening pocket having said window opening at the bottom thereof, and a plate of beryllium sealed at its edges on said sleeve in vacuum tight fashion, said plate being positioned to permit the passage of generated X-rays therethrough.

2. An X-ray generator comprising an evacuated metal casing having a portion formed with a window opening, means for generating X-rays within said casing for transmision therefrom through said opening, means forming a sleeve on and extending outwardly of said casing and forming, thereon, an outwardly opening pocket having said window opening at the bottom thereof, and a plate of beryllium sealed at its edges on said sleeve in vacuum tight fashion, said plate being positioned to overlie said window opening and permit the passage of the generated X-rays therethrough.

3. In an X-ray generator having an evacuated casing, a beryllium window, and a vacuum tight metal joint between said window and said casing, said joint being formed of a soldering alloy comprising a metal which in the molten state goes into solution rapidly with beryllium, alloyed with a metal, which in the molten state goes into solution slowly with beryllium, said alloy having a melting point above about 700° centigrade, but substantially below the melting point of beryllium.

4. In an X-ray generator having an evacuated casing, a beryllium window, and a vacuum tight metal joint between said window and said casing, said joint being formed of a soldering alloy comprising a metal which in the molten state goes into solution rapidly with beryllium, alloyed with a metal, which in the molten state goes into solution slowly with beryllium, said alloy

having a melting point within the range of about 700° to about 900° centigrade.

5. In an X-ray generator having an evacuated casing, a beryllium window, and a vacuum tight metal joint between said window and said casing, said joint being formed of an alloy of copper and silver in which the relative amount of copper present is substantially greater than the amount of copper present in the eutectic composition of said alloy.

6. In an X-ray generator having an evacuated casing, a beryllium window, and a metal joint between said window and said casing, said joint being formed of an alloy of copper and silver in which the relative amounts of copper and silver are approximately equal.

7. In an X-ray generator having an evacuated casing, a beryllium window, and a metal joint for joining said window to said casing, said metal joint being composed of an alloy of copper, nickel and iron, containing approximately 80% copper, 15% nickel, and 5% iron.

8. A vacuum tube comprising an evacuated casing having an outwardly extending sleeve formed thereon and providing an outwardly opening pocket having a bottom formed with a window opening communicating with the interior of the casing, and a plate of metallic beryllium hermetically sealed in the bottom of said pocket in position overlying said window opening and forming an integral part of the casing.

9. An X-ray generator comprising an evacuated casing having an outwardly facing seat formed on a wall thereof and provided with a window opening within the borders of said seat and communicating with the interior of said casing, a plate comprising beryllium substantially transparent to X-rays mounted on said seat in position covering said opening, and means comprising solder hermetically sealing said plate on said seat around said opening, said solder comprising an alloy of copper and silver and being disposed outwardly of the edges of said opening, thereby avoiding solder contamination of the portions of said plate covering said opening.

10. An X-ray generator comprising an evacuated casing having an outwardly facing seat formed on a wall thereof and provided with a window opening within the borders of said seat and communicating with the interior of said casing, a plate comprising beryllium substantially transparent to X-rays mounted on said seat in position covering said opening, and means comprising solder hermetically sealing said plate on said seat around said opening, said solder comprising an alloy of copper, nickel and iron and being disposed outwardly of the edges of said opening, thereby avoiding solder contamination of the portions of said plate covering said opening.

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