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Z. J. ATLEE ET AL

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WINDOW CONSTRUCTION FOR X-RAY TUBES

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*Fig. 1.*

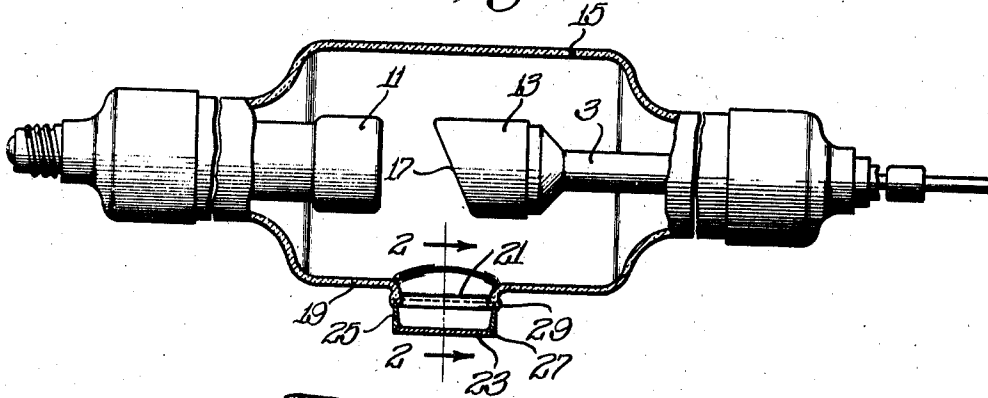


*Fig. 2.*

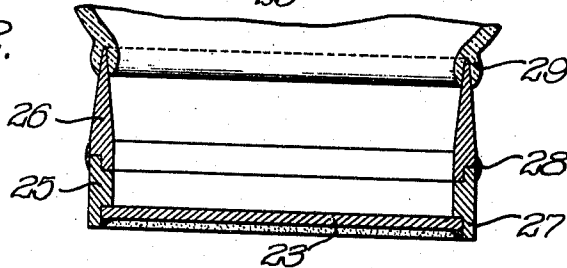


*Fig. 3.*

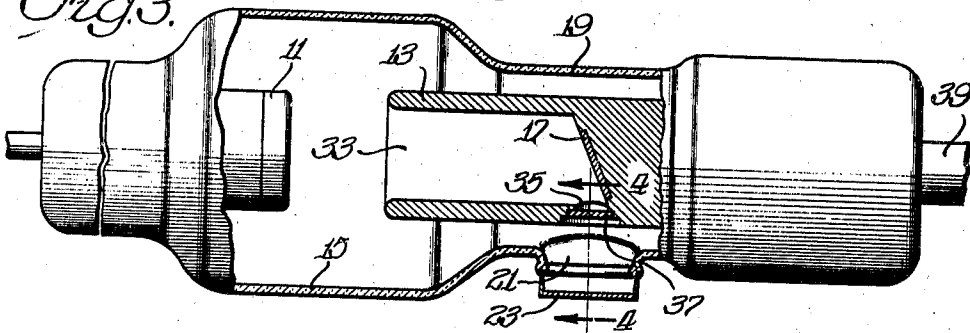
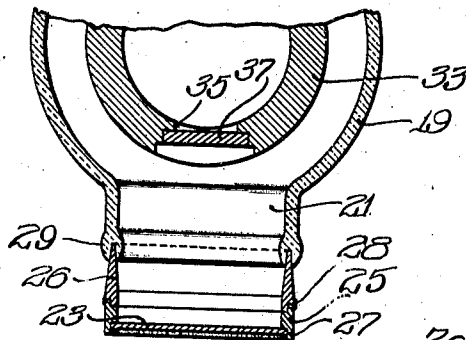


*Fig. 4.*



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## WINDOW CONSTRUCTION FOR X-RAY TUBES

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7 Claims. (Cl. 250—147)

The present invention relates in general to electronics and has more particular reference to X-ray generators.

An important object of the invention is to provide an X-ray generator comprising a cathode and co-operating anode enclosed within a sealed evacuated envelope of suitable material and having window means substantially transparent to X-rays formed in the envelope for the transmission of X-rays outwardly of the envelope without material absorption.

Another important object is to provide a low absorption window structure for use in X-ray generators; a further object being to utilize a plate of beryllium in a low absorption X-ray window.

Another important object is to provide an X-ray generator having a glass envelope fitted with a window comprising a beryllium plate sealed in the glass envelope as a low absorption X-ray window; a further object being to fit the window on the envelope by sealing it in a metal mounting ring of nickel, Monel metal, or other alloy containing a relatively large proportion of nickel to wet or seal with beryllium, and then sealing the mounting to the glass envelope.

These and numerous other important objects, advantages, and inherent functions of the invention will be 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 is a sectional view taken through a high voltage X-ray generator fitted with a window structure embodying the present invention, thereby making possible the operation of the generator at low voltage;

Figure 2 is a sectional view along the line 2—2 in Figure 1;

Figure 3 is a sectional view taken through a high voltage self-rectifying X-ray generator embodying a hooded anode construction and fitted with a low absorption window structure embodying the present invention; and

Figure 4 is a sectional view along the line 4—4 in Figure 3.

To illustrate the invention, the drawing shows two types of high voltage generators, each of which comprises a cathode 11 and a co-operating anode 13 mounted in spaced facing relationship within an envelope 15 of any suitable envelope material such as glass. It will be understood, however, that the invention is not necessarily restricted to any particular type of X-ray gen-

erator but may be employed wherever it is desirable to provide a low absorption X-ray window.

It should be understood, of course, that an X-ray generator functions for the production of X-rays at the anode by the impingement thereon of electrons emitted at the cathode and directed toward the anode, the anode and cathode performing their functions under vacuum conditions maintained in the envelope 15 which comprises an hermetically sealed container.

When the window construction of the present invention is used in a generator designed for high voltage operation, it makes possible the production of usable X-rays at low operating voltages applied on the tube, the same being of value, for example, where so-called "soft" X-rays are needed, as in showing the more delicate, relatively transparent portions of a body or object being examined, as distinguished from the body portions which are relatively opaque to X-rays. For example, in making X-ray pictures of bony body structures, it is necessary to employ X-rays of high intensity, whereas to picture tissue and the structure thereof, relatively soft X-rays, such as may be produced by low voltage operation of the generator, are frequently necessary. In a generator built for high voltage operation, the envelope 15 comprises material capable of absorbing X-rays to an appreciable extent which, of course, impairs efficiency of the generator even when operating at high voltage, and which renders the high voltage generator very inefficient when producing X-rays of low intensity, because of substantially complete absorption thereof by the envelope. By utilizing the window structure of the present invention, however, the generator is constituted as a highly efficient source of X-rays, whether operated at high voltage or at low voltage to produce soft rays of low intensity.

In each of the generators illustrated, the cathode 11 constitutes an electron emission source which may comprise a filament mounted in the cathode and adapted to be electrically energized from a suitable source of filament energy, located outwardly of the envelope, through conductors connected with the filament and extending out through the envelope at one end thereof, said end being formed with a suitable seal which serves also to support the cathode structure. The cathode is positioned in the envelope in position to direct a stream of electrons from the cathode upon the facing end of the anode which forms an electron target 17, X-rays being generated at the target as a result of electron impingement thereon and traveling from the target in

a direction radially of the axis of the generator. In order to penetrate outwardly of the envelope for effective use, the X-rays necessarily must pass through the wall of the envelope opposite the target 17.

The envelope may, of course, be of any preferred, usually sleeve-like configuration, including a preferably cylindrical portion 19 surrounding the anode opposite the target; and the envelope may comprise any suitable or preferred envelope material, the envelope, in the illustrated embodiment, comprising a hard glass of the borosilicate type, such as Corning No. 705 A. J., which is particularly well suited for use as an envelope material for various considerations. Glass, however, as well as other suitable envelope materials, absorbs X-rays to an appreciable extent, thus materially reducing the intensity and amount of X-rays which may pass outwardly through the envelope from the source or target 17. In order to improve the over-all efficiency of the generators, the envelope wall 19 opposite the target 17 is formed with an opening 21 at the place where the emission of usable X-rays from the envelope is desired. This opening is fitted with a pane of material 23 which is substantially transparent to X-rays and which is hermetically sealed in the opening 21 in a fashion preserving the vacuum-tight condition of the envelope. The window-pane 23, according to the present invention, comprises a disk of suitable X-ray transparent material, such as beryllium, which, however, is difficultly sealable to glass. Beryllium, however, may be hermetically sealed with metal containing a high proportion of nickel which, in turn, may be sealed to glass. Fernico, an alloy of nickel and iron containing about 42% nickel, may be readily sealed to glass. Beryllium also may be sealed directly to Fernico but is more easily sealed to Monel metal, a copper alloy containing about 67% nickel. In applying the pane 23 to the envelope, therefore, it is first sealed in a preferably annular mounting member formed of metal containing nickel in substantial quantities, the mounting member being then sealed in the envelope. The mounting preferably comprises a short sleeve 25 of Monel metal having an annular recess 27 at one end for receiving the edges of the disk 23, which is sealingly secured in the recess as by soldering the edges of the disk to the mounting. The opposite end of the mounting sleeve 25 is formed with a recess to fit a corresponding recess in a short sleeve 26 of Fernico, the sleeves 25 and 26 being secured together at a butt joint 28 by brazing or soldering. The opposite end of the sleeve 26 forms an annular tapered edge which is sealed to the glass envelope by means of a glass-to-metal seal 29 at the edges of the envelope defining the opening 21, said edges being preferably turned outwardly of the envelope to form a short neck.

The beryllium window is sealed in the mounting, and the mounting sleeves 25 and 26 are secured together by means of an improved soldering or brazing material, preferably comprising an alloy of copper and silver, containing gold as an alloy ingredient, together with lithium, calcium or silicon as a flux. The proportions of the ingredients in the soldering alloy are not critical. The copper constituent may vary between 25% and 50%; the silver between 30% and 60%; the gold between 10% and 35%; and the fluxing medium (lithium, calcium, or silicon, or combinations of lithium, calcium and silicon) in any proportions not exceeding 1%.

The following examples illustrate the proportions of constituents successfully used as soldering material:

| Constituents   | Examples of soldering alloys |    |    |    |    |    |
|----------------|------------------------------|----|----|----|----|----|
|                | 1                            | 2  | 3  | 4  | 5  | 6  |
| 10 Silver----- | 60                           | 61 | 33 | 33 | 45 | 45 |
| Copper-----    | 30                           | 28 | 33 | 33 | 45 | 44 |
| Gold-----      | 10                           | 10 | 33 | 32 | 10 | 10 |
| Flux-----      |                              | 1  |    | 1  |    | 1  |

Where the soldering alloy is used without fluxing material in the alloy itself, it is necessary to use a separate fluxing material even where the brazing is done in a hydrogen furnace or other reducing atmosphere. For this purpose, the halide salts of sodium, potassium, lithium, beryllium, magnesium, barium and similar substances may be used; and a highly satisfactory fluxing material for use with silver alloy solder is a mixture comprising one part lithium chloride and two parts lithium fluoride.

The foregoing window construction affords a substantially transparent route for the egress of usable X-rays outwardly of the envelope without, however, impairing the essential vacuum-tight condition of the envelope. The window construction is preferably applied to the envelope prior to the assembly therein of the anode and cathode and prior to the evacuation of the envelope, which comprises a final step in the fabrication of the generator and the conditioning thereof for service.

As shown in Figure 1, illustrating a high voltage therapy generator, the anode is of the plain open stationary type supported on a stem 31 which is supported at and which extends outwardly of the envelope through a suitable seal at the end of the envelope opposite the cathode carrying end thereof.

The generator shown in Figure 3 comprises a high voltage self-rectified therapy tube having a hooded anode in which the target 17 is disposed at the bottom of a cavity 33 which opens toward the cathode, the anode walls defining the cavity 33 being formed with an opening 35 forming an anode window opposite the target 17, which opening is fitted with a pane of material 37, such as graphite, beryllium, or other suitable material substantially transparent to X-rays, whereby to obtain the benefits of a hooded anode construction without, however, impeding the exit of X-rays from the target 17 through the anode and envelope windows. The hooded anode is supported in the envelope on a suitable seal at the end thereof remote from the cathode carrying end of the envelope, the anode having an extension 39 extending outwardly of the envelope at the anode mounting end thereof.

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 envelope, anode and cathode means sealed in said envelope, said envelope including a glass en-

velope portion surrounding said anode, said portion having an opening opposite the anode, sleeve-like mounting means comprising a Fernico ring sealed on said envelope at said opening, a mounting section comprising a ring of Monel metal sealed on said Fernico ring, and a pane of beryllium sealed in said ring of Monel metal.

2. An X-ray generator comprising an envelope of material substantially opaque to X-rays, anode and cathode means sealed in said envelope, said envelope including a glass envelope portion surrounding said anode, said portion having an opening opposite the anode, an annular metallic mounting member sealed on said envelope at said opening in glass-to-metal sealing relation, and a pane of material substantially transparent to X-rays sealingly secured on said mounting member, said pane being brazed to the mounting member by means of solder comprising a substantial proportion of silver.

3. An X-ray generator comprising an envelope of material substantially opaque to X-rays, anode and cathode means sealed in said envelope, said envelope including a glass envelope portion surrounding said anode, said portion having an opening opposite the anode, an annular metallic mounting member sealed on said envelope at said opening in glass-to-metal sealing relation, and a pane of material substantially transparent to X-rays sealingly secured on said mounting member, said pane being brazed to the mounting member by means of solder comprising a silver alloy containing copper as an alloy ingredient.

4. An X-ray generator comprising an envelope of material substantially opaque to X-rays, anode and cathode means sealed in said envelope, said envelope including a glass envelope portion surrounding said anode, said portion having an opening opposite the anode, an annular metallic mounting member sealed on said envelope at said opening in glass-to-metal sealing relation, and a pane of material substantially transparent to X-rays sealingly secured on said mounting member, said pane being brazed to the mounting member by means of solder comprising a silver alloy containing gold as an alloy ingredient.

5. An X-ray generator comprising an envelope of material substantially opaque to X-rays, anode and cathode means sealed in said envelope, said envelope including a glass envelope portion surrounding said anode, said portion having an opening opposite the anode, an annular metallic mounting member sealed on said envelope at said opening in glass-to-metal sealing relation, and a pane of material substantially transparent to X-rays sealingly secured on said mounting member, said pane being brazed to the mounting member by means of solder comprising a silver alloy containing gold and copper as alloy ingredients.

6. An X-ray generator comprising an envelope of material substantially opaque to X-rays, anode and cathode means sealed in said envelope, said envelope including a glass envelope portion surrounding said anode, said portion having an opening opposite the anode, an annular metallic mounting member sealed on said envelope at said opening in glass-to-metal sealing relation, and a pane of material substantially transparent to X-rays sealingly secured on said mounting member, said pane being brazed to the mounting member by means of solder comprising a silver-copper alloy containing a substance from the group consisting of calcium, lithium and silicon as a fluxing medium.

7. An X-ray generator comprising an envelope of material substantially opaque to X-rays, anode and cathode means sealed in said envelope, said envelope including a glass envelope portion surrounding said anode, said portion having an opening opposite the anode, an annular metallic mounting member sealed on said envelope at said opening in glass-to-metal sealing relation, and a pane of material substantially transparent to X-rays sealingly secured on said mounting member, said pane being brazed to the mounting member by means of solder comprising a silver-copper alloy containing gold as an alloy ingredient, together with a fluxing substance comprising a material or materials from the group consisting of calcium, lithium and silicon in quantities not exceeding 1% of the alloy.

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