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X-RAY TUBE STRUCTURE

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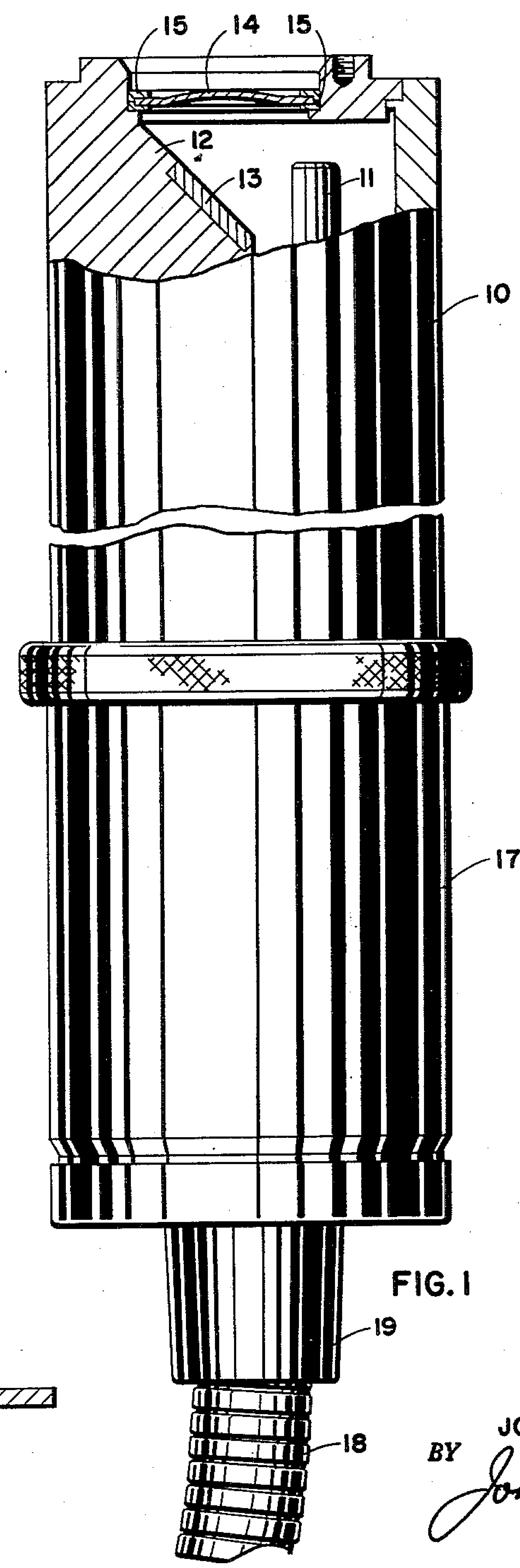

FIG. 1

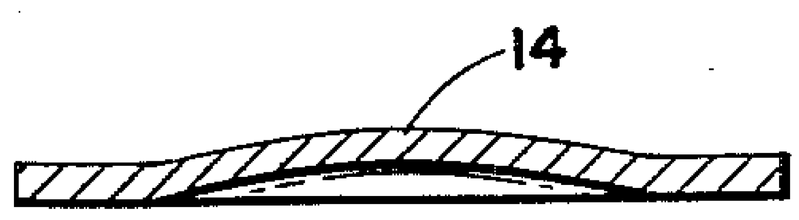

FIG. 2

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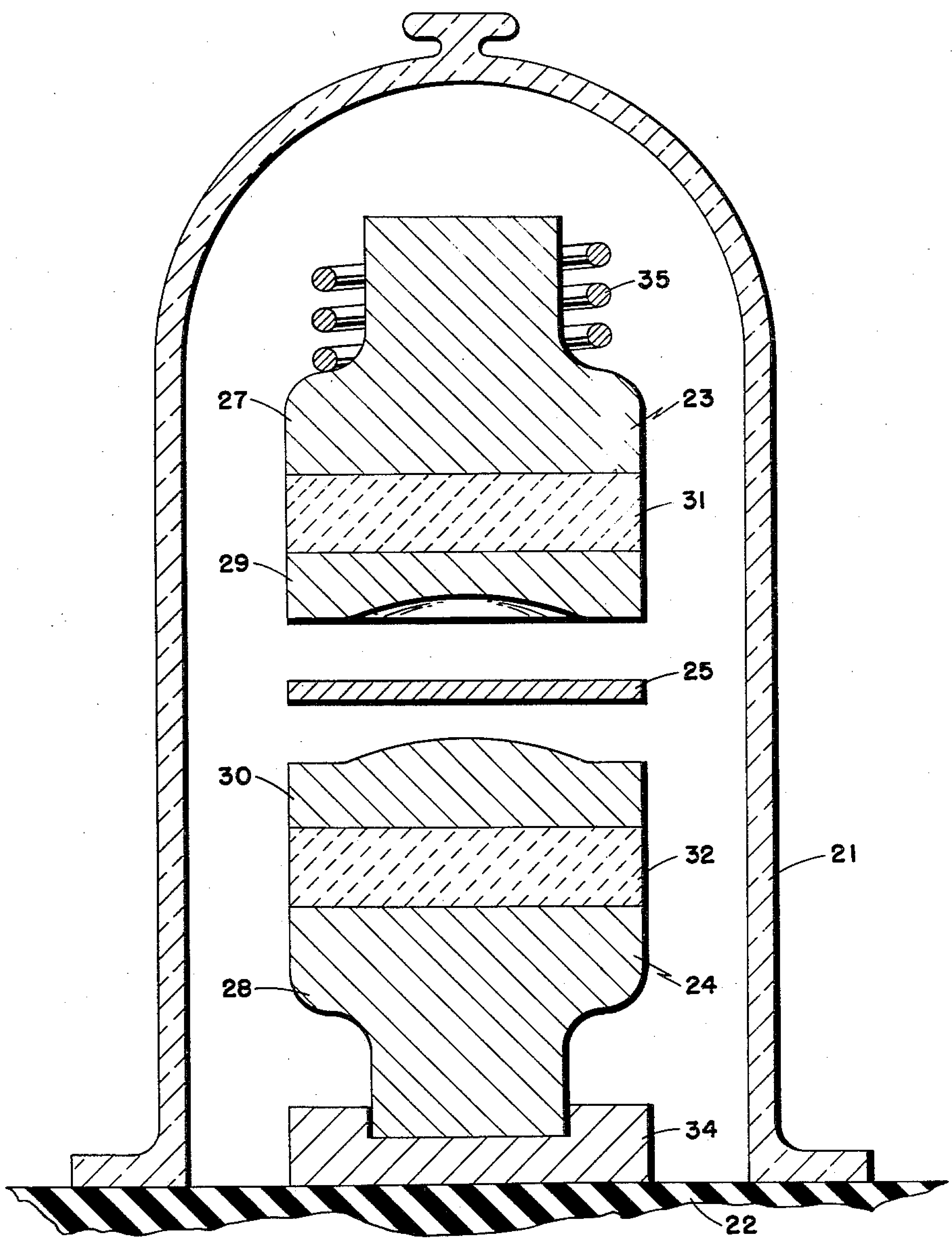

FIG. 3

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X-RAY TUBE STRUCTURE

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3 Claims. (Cl. 313—59)

This invention relates to a novel X-ray permeable window for use in X-ray tubes. More specifically, this invention relates to an X-ray window which is bowed or corrugated in such a manner that it is able to change its shape in order to compensate differential expansion.

A high rate of failure of beryllium windows in certain types of X-ray tubes has been observed for some time. It has been found that changes in tube geometry will sometimes prevent destruction of the windows. However, changes in geometry also change characertistics in many instances, and often characteristics of the modified design are less desirable than those of the original.

My observations indicate that the principal cause of destruction of beryllium windows is the sudden, severe heating produced by bombardment of the windows by secondary electrons. More specifically, it is the non-uniform heating of various regions in the window and its support which results in the destruction. Beryllium is a material which has a relatively high expansion coefficient and relatively low thermal conductivity. Consequently, regions removed from parts of the beryllium window which are heated by bombardment tend to become heated relatively slowly so that upon beginning tube operations extreme differences are encountered in the temperature of different regions in the window. In fact, it is possible for secondary electrons to generate a high surface temperature on the inside surface of the beryllium window while the rest of the window, including the outer surface, remains relatively cool for a period long enough for undesirable expansion effects to occur. Since the windows are rigidly fixed to the envelope structure in order to complete the vacuum envelope, the differential expansion which results will inevitably cause high internal stresses and possible deformation. If such is the case, the repetition of straining and relieving the strains during a period of use will cause cracks and fissures in the window and a consequent loss of vacuum.

My invention permits the relief of expansion-produced strains so that they will not cause window destruction. My invention permits adjustability in the window structure itself so that expansion effects may be relieved despite the fact that the window is rigidly affixed at all its edges to the relatively massive envelope structure. This adjustability is provided by shaping the window itself in such a manner that its expansion will merely exaggerate the shape which has already been provided in the window. Ordinarily, in accomplishing this end, the windown is convoluted in the same general pattern as the supported periphery of the window structure. For instance, when employing the invention with a conventional round disk window, the pattern of the convolution is circular wherein the circles are concentric with junction of the window and the support structure. In its simplest form, such a round window is provided with a single slight bow in one direction or the other, but preferably extending away from the target. Despite the relative rigidity of its support at its periphery, which rigid support prevents outward expansion, such a window when

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heated is able to absorb its expansion by increasing the gradient of the slopes of the convoluted or bowed part of the window. Thus, strains which would otherwise be produced by expansion are relieved without damaging the window structure.

For a better understanding of the present invention reference is made to the following drawings:

Fig. 1 illustrates in partial section an electron tube wherein one version of the present invention is employed;

Fig. 2 illustrates in cross-section a window construction of the present invention;

Fig. 3 illustrates schematically and in section an apparatus for forming the window structure shown in Fig. 2.

Referring to Fig. 1 an X-ray tube is illustrated wherein part of the vacuum envelope **10** is composed of a metal casing. The remainder of the envelope may be composed of glass or other suitable dielectric material through which leads from the cathode are brought out. Within the vacuum envelope are cathode **11** and anode **12**. The cathode filament is not illustrated but is enclosed within the shielding and focusing member which is illustrated in elevation. The anode is a heavy copper block which, in this case, is kept at ground potential by directly coupling it to the envelope **10**. Within the envelope the active surface of the anode is provided by a target block **13** of tungsten or other suitable dense material. The filament within focusing member **11** produces an electron focal spot on target **13**. From this focal spot, in turn, originate X-rays which leave the vacuum envelope through beryllium window **14** in the end of the structure. Unfortunately, in addition to the X-rays, high energy secondary electrons are emitted from the target and impinge the beryllium window. These high energy electrons cause severe heating of the window and repetition of this heating in a conventional window may produce a recurrence of strains which will eventually cause breakage of the window. The window **14** is mounted in a pair of annular bezel members **15** which are fixed securely and vacuum tight to the metallic casing of vacuum envelope **10**.

A casing **17** is provided to slip over the envelope portion **10**. The space between the casing **17** and the envelope member is filled with insulating oil. Member **17** also provides a socket for connection to a terminal **19** on the end of cable **18**. This terminal **19** may be partially viewed in Fig. 1, but, for the most part, it extends inwardly into the socket provided for it in member **17**.

As may be seen in Fig. 2, the X-ray permeable window **14** in accordance with this invention is provided with a slight convolution or bow in order to give it flexibility. This convolution or bow is located concentrically with the supported periphery of the window. Since the window **14** is located directly in the path of X-rays produced at target **13** and also in the path of secondary electrons, it is subjected to rapid heating to which its supporting structure is not subjected. This heating tends to produce expansion which, were no provision made to accommodate it, would result in the build up of internal strains within the window structure. However, with the structure of the present invention expansion produces an increased bowing of window **14**. In other words, the gradient of the bow increases or becomes exaggerated so that expansion is easily compensated.

An alternative construction of the window would be to make it corrugated with any number of convolutions arranged concentrically with the support for the window. The term "convoluted shape" is intended to include a single bow or multiple convolutions in a window.

The beryllium or other X-ray-permeable material may be formed into a window for use in accordance with this invention by the apparatus shown in Fig. 3. This apparatus is meant to be representative only and many other devices may be employed to accomplish essentially the same ends. In the structure shown in Fig. 3, a glass or transparent bell jar **21** covers the apparatus and rests against platform **22** in such a manner that the bell jar may be evacuated or filled with a non-oxidizing gas. Advantageously, the structure basically consists of a pair of jaws generally designated **23** and **24** between which the beryllium disk **25** to be formed is placed. The jaws are the heating elements of a resistance heating system which consists of copper block members **27** and **28**, stainless steel die members **29** and **30** and refractory members **31** and **32**, of such material as graphite. The bottom copper block is made to fit a base piece **34** which holds it securely in place. The upper block **27** is urged downwardly by spring member **35**. Electrical connections (not shown) are employed to provide a current through the forming assembly.

In operation of the assembly shown in Fig. 3 the region under the vacuum jar **21** is evacuated or filled with non-oxidizing atmosphere. Block **23** is acted upon by spring **35** and presses downward against disk **25** which it urges toward block **24**. The spring pressure of spring **35** is sufficient to urge the blocks into good electrical contact with disk **25** but not sufficient to deform the disk while cold. Current is then permitted to flow through the block. Because of the resistance encountered in refractory material **31** and **32**, the die pieces **29** and **30** are heated and the heat is conducted to disk member **25**. The heating is sufficient to soften the disk which then deforms under the urging of spring **35** into the shape provided by the die members **29** and **30**. Inasmuch as pressure is retained on this disk until it is cool, the disk will retain the formed shape, as illustrated in Fig. 2, and may be employed in a tube assembly in accordance with the present invention.

Die members of various shapes may be employed in order to obtain windows of shapes different from that illustrated in Fig. 2. Other changes in the apparatus and the geometry of the window illustrated will occur to those skilled in the art. All such changes or modifications within the scope of the claims are intended to be within the scope and spirit of the present invention.

I claim:

1. An X-ray tube embodying an elongated housing containing a cathode and an anode and having in one end thereof an opening for exit of X-rays from the anode, and within the opening a window formed of material having expansion characteristics different from those of the material of the housing adjacent the opening, the window being of a metal relatively easily penetrated by X-rays and of relatively inflexible characteristics, the window further being a relatively rigid disclike member lying in a plane normal to the longitudinal axis of the housing and having an annular marginal portion lying in said plane and vacuum-sealed throughout its periphery to the inner wall of the opening, and further having its central portion integral with the annular marginal portion and formed with an outwardly bowed convolution whereby the central portion of the relatively rigid window may expand freely with respect to the housing.

2. An X-ray tube substantially as set forth in claim 1 wherein the window is beryllium.

3. An X-ray tube embodying a cylindrical housing containing a cathode and an anode and having in one end thereof a substantially circular opening for exit of X-rays from the anode, within the opening a relatively thick and rigid beryllium window having expansion characteristics different from those of the material of the housing, and an annular bezel vacuum-sealed throughout its periphery to the inner wall of the opening and having a groove formed in its inner peripheral edge, the window being a disclike member having a substantially planar annular marginal portion which is positioned within and vacuum-sealed in the groove in the bezel and further having its central portion integral with the annular marginal portion formed with an outwardly cupped shape whereby the central portion of the relatively rigid window may expand freely and unrestrictedly with respect to its supporting structure.

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