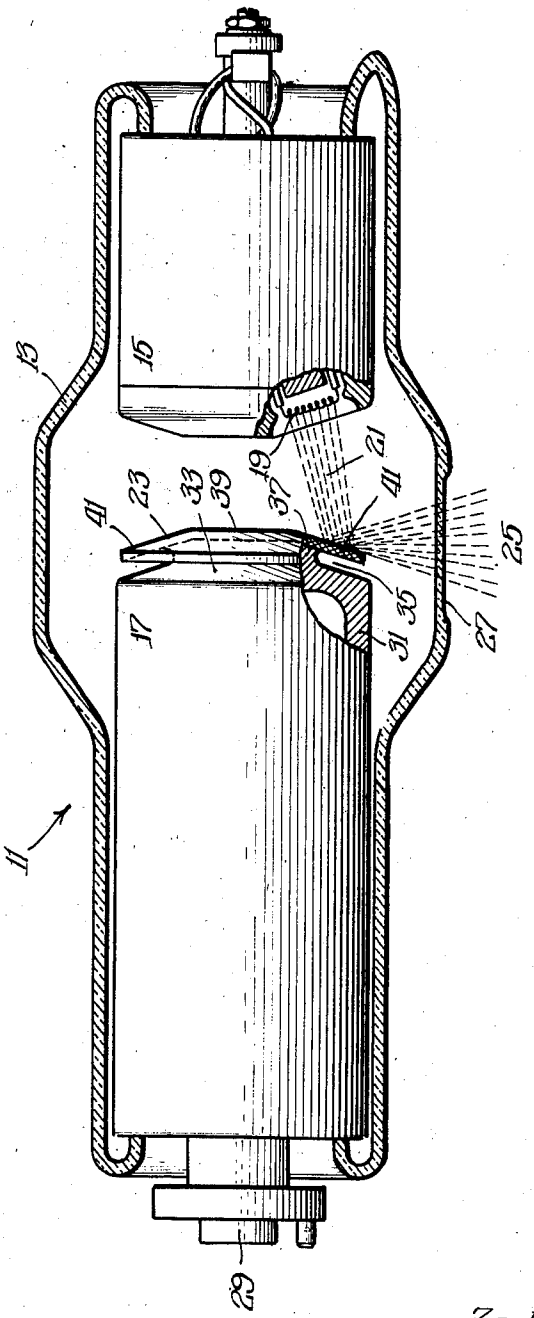
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X-RAY TUBE

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## X-RAY TUBE

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2 Claims. (Cl. 250—148)

The present invention relates in general to electronic devices and has more particular reference to X-ray generators, the invention more especially pertaining to anode construction for use in X-ray generating tubes.

An important object of the present invention is to provide an improved rotating anode structure especially well adapted to withstand the effects of electronic bombardment thereof in the generation of X-rays; a further object being to provide an anode structure including an electron target having the ability to resist target deterioration under the influence of the excessive heat developed at the target when subjected to electronic bombardment.

Another important object is to provide a rotating anode adapted to withstand the relatively high operating temperatures developed therein when subjected to electronic impact in the generation of X-rays, the anode structure of the present invention being particularly well suited for operation at high temperatures without cracking, peeling or flaking of the target.

Another important object is to provide an anode comprising a base carrying an electron target member mounted on the base in position for bombardment, including means for supporting the target member on the base for the transfer of heat developed in the target to the base while dissipating forces due to thermal expansion in a fashion preventing mechanical deterioration of the target and its mounting; a further object being to utilize a target member comprising a disc or plate bonded to the base at the central portions of the disc to provide a target rim extending outwardly of the supported portions of the disc in position to receive electron bombardment, whereby thermal expansion and contraction will take place mainly in the peripheral, mechanically unsupported portions of the target member, and be transferred thence inwardly to the relatively cooler, centralized, supported portions of the plate, and transferred thence to the supporting base without danger of rupturing the bond between the plate and the base, and without danger of the development of checks, cracks and flakes at the working surface of the target.

A still further object of the invention is to form an anode target member having portions thermally isolated from the target-supporting base whereby the expansion and contraction of said portions through the excessive range of temperature generated in said portions may be transferred first to relatively cooler portions of the plate before being dissipated into the support base to thereby minimize the deleterious effects of unequal rates of expansion of the target and the base materials, which tends to disrupt the mechanical bond between the target member and the base member on which it is supported.

Another important object is to provide an anode comprising a target plate bonded on a heat conducting base for heat conduction from plate to base, the plate being mounted in a manner presenting a portion of the plate in position thermally isolated from direct contact with the base so that, by confining electronic bombardment of said target plate to a target area within said isolated plate portions, the same may be heated substantially uniformly throughout the entire thickness of said portions to thereby avoid surface cracking and flaking due to unequal heating of the said plate portions inwardly of the target surface.

The foregoing 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 and the manner of practicing the same.

Referring to the drawing:

The single figure comprising the drawing is a sectional view taken through an X-ray generator having an anode embodying the present invention.

To illustrate my invention, I have shown, in the drawing, an X-ray generator comprising an hermetic envelope 13 of tubular form, within the opposite ends of which is mounted electrode means comprising an electron emitting cathode 15 and an anode 17, said electrodes being sealed within the envelope in opposing relationship.

The cathode 15 comprises an electron emitting filament 19 disposed in position to project electrons as a stream 21 toward the facing end of the anode which is provided with target means 23 disposed in the path of the electron stream 21, and it should be understood that impingement of electrons projected by and from the cathode upon the target 23 results in the production of X-rays at the target and the projection of such X-rays as a beam 25 outwardly of the envelope through a window 27 formed therein opposite the target. The anode is supported within the envelope on a spindle 29, said spindle extending outwardly of the envelope through a seal in the end thereof.

In the illustrated embodiment, I have shown

an anode 17 of the rotating type, the same comprising a hollow anode base 31 having an integral closed end 33 carrying the target 23. The hollow base 31 encloses the spindle 29 within the envelope and is turnably supported thereon by suitable bearing means which may be, and preferably is, of the sort illustrated and described in my co-pending application Serial No. 284,273 filed July 13, 1939, which has become Patent No. 2,293,037, or modifications as shown in other co-pending patent applications.

The anode base 31 is made of copper, or other cupreous material adapted to conduct heat readily. The target member 23 preferably comprises tungsten, or other suitable material, the member 23, in the illustrated embodiment, being formed as a plate and being secured upon the closed end of the base 31 in position facing the cathode 15, the plate 23 being adhered or bonded to the base in any preferred fashion, as by preforming the plate 23 and casting the material of the base 31 upon the pre-formed plate in a suitable mold, the base material becoming alloyed with the surface material of the plate during the casting operation so that the target plate is integrated with and becomes a part of the base, while at the same time maintaining the separate identity of the target material and the base material.

Impingement of electrons on the target results in the generation of substantial heat at the target, and the anode, as a result of electron bombardment, may reach a temperature of the order of several hundred degrees centigrade when the generator is in operation. This heat is dissipated by conduction through the anode and radiation therefrom outwardly of the envelope.

It will be seen, however, that all of the heat generated in the target member necessarily is dissipated thence through the relatively larger mass of metal comprising the base 31. The material of the base 31 is adapted to conduct heat away from the target rapidly, but because of the greater mass of material in the base 31 and its higher heat conducting ability, the base at all times during operation of the device will be at a temperature appreciably lower than target temperature. The temperature in the target is a maximum at the surface of that portion of the target which is disposed in the path of the electron stream and subjected to electronic bombardment. In a rotating target the target area is annular, each portion of the target area being successively presented for bombardment in the electron stream as the anode is rotated. The temperature of the target surface is a maximum, of course, at the instant when it is subjected to electronic bombardment, the temperature dropping slightly due to rapid heat conduction therefrom into the base during the period while the target area is rotating out of the path of the electron stream 21. When the generator is in operation each portion of the target thus is successively raised to a maximum temperature and then cooled substantially. This results in alternate expansion and contraction of the target material. The rate of thermal expansion of the material of the plate 23 is usually substantially lower than the rate of thermal expansion of the material of the base, which condition, in conjunction with the lower operating temperature of the base 31, tends to interfere with and damage the bond between the target member and the base.

The base ordinarily comprises copper and the target member usually comprises tungsten. The thermal expansion of copper is roughly three times the thermal expansion of tungsten. Unfortunately, there is no metal having high conductivity for heat dissipation having a low coefficient of thermal expansion comparable with the thermal expansion coefficient of tungsten and other usual target materials. Because of high heat conductivity, copper is the obvious choice for use in the backing or base. If use of other metals be attempted, the lack of heat storage and conducting capacity of the material used may require the target to function at destructively high temperatures, it being an important function of the base to cool the target member rapidly to prevent destructive heating thereof.

In anodes built in accordance with existing principles of design, the back of the target plate is bonded throughout its entire area as tightly as possible on the base. The service life of X-ray generators containing such anodes is definitely limited by anode failure through weakening or destruction of the target bond on its support base. Not only is there a tendency for the target member to work loose from the base, but also there is a tendency, heretofore unexplained, for the face of the target member to crack, peel and flake in the portions thereof which are directly exposed to electron bombardment. I have discovered that this surface cracking and flaking is due, at least in part, to the fact that the back of the plate opposite the target area is mechanically and thermally bonded to the base. The temperature of the portions of the target plate bonded to the base at any instant while the generator is in operation are at a substantially lower temperature than the material of the plate at the working surface thereof. This temperature differential through the plate is due to the fact that the base abstracts heat relatively rapidly from the base attached portions of the target member. It is thought, therefore, that surface cracking and peeling are due to internal stresses set up within the target member itself as a result of the constantly fluctuating temperatures which prevail in the portions of the member under electronic impact, which temperature is lower at the base connected portions than at the target surface portions of the plate. Where the back of the plate vertically beneath the target area is bonded to the base, it is mechanically held on the base and is at all times much cooler than the target surface portions of the plate. The expansion and contraction of the target plate portions at and adjacent the base is thus much less than the expansion and contraction of the target surface portions, which consequently are highly susceptible to cracking and flaking.

In order to overcome the foregoing difficulties and to provide a target carrying anode in which the bond between the target member and the base will be maintained substantially throughout the service life of the generator, and to inhibit cracking and peeling at the electron receiving surface of the target, I provide an anode in which there is neither mechanical nor heat conducting connection directly between the base and the portions of the target member which are bombarded by the electron stream 21. By forming the anode in this fashion, the target member, when under bombardment, will become heated to substantially the same temperature throughout the thickness of the plate, and also will be free to expand and contract without the restriction of a mechanical bond tending to prevent expansion of the back of the plate portions.

The target member thus is allowed to have substantially the same expansion and contraction throughout its thickness, thereby eliminating the tendency of the target surface to crack, flake or peel.

By thermally and mechanically isolating the target portions of the target member from direct thermal connection with the base, all of the heat generated in the target member at the zone of electronic impact will necessarily be caused to flow toward relatively cooler portions of the member **23** for transfer thence to the supporting base from said relatively cooler plate portions which are bonded on the base. These relatively cooler portions of the target member, since they are not subjected to periodic bombardment, will tend to have a substantially uniform temperature when the generator is in operation, which temperature will be but slightly higher than that of the attached base. Disruptive forces tending to destroy or impair the bond between such relatively cooler portions and the base are thus substantially eliminated, so that the bond may be maintained in unimpaired condition throughout the service life of the generator.

Thermal isolation of the electron receiving portions of the target member **23** may be accomplished, as shown in the illustrated embodiment, by slotting, grooving or otherwise cutting away the material of the base immediately behind the portions of the target member **23**, which, when the generator is in operation, are subject to electronic bombardment.

As shown in the drawing, the target carrying end of the anode base **31** is formed with an annular recess or groove **35** behind the marginal portions of the target plate **23**. The groove **35** defines a central neck **37** which is bonded to and thermally connected with the central portions **39** of the target plate, the marginal portions **41** of which extend outwardly of the central neck to form an annular electron receiving target area, said outwardly extending plate portions being thermally isolated from direct contact with the base **31** by the cutout groove **35**.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that 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 its attendant advantages, the form disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. An X-ray tube comprising a sealed envelope, an electron emitting cathode and rotary anode in said envelope, said anode comprising a support of heat conducting material having a target mounting neck, and a target plate having a central portion bonded on and thermally connected to said neck, said plate having an annular marginal portion projecting outwardly of said neck and forming an annular target surface isolated from direct thermal connection with said support, said neck having a tapered portion and said target plate having an integral peripheral portion in spaced relation with the tapered portion of said neck, whereby to preserve substantially uniform temperature conditions in said annular portion and thus prevent rupture from internal stresses set up in said portions.

2. An X-ray tube comprising a sealed envelope, an electron emitting cathode and a rotary anode in said envelope, said anode comprising a support of heat conducting material having a groove defining a neck at one end, and a target plate having a central portion secured on said neck and integrally bonded thereto, said plate having integral peripheral portions extending outwardly of said neck in position overlying said groove and isolated from direct thermal connection with said support, said peripheral portions forming an annular target zone in position to receive impact of electrons emitted by said cathode, and said neck being tapered in the direction of the central portion of said target plate, whereby heat developing in said peripheral portions as a result of electron impingement on said target zone may pass to said support through the central portions of said plate.

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