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ROTARY ANODE X-RAY TUBE

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Fig. 1.

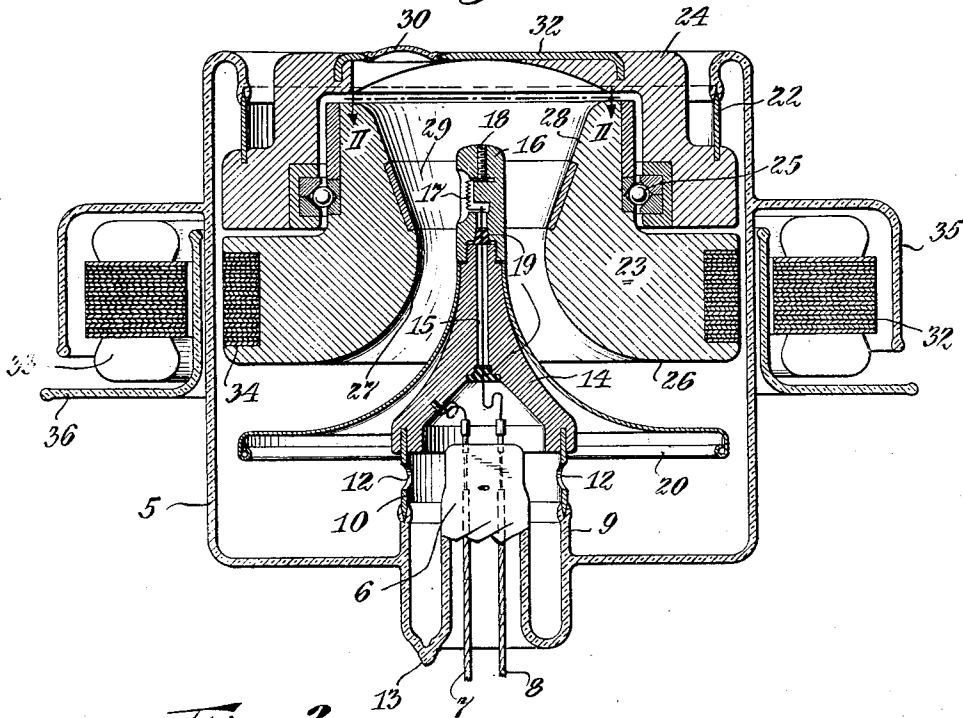


Fig. 3.

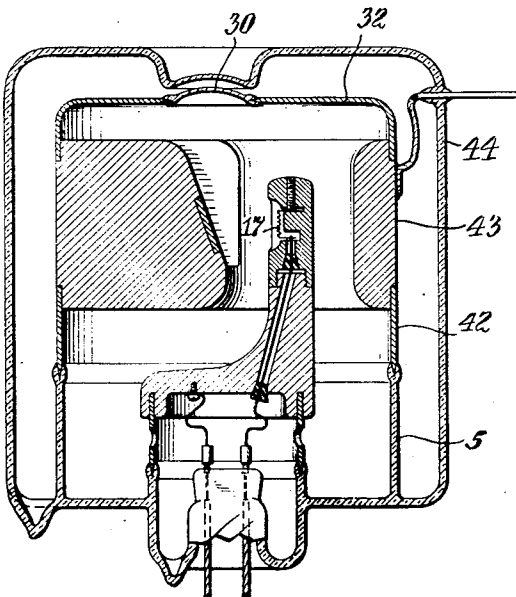
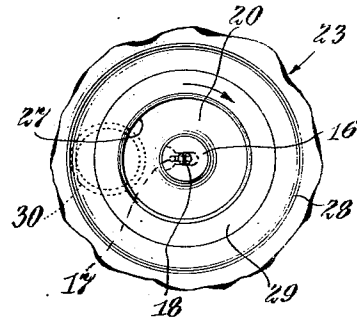


Fig. 2.



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ROTARY ANODE X-RAY TUBE

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4 Claims. (Cl. 250-148)

The present invention relates to X-ray tubes and particularly to what are known in the art as rotating anode X-ray tubes. It has long been recognized that continued bombardment of the refractory metal target by the electron stream to cause the generation of X-rays localizes considerable heat on the surface of the target, which eventually melts the refractory metal surface, rendering the tube useless.

To overcome this disadvantage rotary anode X-ray tubes are now employed wherein the anode rotates during operation of the tube so that the electron beam is no longer confined to a restricted area of the target surface, but on the contrary impinges upon a larger area due to the rotation of the anode.

However, several disadvantages have been inherent in rotary anode X-ray tubes of the prior art, particularly the necessity for cooling the anode during operation of the tube by proper dissipation of the heat.

It is accordingly the primary object of the present invention to provide a rotating anode X-ray tube of compact construction and economical manufacture.

Another object of the present invention is the provision of a rotating anode X-ray tube wherein the stationary portion of the bearing of the anode forms a part of the envelope of the tube so that the heat generated during operation is readily dissipated to the atmosphere.

Another object of the present invention is the provision of a rotating anode X-ray tube wherein the discharge chamber is entirely metal enclosed, which renders the tube practically ray-proof without additional shielding.

Another object of the present invention is the provision of a rotating anode X-ray tube wherein the anode forms a closure cap for one end of the tube so that the heat generated during operation is readily dissipated to the atmosphere and wherein homogeneous electric fields are obtained within the tube with inherent shielding of the glass walls of the envelope from X-rays and secondary electrons, which reduces the possibility of envelope puncture by prevention of the accumulation of negative charges thereon.

A further object of the present invention is the provision of a rotating anode X-ray tube wherein the anode is of a considerable mass of high heat conductivity metal which forms an end closure for the tube so that a substantial portion of the surface of the anode is exposed to the atmosphere to dissipate heat during operation of the tube and wherein the anode is provided with an opening

into which the concentrically disposed cathode projects, with the anode being provided with an angular surface having secured thereto a target of annular form adjacent the electron emitting surface of the cathode, resulting in an enclosed discharge chamber from which the X-rays are projected in the direction of the longitudinal axis of the tube.

Still further objects of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing wherein:

Fig. 1 is a sectional view of a rotating anode X-ray tube constructed in accordance with the present invention;

Fig. 2 is a cross-sectional view taken on the line II-II of Fig. 1, and

Fig. 3 is a sectional view of a stationary anode X-ray tube incorporating some of the features of the present invention.

Referring now to the drawing in detail, in Fig. 1 an evacuated vitreous envelope 5 is shown provided with a reentrant press 6 through which leading-in conductors 7 and 8 are sealed for supplying heating current as well as a negative potential to the cathode electrode. An inwardly projecting annular collar 9 is concentrically disposed with respect to the longitudinal axis of the tube and is formed of the same material as that of the envelope 5.

This annular collar 9 has sealed thereto an annular metallic collar 10 having openings 12 therein to enable exhaustion of the envelope through the exhaust tip 13, and the upper extremity of the annular metallic collar 10 has secured thereto a metallic member 14 of substantially cone shape and having an opening 15 extending therethrough. To facilitate assembly the upper portion of the metallic member 14 is provided with a detachable end 16 threadably connected thereto, which upper portion supports the thermionic emitting surface of the cathode 17 parallel to the longitudinal axis of the tube.

One end of the thermionic cathode 17 is connected to the end portion 16 of metallic member 14 by means of a set screw 18 and the opposite end of the thermionic cathode 17 is connected to the leading-in conductor 8 which extends upwardly through the opening 15 provided in the metallic member 14 with the conductor 8 being insulated from the metallic member 14 and the upper end thereof 16 by means of insulating bushings 19.

A shield 20 is provided to prevent scattered electrons from impinging upon the envelope in

the vicinity of the seal of the cathode with the envelope and also to prevent the accumulation of a negative charge on the inner walls as well as the emission of X-rays except in the desired direction. The upper end of the envelope 5 may be bent inwardly and has secured thereto an annular metallic collar 22 of a material, such as an alloy sold under the trade-mark "Kovar," having a coefficient of expansion approximating that of the vitreous material 5 of which the envelope is formed.

Secured to this annular collar 22 is an anode, shown generally at 23, of considerable mass of high heat conductivity material, such as copper or the like. The anode 23 is shown as being of two parts, the upper portion thereof 24 forming a sealed end closure for the envelope and having a large portion of its exterior surface exposed to the atmosphere. A rotatable portion 26 of substantially annular form is secured to the upper portion by bearings 25 with a very small spacing therebetween so as to facilitate heat transfer between adjacent surfaces. The rotatable portion 26 is provided with an opening 27 into which the thermionic cathode projects, which thus forms an enclosed discharge chamber.

The opening 27 is of substantially inverted frusto-conical configuration with the converging end flared outwardly to conform to the contour of the shield 20 and the angular surface 28 of the anode 23 is provided with an annular target 29 of refractory metal, such as tungsten or the like, which is disposed adjacent the electron emitting surface of the cathode 17 so that the electron beam emanating from the cathode impinges upon the annular target 29 and, due to the angle of the surface 28 carrying the target 29, the generated X-rays are projected from the tube in the form of a cone in the direction of its longitudinal axis.

In order to confine the cone of X-rays emanating from the tube to a restricted area, the sealed end closure cap portion of the anode 24 may be provided with a vitreous window 30 pervious to X-rays which is sealed to an annular member 32 having a coefficient of expansion approximating that of the vitreous window 30.

For the purpose of rotating the anode 23 upon the bearings 25, a stator winding 33 surrounds the envelope 5 exteriorly thereof and the surface of the anode 23 adjacent the stator winding 33 is provided with laminations 34 of ferro-magnetic material. Also in order to shield the stator winding 33 the envelope may be provided with a suitable collar 35 of the same material as the envelope 5 sealed thereto and substantially covering the stator winding. Likewise, in order to support the entire tube, a similar collar 36 may be provided.

Inasmuch as the cathode is disposed concentrically with the longitudinal axis of the tube and is surrounded by the annular shaped anode 23, an entirely metal enclosed discharge chamber, as before noted, is provided. Moreover, since the thermionic emitting surface of the cathode 17 is disposed parallel to the longitudinal axis of the tube and adjacent the refractory metal target carried by the angular surface on the inner periphery of the anode 23, the bombardment of the target by the electrons causes the generation of X-rays which are projected exteriorly of the envelope in the direction of the longitudinal axis of the tube and scattered X-rays or secondary

emission are more or less precluded by the retarding metal enclosed discharge chamber.

By this arrangement very homogeneous electric fields are obtained within the tube which, together with the metal enclosed discharge chamber, substantially eliminates the possibility of puncture due to secondary electrons which otherwise would impinge upon the glass walls of the envelope, creating a negative charge on the surface thereof. Due to the considerable mass of which the anode is constructed and which has a substantial portion of its exterior surface exposed to the atmosphere, the heat generated during operation is readily dissipated to the surrounding atmosphere, thus increasing the efficiency of operation of the tube.

In Fig. 3 an X-ray tube is shown which differs from that above described with reference to Fig. 1 in that it is of the stationary anode type. In this particular modification the envelope 5 has an annular metallic collar 42 sealed thereto of a material having substantially the same coefficient of expansion as that of the vitreous envelope material, which annular collar 42 supports an annular anode 43 of substantially the same construction as that above described relative to the anode 23 of Fig. 1.

However, in this modification the angular surface of the anode 43 is not of annular form, but is restricted to that portion immediately adjacent the electron emitting surface of the cathode 17. Like Fig. 1, the anode 43 in this modification forms a substantial part of the envelope 5 and has a substantial portion of its exterior surface exposed so as to readily dissipate the heat generated during operation.

Again, as in Fig. 1, the anode 43 is provided with the window 30 sealed to the annular member 32 having the same coefficient of expansion as that of the vitreous window. In all other respects the modification of Fig. 3 is substantially identical to that above noted with respect to Fig. 1. In addition, the envelope 5 of Fig. 3 may be surrounded by an outer envelope 44 of the same vitreous material as that of the envelope 5, which thus forms a chamber about the tube and such chamber may be filled with a material such as a liquid or gas which readily dissipates the heat generated during operation of the tube. It should be understood, however, that if a liquid cooling medium is utilized, the outer envelope would naturally be provided with a suitable expansion chamber or the like (not shown).

It thus becomes obvious to those skilled in the art that an X-ray tube is herein provided in which the discharge chamber is entirely metal enclosed, and since the anode is of a considerable mass of high heat conductivity material having a substantial portion of its exterior surface exposed to the atmosphere, the heat generated during operation is readily dissipated.

Moreover, a compact X-ray tube is thus formed wherein the anode is of substantially annular form and by the provision of an annular target of refractory metal the anode may be rotated by generation of an electric field, thus constantly renewing the target surface impinged by the electron beam and prolonging the useful life of the tube.

Although I have shown and described several embodiments of my present invention, I do not desire to be limited thereto as various other modifications thereof may be made without departing from the spirit and scope of the appended claims.

I claim:

1. An X-ray tube comprising an evacuated envelope provided with a thermionic cathode and an anode surrounding said cathode, said anode being of substantially annular form and provided with an annular target of refractory metal adjacent said thermionic cathode, a focusing cup for said cathode for confining electron bombardment of said target to a linear area to cause the X-rays generated at the target to be projected exteriorly of said tube in the direction of the longitudinal axis thereof and to form a foreshortened linear focal spot, and means disposed exteriorly of said envelope for rotating said anode about said cathode.

2. An X-ray tube comprising an evacuated envelope provided with a thermionic cathode and an anode, said anode being concentrically disposed relative to said cathode and of substantially cylindrical form, an annular target of refractory metal carried by said anode on the inner periphery thereof adjacent said cathode, a focusing cup for said cathode for confining electron bombardment of said target to a linear area to cause the X-rays generated at the target to be projected exteriorly of said tube in the direction of the longitudinal axis thereof and to form a foreshortened linear focal spot, and means disposed exteriorly of said envelope for rotating said anode about said cathode.

3. An X-ray tube comprising an evacuated envelope provided with a thermionic cathode and an anode of substantially annular form and of considerable mass of high heat conductivity metal, means forming a closure member for one end of said tube and having a large portion of its surface area exposed to the atmosphere for rotat-

ably supporting said anode and for dissipating heat from said anode during operation of said tube, said anode having an opening therein into which said cathode projects and provided with an angular surface on its inner periphery adjacent said thermionic cathode, a target of refractory metal carried by the angularly disposed surface of said anode, and means disposed exteriorly of said envelope for rotating said anode about said cathode.

4. An X-ray tube comprising an evacuated envelope provided with a thermionic cathode and an anode of substantially annular form and of considerable mass of high heat conductivity metal, means forming an end closure for said tube and having a large portion of its surface area exposed to the atmosphere for rotatably supporting said anode and for dissipating heat from said anode during operation of said tube, an X-ray pervious window in said means for the egress of X-rays from said tube, said anode having an opening therein into which said cathode projects and provided with an angular surface on its inner periphery adjacent said thermionic cathode, a target of refractory metal carried by the angularly disposed surface of said anode, a focusing cup for said cathode for confining electron bombardment of said target to a linear area to cause the X-rays generated at the target to be projected exteriorly of said tube in the direction of the longitudinal axis thereof through said X-ray pervious window and to form a foreshortened linear focal spot, and means disposed exteriorly of said envelope for rotating said anode about said cathode.

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