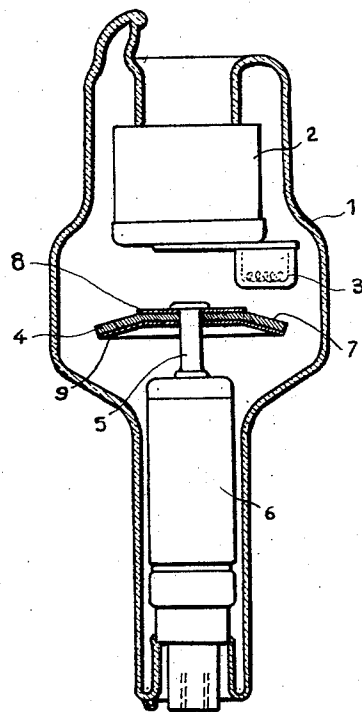


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ROTARY ANODE FOR X-RAY TUBES

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ROTARY ANODE FOR X-RAY TUBES

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This invention relates to a rotary anode for X-ray tubes and is more particularly concerned with means for improving both the cooling of the anode and the operational stability of the tube.

For a better understanding of the invention, reference will now be made to the accompanying diagrammatic drawing which is an axial section of an X-ray tube provided with an improved anode according to the invention.

Rotary anode X-ray tubes basically consist of a fluid-tight glass envelope 1 which is evacuated to the greatest possible extent. A cathode forming unit 2 serves to heat a filament 3 to a temperature such that it can emit electrons. Opposite the cathode is located a tungsten disk 4 mounted on a stem 5 of refractory metal (molybdenum or tantalum). This assembly is mounted on a rotor 6 adapted to be driven at a speed ranging from 3000 to 9000 r.p.m. under the action of a rotating field external to the tube. If a high rectified voltage is applied between the two electrodes 2 and 6, the electrons emitted by the negative filament 3 impinge upon disk 4 in a spatially fixed zone termed focus point; it is at this point that the X-rays are produced. This focus point is located on the frusto-conical marginal portion 7 of disk 4, which portion forms a track. Since the energy of the moving electrons that impinge upon disk 4 is almost entirely converted into heat, the temperature of the disk reaches a very high value.

The dissipation of this heat mainly takes place through radiation, in accordance with the Stefan-Boltzmann law

$$W = S \epsilon K T^4$$

This formula shows that if it is desired to increase the emission of heat from the disk, only the surface S and the coefficient of heat emissivity ϵ of the disk can be acted upon.

An increase of the surface by sand-blasting or by chemical or electrochemical attack does not yield significant results. In order to increase ϵ , it has been proposed to resort to films of refractory carbides, of metallic oxides, of metals such as rhenium and zirconium; the use of this latter metal limits the temperature of the disk to a low value. Surface blackening by superficial carburization has also been resorted to.

When it is sought only to increase the heat emissive capacity of the disk, the increased energy thus made available to the user may raise the temperature of the glass and of the rotor to a value liable to bring about the release of gases detrimental to a proper operation of the tube.

Moreover, the parts that make up the rotor of a rotary anode cannot be completely freed of occluded gases when pumping out the tube, for these parts cannot be heated to a temperature above 500° C. without affecting the lifetime of the rotor roller bearings. Consequently:

(1) Arcs or ionic discharges between the cathode and the electron-bombarded anode track are initiated and cause the glass to metallize in the region adjacent the two electrodes, the presence of these arcs being detectable through traces of metal stripping.

(2) The ionic discharges give off considerable heat which hardens the inner surface of the glass to form thereon a "mosaic,"

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(3) The flow of positive ions to the cathode causes a reemission of electrons which have a trajectory that is less flat than that of the useful beam and which, upon reaching the anode, gives rise to the emission of non-focussed X-rays detrimental to the quality of a radiographic negative.

Furthermore, this additional stream of electrons causes a voltage drop across the terminals of the tube so that the X-rays produced do not correspond to the voltage applied to the tube.

The above observations have thus led to the use in tubes of a getter capable of absorbing, during operation of the tube, the gases released by the glass due to the increase in power made possible by the improvement of the emissive capacity, and the gases released by the rotor which could not be fully removed during evacuation of the tube.

There are known methods either for increasing the heat emissive capacity of a disk, or for achieving a getter effect by resorting to tantalum or zirconium parts arranged near the disk and heated by radiation from the latter.

The present invention makes it possible to obtain simultaneously both of the above effects, i.e. an increase of the emissive capacity together with a getter effect.

The anode according to the present invention is characterized in that the rear face of the disk and preferably also its front face, except for the track, are wholly or partly provided with a film basically consisting of tantalum, niobium or their compounds. This film may have a thickness ranging from 0.2 to 0.5 mm. It may be obtained by sintering a layer of tantalum or niobium in powder form, by plasma torch spraying, or by vapor plating, i.e. by treating the disk in a heated enclosure in which, upon evacuation, vapors of a halogenated tantalum or niobium salt and a reduction gas such as hydrogen are simultaneously introduced.

The increase in emissive capacity coefficient imparted to a tungsten disk having a film according to the invention improves by 25% the power of the tube in relation to a non treated tungsten anode. Moreover, the affinity of tantalum for all chemically active gases makes it possible for the film to absorb the greater part of the gases given off by the electrodes during operation of the tube.

The disk 6 of the rotary anode illustrated in the drawing is provided on its front face with a film 8 which does not extend on to track 7 and, on its rear face, with a film 9.

The invention also relates to a method of making the above described film. This method consists in coating the tungsten disk faces to be treated with tantalum or niobium powder in suspension in an organic liquid leaving no carbon traces after heating, for example in a solution of acetone or of amyl-collodion acetate. The coated tungsten disk is dried in hot air at a temperature of 80 to 100° C. and is then subjected to a heat treatment in vacuo at a temperature of 1800 to 2000° C. This heat treatment does not constitute an additional operation since ordinary tungsten disks must in any case be heated in vacuo at the above temperatures before being mounted in the tubes. However, in order that the film may preserve its full capacity for absorbing residual gases when the anode is placed in the X-ray tube, the sintering operation must be carried out in an enclosure having an internal pressure of less than 10⁻⁵ mm. of Hg. The heat emissive capacity imparted by the sintered film of tantalum or niobium will of course depend on the grain coarseness of the powder that is used; it will be all the greater when a coarse grained powder is resorted to.

The production of a sintered film of tantalum may be facilitated by first forming on the tungsten disk, by sintering also, a film of zirconium.

By adding from 2 to 10% of pulverulent zirconium to

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the tantalum powder, sintering of the film can take place at a temperature of about 1800° C., this being the maximum temperature that the disk can reach on its treated face during operation.

If a particularly high heat emissive capacity is required, it is possible to surface carburize the sintered film of tantalum.

The superficial layer of tantalum carbide so obtained has an emissive capacity 35% greater than that of tungsten.

It is also possible to produce a film of pure tantalum on the previously treated tungsten disk to form an intermediate layer of tungsten carbide, or after depositing an intermediate layer of graphite.

The emissive capacity of the tantalum or niobium film can still further be improved by covering it with a film of zirconium oxide. Zirconium oxide ZrO_2 when heated in vacuo at about 1800–2000° C. undergoes a partial reduction and then has an emissive capacity of approximately half that of the black body.

The grain coarseness of the metals used is so chosen as to obtain a rough surface after sintering, thereby improving still further the heat emissive capacity of the latter through an increase of its surface.

I claim:

1. A rotary anode for X-ray tubes consisting of a tungsten disk having near the periphery thereof an annular track-like cathodic beam impingement surface, said disk being provided on at least one of its faces, with the exception of said track-like surface, with a coating film made of an alloy basically consisting of a metal selected from the group comprising tantalum and niobium, and of zirconium.

2. A rotary anode for X-ray tubes consisting of a tungsten disk having near the periphery thereof an annular track-like cathodic beam impingement surface, said disk being provided on its entire rear face and over its front face, except for said track-like surface, with a coating film made of an alloy basically consisting of a metal selected from the group comprising tantalum and niobium, and of zirconium, said film having a thickness of about 0.2 to 0.5 mm.

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3. A rotary anode for X-ray tubes consisting of a tungsten disk having near the periphery thereof an annular track-like cathodic beam impingement surface, said disk being provided on at least one of its faces, with the exception of said track-like surface, with a coating film made of an alloy basically consisting of a metal selected from the group comprising tantalum and niobium, and of zirconium.

4. A rotary anode for X-ray tubes consisting of a tungsten disk having near the periphery thereof an annular track-like cathodic beam impingement surface, said disk being provided on at least one of its faces, with the exception of said track-like surface, with a sintered film made of a metallic powder basically consisting of a metal selected from the group comprising tantalum and niobium and of an addition of zirconium, the grain coarseness of the metallic powder being chosen as to obtain a sintered film having a rough surface.

5. A rotary anode for X-ray tubes consisting of a tungsten disk having near the periphery thereof an annular track-like cathodic beam impingement surface, said disk being provided on at least one of its faces, with the exception of said track-like surface, with a coating film made of an alloy consisting of 90 to 98% of a metal selected from the group comprising tantalum and niobium, and of 10 to 2% of zirconium.

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