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[54] **X-RAY TUBE HAVING A ROTARY ANODE**

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[51] **Int. Cl.**..**H01j 35/10**

[58] **Field of Search**................................313/330, 352

[56] **References Cited**

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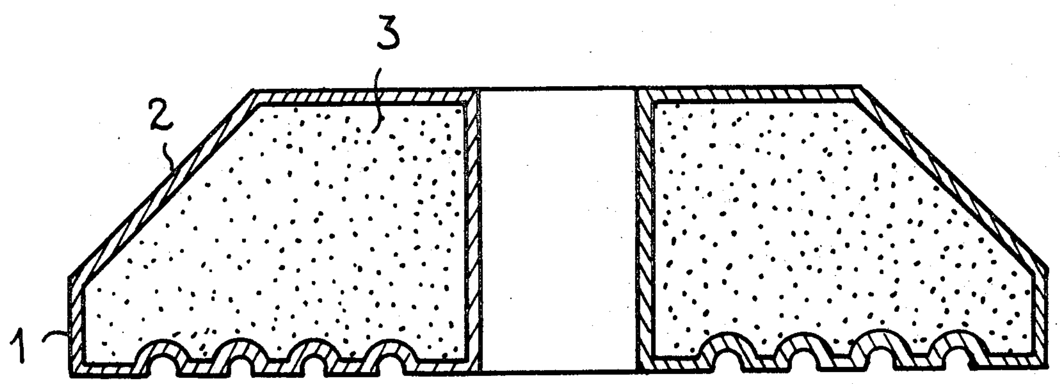
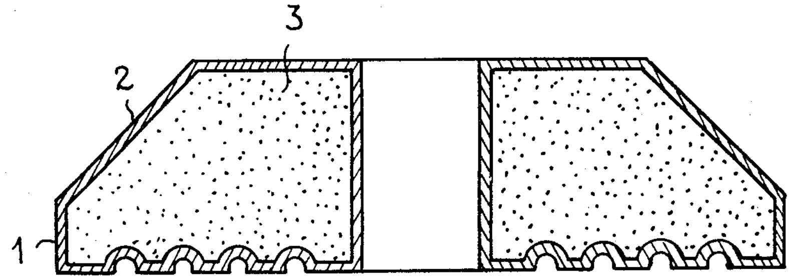
[57] **ABSTRACT**

X-ray tube having a rotary anode comprising a thin outer wall made of a refractory metal preferably of high atomic number, such as tungsten. This wall forms a closed receptacle filled with a metal or an alloy in liquid state or melting at a relatively low temperature, such as sodium.

7 Claims, 1 Drawing Figure

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X-RAY TUBE HAVING A ROTARY ANODE

The present invention relates to X-ray tubes having disk-shaped rotary anodes these anodes comprising a thin outer wall, closed and filled with a liquid metal or alloy.

On production of X-rays at the anode of an X-ray tube, the major part of the energy applied at the point of impact of the beam of electrons accelerated by the anode voltage, that is to say at the thermal focus, is converted to heat. This heat is dissipated by the known phenomena of conduction through the body of the anode and of radiation towards the external environment. Thus, part of the heat produced at the surface of the anode is distributed through the mass or volume thereof by thermal conduction and is dissipated thence mostly by radiation.

On the other hand, it is known to rotate the anode in order to increase the surface area bombarded per unit time, the local application of heat then being distributed, during the time of one revolution, over what is termed the focal track, which is a part of the surface area of the anode.

A rotary anode of this type can be of solid design and made of a refractory metal or two such metals or refractory bodies which facilitate heat transmission to a greater or lesser extent.

It is likewise known to cool fixed anodes in an X-ray tube, by circulating a fluid (water or oil for example) through the interior, in order to impose an upward limit on the temperature. However, this method of cooling is limited to applications where the heat flow is relatively small but is present for a protracted period of time, this generally being the case with fixed anodes.

In X-ray diagnostic work, for reasons which those skilled in the art will fully appreciate, the aim is towards achieving very high power emission for short times (ranging from some few milliseconds to some few seconds), this giving rise to a heat flow which results in a very rapid local rise in temperature at the bombarded surface, which can damage this surface and indeed the entire body of the anode.

The X-ray tube in accordance with the invention enables these drawbacks to be overcome. In such an X-ray tube, which contains within the anode body a liquid metal or alloy, there is added to the phenomenon of conduction a convection phenomenon due to the movement of the liquid metal. This convection mechanism promotes more rapid distribution of the heat and more rapid dissipation through surfaces which are more quickly raised to the radiation temperature.

According to the invention, there is provided an X-ray tube having a disk-shaped rotary anode ; said anode comprising a hollow body having a thin outer wall made of a refractory metal or an alloy of such metals, one of the outer surfaces of said wall being subjected to electron bombardment forming a so-called focal track; said hollow body being filled with a metal or an alloy, which is in liquid state at least at a temperature well below the normal operating temperature of the anode.

The invention will now be further described, by way of example with reference to the accompanying drawing which illustrates in section an embodiment of a rotary X-ray tube anode in accordance with the invention.

In the accompanying Figure, the anode takes the form of a hollow body or closed capsule, with thin outer walls **1**. These walls can be made of a refractory metal such, for example, as tungston. The interior of the hollow body **1** is filled with a liquid metal or alloy or one which becomes liquid i.e., melts at a relatively low temperature i.e., well beneath the anode operating temperature. This metal or alloy should be selected for its coefficient of thermal conductivity as well as for its specific heat and specific weight, in order to make it possible to lighten the parts which are to be rotated and achieve a relatively short start-up time.

Amongst the metals which present the desired characteristics in this direction, sodium is an advantageous one, its properties, which are doubtless well known to those skilled in the art, being listed in the following table and compared with those of tungsten which is most often used as a refractory metal in rotary anodes.

	melting point °C.	boiling point °C. to	specific weight. g. cm^{-3}	specific heat. cal.g^{-1} °C^{-1}	thermal conductivity.	thermal diffusion
W	3410	5600	19.3	0.032	0.40	0.646
Na	97.8	883	0.97	0.3	0.31	1.067

It can readily be seen from the above table, that the specific heat of sodium is around 10 times higher than that of tungsten and its specific weight around 20 times lower.

In addition to the lightening of the anode mass which this achieves, the significance of filling the anode (which has a thin closed wall) with a liquid metal, resides in the fact that in the liquid metal an exchange of liquid takes place between the hot and cooler parts thereof and that there is added to the mechanism of heat diffusion by conduction, that of diffusion by convection, this contributing to acceleration of the establishment of thermal equilibrium between different parts of the anode. In turn, this acceleration makes it possible to increase the load applied to the tube during the relatively short periods involved.

In one embodiment of the invention, the wall of the anode which forms a cover and is opposite the wall on which the focal track **2** is formed, presents annular and concentric undulations (in the manner of a pressure bellows), in order to enable this wall to distort as a consequence of differential expansion between the metal envelope and the liquid metal contained therein, under the effect of rise in temperature.

It is worthy of note here that the wall **1** can advantageously be made entirely of a refractory metal of high atomic number or of an alloy of two or more such metals, which are X-ray emissive under electron bombardment. It is equally possible to make this wall of some other refractory metal, in this case the focal track **2** at least must be covered by an X-ray-emitting metal layer.

The anode in accordance with the invention can advantageously be manufactured from preshaped sheet metal blanks forming two cheeks which are subsequently placed together and welded at their ends by electron bombardment, in a manner known per se.

The filling of the hollow body thus obtained with for example liquid sodium, is carried out under vacuum and sealing of the walls is effected after filling has been completed.

The anode thus obtained is assembled on a spindle fixed to the rotor, in the same way as prior art anodes.

Experience has shown that an anode in accordance with the invention makes it possible to increase the X-ray tube load by about 1.5 times as compared with a solid tungsten anode of the same size.

The rotary anode in accordance with the invention can be utilized in X-ray tubes for X-ray diagnostic applications, which have to carry substantial loads, as for example in examinations requiring sequences of exposures involving substantial numbers thereof over a relatively short time.

Of course, the invention is not limited to the embodiments described and shown which were given solely by way of example.

What is claimed, is:

1. X-ray tube having a disk-shaped rotary anode; said anode comprising a hollow body having a thin outer wall made of a refractory metal or an alloy of such metals, one of the outer surfaces of said wall being subjected electron bombardment forming a so-called focal track; track ; hollow body being filled with a metal or an alloy, which is in liquid state at least at a temperature well below the normal operating temperature of the anode and a boiling point above the latter and which has a thermal conductivity close to or above that of the metal or alloy forming the wall and a specific weight much lower that the latter one.

2. X-ray tube as claimed in claim 1, wherein said filling metal is sodium.

3. X-ray tube as claimed in claim 1, wherein said refractory metal or alloy is a metal or an alloy of metals having a high atomic number which are X-ray emissive under electron bombardment.

4. X-ray tube as claimed in claim 3, wherein said refractory metal is tungsten.

5. X-ray tube as claimed in claim 1, said hollow body being made of a refractory metal or an alloy of such metals which do not emit X-rays having a desired spectrum, wherein at least said focal track is covered by a layor of an X-ray emissive refractory metal or alloy.

6. X-ray tube as claimed in claim 1, wherein the part of the outer wall opposite said focal track contains concentric annular undulations, like a pressure bellows, enabling it to be deformed under the influence of the difference between the coefficients of expansion of the metal forming the hollow body and the liquid metal filling same, without deforming the rest of the anode body.

7. X-ray tube as claimed in claim 1, wherein said anode is manufactured from pre-shaped sheet metal blanks, the space between the blanks being filled with a liquid metal and the sealing of the walls being effected after filling by welding them together by means of electron bombardment.

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