United States Patent

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[54] **ROTARY ANODE FOR X-RAY TUBE**
2 Claims, 2 Drawing Figs.

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[50] **Field of Search** 313/60, 330

[56] **References Cited**
UNITED STATES PATENTS

2,863,083	12/1958	Schram	313/60X
3,136,907	6/1964	Kieffer et al.	313/60X
3,328,626	6/1967	Natter et al.	313/330

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ABSTRACT: A rotary anode for an X-ray tube, the anode body consisting essentially of graphite, and having a target layer bonded thereto consisting essentially of a tungsten-rhenium alloy; in an alternate embodiment, to improve the bonding between the target layer and the anode body, a thin stratum consisting essentially of rhenium is interposed between the anode body and the tungsten-rhenium target layer;

and processes of uniting the target layer to the anode body, including depositing the tungsten and rhenium layer on the anode body out of a gas phase, and depositing the intermediate rhenium layer between the target layer and the anode body out of a gas phase.

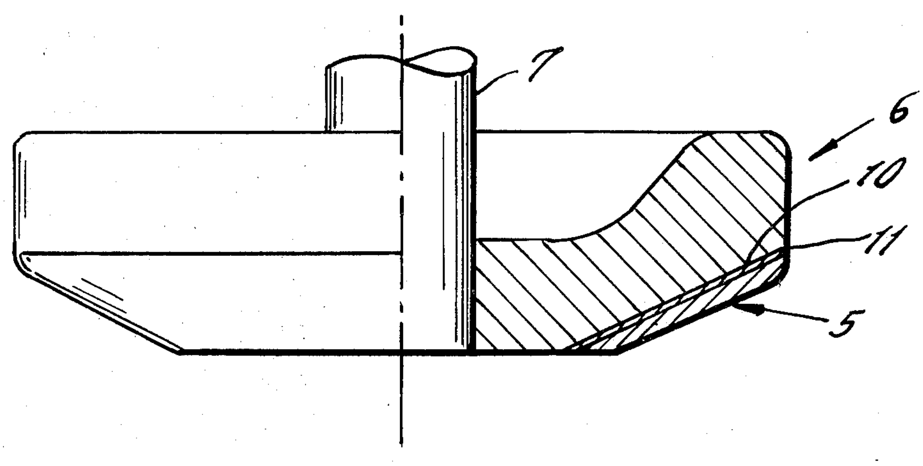


FIG. 1

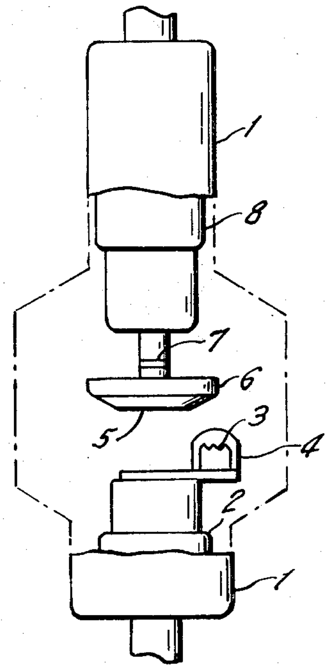
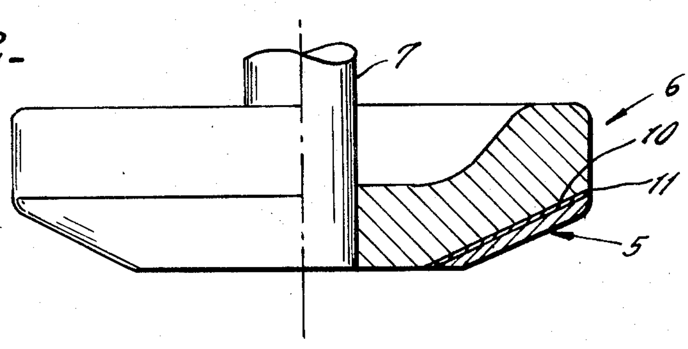


FIG. 2



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ROTARY ANODE FOR X-RAY TUBE

This invention relates to X-ray tubes which operate with rotary or fixed anodes and which are used for medical applications, for determining the crystal structures of various substances, and for other services. Such X-ray tubes usually employ an anode body formed of tungsten or molybdenum having a target layer attached thereto, consisting for example, of a tungsten-rhenium alloy, as shown in U.S. Pat. No. 3,136,907 **issued on June** 9, 1964, entitled "Anticathodes For X-Ray Tubes," and assigned to the assignee hereof.

Rotating anodes for X-ray tubes have heretofore been made generally of tungsten, since this metal, because of its high density and its high atomic number in the periodic system, assures a good yield of X-rays. Furthermore, tungsten, due to its high melting point, can be subjected to very high temperatures. In order to utilize the advantageous properties of tungsten, it is sufficient, however, to produce from tungsten merely those parts of a rotating anode which are subjected to bombardment from electrons.

It is desirable to find a more suitable material than tungsten for the body of a rotating anode. Molybdenum has proven its suitability for this purpose because it has higher thermal capacity and lower specific weight than tungsten.

The prior art also shows the employment of graphite for the body of a rotary anode. To the body is bonded an exposed target layer consisting of tungsten metal. Because of the high specific heat of graphite, as compared with tungsten and molybdenum, the anode body comprised of graphite can operate with a higher thermal loading or load factor and is well suited to take up brief peak loads on the anode.

Heretofore, it has been impossible to provide an operative anode having a graphite base with a tungsten target layer thereto bonded. In operation, the tungsten target layer develops cracks and, at least in part, peels from the graphite base. This results from reactions between the tungsten layer and the graphite body which lead to the formation of brittle intermediate layers and also results from the differences in the expansion rates of these components.

The present invention relates to a rotary anode for an X-ray tube, wherein the anode has a body formed of graphite and does not suffer from the disadvantages of prior art. In accordance with the invention, a rotary anode for an X-ray tube is formed of a graphite body having a target area for electrons on which is bonded a ductile target layer consisting essentially of tungsten-rhenium alloy. X-ray tube anodes constructed in this manner have a high X-ray output and a long life. The high thermal capacity of the graphite protects the tungsten-rhenium alloy coating even under very high stresses resulting from the impingement of electrons on the alloy layer. The dangers of cracking or peeling of the tungsten rhenium cover layer are eliminated due to the high ductility of this alloy. Furthermore, tungsten-rhenium alloys are considerably less reactive with graphite than pure tungsten, whereby no brittle interface is formed between the target layer and the anode body.

In accordance with another feature of the present invention, reactions between the graphite anode body and the tungsten-rhenium alloy target layer can be completely eliminated through the use of an intermediate layer of rhenium between these components.

It is the primary object of the present invention to provide an anode for an X-ray tube.

It is another object of the present invention to provide such an anode which can operate efficiently with a high load factor.

It is another object of the present invention to provide such an anode which can have a long useful life.

It is a further object of the present invention to provide such an anode which can withstand high thermal stresses without deterioration.

It is another object of the present invention to provide such an anode which will not break apart due to the stresses of operation.

It is a further object of the present invention to provide such an anode having a graphite body.

It is another object of the invention to provide such an anode which is formed with a graphite body having united to it a target layer which contains tungsten and which anode is free of the difficulties heretofore encountered with graphite base X-ray tube anodes.

It is another object of the present invention to provide a novel process for forming an anode for an X-ray tube.

It is a further object of the present invention to provide a process for applying a target layer to an anode body for an X-ray tube.

It is another object of the present invention to provide such a process comprising depositing a target layer out of a gaseous mixture.

It is another object of the invention to provide a process for applying a target layer to an anode body and for applying an intermediate stratum between the target layer and the anode body.

The foregoing and other objects of the invention will best be understood from the following description of exemplifications thereof reference being had to the accompanying drawings wherein:

FIG. 1 is a partially diagrammatic elevational view of an X-ray tube having a rotary anode exemplifying the invention; and

FIG. 2 is a partially cross-sectional and partially elevational view of the bottom part of the anode of FIG. 1 on a greatly enlarged scale.

FIGS. 1 and 2 show partially diagrammatically an example of an X-ray tube operating with a rotary anode exemplifying the invention. A glass envelope **1** contains in its highly evacuated interior space a cathode structure **2** carrying filament **3** and an electron-concentrating element **4** located opposite a narrow portion of the conical target layer **5** of rotary anode **6**. The anode **6** has central anode shaft **7** which is rotated by a motor **8**.

Under application of high voltage a concentrated electron beam emitted by the negative cathode filament **3** will bombard a facing portion of the positive anode target area **5** and cause it to emit X-rays. The energy of the electron beam impinging upon the anode target area **5** is transformed almost entirely into heat which is transmitted to and heats the entire mass of the anode **6**. Under excessive heat the metal of the target area **5** of anode **6** develops cracks which reduce the X-ray emission therefrom.

The anode body **6** is formed of graphite. The graphite anode body is considerably thicker than known rotating anodes using a base of tungsten or molybdenum. However, the weight of the rotating anode is slight due to the low specific gravity of graphite.

The difficulties previously encountered with graphite base rotary anodes are overcome in the present invention because the target layer **5** is formed of a tungsten-rhenium alloy.

Unless otherwise specified all proportions are given by weight throughout the specification and claims.

The tungsten-rhenium alloy conically shaped target layer **5** has a rhenium content within the range of 1—35 percent, and preferably within the range of 5—25 percent. It has a thickness of at least 0.1 mm.

FIG. 2 shows one example of an anode designed in accordance with the invention. The inclined surface **10** of the anode body **6** is the region of the anode which is bombarded by electrons from the cathode. To inclined surface **10** is bonded a target layer **5** of the above specified tungsten-rhenium alloy. For example the alloy of the target layer contains 10 percent rhenium.

To enhance the permanence of the bond between the target layer **5** and the surface **10**, an intermediate bonding stratum **11** may be applied. This stratum is formed of rhenium and has a thickness of a few microns. This layer prevents undesired interaction between the alloy layer and the graphite anode body, which would lead to deterioration of the anode.

Both the alloy target layer and the intermediate rhenium stratum can be applied to the graphite anode body by known methods such as spraying, electrolytic deposition, thermal decomposition of corresponding metal compounds, and the like.

A relatively simple and effective process for uniting the anode body to both the stratum **11** and the target layer **5** consists of separation of these metal compositions from corresponding gaseous compositions, such as fluoride or other halogenous compositions of these metals. For example, the rhenium layer is applied through thermal decomposition of a mixture of hydrogen and rhenium hexafluoride. Thereafter, the tungsten-rhenium alloy layer is deposited through decomposition of the same gas as described above, which additionally contains a portion of tungsten hexafluoride.

The successive deposition of the rhenium stratum **11** and of the tungsten-rhenium target layer **5** may be effected in a single procedure since alternation of this deposited material merely requires a change in the composition of the gaseous mixture which provides the metals for deposition.

Although the invention has been described herein by specific exemplification thereof, its scope should not be limited by the specification but only the the annexed claims.

We claim:

1. In an X-ray tube, the combination of an anode having an exposed target area and beam means, including an electron source for producing an electron beam for impinging on said exposed target area and causing said exposed target area to emit X-rays,

the improvement comprising,

said anode including a body consisting essentially of graphite;

said target area on said anode body having an overlying target layer thereto bonded; said target layer consisting essentially of a tungsten-rhenium alloy containing rhenium, by weight, in the range of 1—35 percent, and a stratum consisting essentially of rhenium interposed between and bonded to said anode body and said target layer.

2. In the X-ray tube of claim **1**, the improvement in which said tungsten-rhenium alloy contains by weight, rhenium in the range of 5—25 percent.