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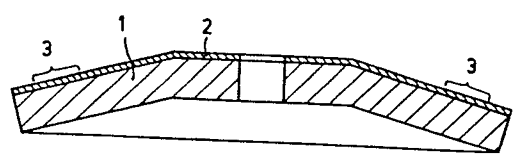
(54) **Method of producing a rotary anode for X-ray tubes and anode thus produced.**

(57) A layer (2) of W or a W-alloy is provided on a support (1) of a rotary anode for X-ray tubes by plasma spraying. A dense layer is obtained by carrying out the plasma spraying operation at a pressure of 2 - 55 kPa in an oxygen-free medium.



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Croydon Printing Company Ltd.

"Method of producing a rotary anode for X-ray tubes and anode thus produced".

The invention relates to a method of producing a rotary anode for an X-ray tube, wherein a tungsten or a tungsten alloy target layer is provided on a support by plasma spraying.

The invention also relates to an anode thus produced.

Rotary anodes produced by a method embodying the invention are particularly suitable for X-ray tubes to which a high load is applied during use, such as X-ray tubes for medical purposes.

German Patent Application 2346925 discloses a method of producing a rotary anode for an X-ray tube wherein a tungsten or a tungsten-rhenium alloy target layer, that is to say the layer which is bombarded by the electrons when the rotary anode is used in an X-ray tube, is provided on a molybdenum or a molybdenum alloy support by plasma spraying. A similar method in which a graphite support is used is described in German Auslegeschrift 2251656.

With plasma spraying of tungsten or tungsten alloys in atmospheric conditions, it is generally not possible to obtain a density of more than 92-94 % of the theoretical density (R. Glätzle et al, Metall 24, page 823 et seq., 1970). Such a density is insufficient for rotary anodes; it is not possible to obtain or maintain a proper vacuum inthe X-ray tube at such a density.

Experiments have been made to try and increase the density by densely sintering the tungsten layer. A maximum density of 97 % is then obtained (R.Glätzle et al, ibid.). The prescribed sintering treatment (up to 15 hours at 2600 °C) causes unacceptable loss of strength in many molybdenum alloys.

According to the invention, a method of producing a rotary anode for an X-ray tube wherein a target layer consisting of tungsten or a tungsten alloy is provided on a support by plasma spraying is characterized in that the target layer is provided by plasma spraying in an oxygen-free medium at a pressure of 2 - 55 kPa.

With a method embodying the invention, a target layer having a density of over 97 % can be obtained. Plasma spraying W at a reduced pressure is known <u>per se</u> from Moses A. Levinstein, Cienca Y technica de la Soldadura (Madrid) 12, No. 66, pages 1-9 (1962) (see also Chemical Abstracts, 58, 4243f 1963), but in contrast with the results obtained by the Applicants, a density of not more than 92.7 % was then obtained. It was also reported that a reduction in pressure resulted in lower densities.

E. Muehlberger, in "A high energy plasma coating process", Proc. 7th International Metal Spraying Conf., 1973, London, discloses a method for plasma spraying of materials such as tantalum and tungsten carbide wherein plasma currents with velocities of Mach 3 can be used. To obtain such velocities, spraying is effected in a chamber at a pressure of approximately 10 kPa.

In a method embodying the invention, the support is preferably preheated to a temperature above 1000°C prior to the provision of the target layer. This results in an improved adhesion and density of the target layer on the support.

Plasma spraying with a power of more than 30 kW generally results in a higher density of the target layer.

To improve the density, the tungsten or tungsten alloy to be sprayed is preferably used in the form of a powder having a particle size of not more than 45 µm.

To ensure that the particles of material to be sprayed are sufficiently heated, for obtaining a good bonding, a spraying distance, (i.e. the distance between the spray gun nozzle and the support) of not less than 150 mm is preferred.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawing, the sole Figure of which is a diametrical cross-section of a rotary anode produced by a method embodying the invention.

The drawing shows a rotary anode comprising a support 1 and a target layer 2. The portion of the target layer denoted by 3 is the place onto which the electron beam in the X-ray tube is focused (i.e. the focal path).

The support 1 may consist of molybdenum or of a molybdenum alloy known to be suitable for X-ray rotary anodes. Particularly suitable is a molybdenum alloy having 0.40-0.55 % by weight of Ti, 0.06 - 0.12 % by weight of Zr and 0.01 - 0.03 % by weight of C. The support may alternatively consist of graphite. In that case a carbon transfer inhibiting layer, for example a rhenium layer, should be provided between the support and the target layer.

One or more further layers may be present between the target layer and the support, for example a layer of pure tungsten.

The target layer 2 consists of tungsten or a tungsten alloy. All alloys known to be suitable for this purpose are very satisfactory. Particularly good results (high density) have been obtained with tungsten-rhenium alloys (0.7 % by weight or rhenium) and with tungsten-rhenium-tantalum alloys (0-7 % by weight of rhenium, 0-4 % by weight of tantalum).

To improve heat radiation from the anode, the surface of the target layer (except the focal path 3) and/or the surface of the support may be roughened, or these surfaces may be coated with heat-radiation improving material (for example rough tungsten).

It is possible for the target layer to have a composition which varies from the inside to the outside (for example in respect of the rhenium content).

The rotary anode is produced in the following manner. A support 1 is produced in a manner which is known <u>per se</u>, for example by casting, forging and pressing.

The surface of the support is properly cleaned. The support is then placed in a special, hermetically sealable chamber of the type described in the above-mentioned article by E. Muehlberger. The chamber is evacuated and filled with Ar. He or N_2 may alternatively be used. These gases may be mixed together and/or be mixed with H_2 (0 - 10 % by volume). This cycle is preferably repeated a few times to remove any residual oxygen. Finally, the chamber is filled with one of the above-mentioned gases or gas mixtures to the desired pressure (2 - 50 kPa). A pressure of 2 - 25 kPa is preferably used. Thereafter the material for the target layer is sprayed onto the support with a plasma gun. (Approximately 35 kW of power is supplied to the plasma gun). Preferably the support is preheated with the plasma gun to a temperature above 1000^{o}C before the material of the target layer is sprayed. It is possible to vary the composition of the sprayed material continuously during spraying in order to obtain a gradient in the composition of the target layer. A target layer of a thickness of 1.5 - 2.0 mm is preferably applied. It is possible to provide the target layer only in the region of the focal path 3 by using a mask.

At the end of the plasma spraying operation, the support together with the target layer is allowed to cool in the chamber. Finally, the product obtained is removed from the chamber and worked further, the focal path 3 then being ground.

With a method embodying the invention a density of more than 97 % was obtained with all the above-mentioned tungsten alloys, good bonding of the target layer to the support also being obtained.

CLAIMS:

1. A method of producing a rotary anode for an X-ray tube, wherein a tungsten or a tungsten alloy target layer is provided on a support by plasma spraying, characterized in that the target layer is applied by means of plasma spraying in an oxygen-free medium at a pressure of 2 - 55 kPa.

2. A method as claimed in Claim 1, characterized in that the support is preheated to a temperature above 1000 °C before the target layer is applied.

3. A method as claimed in Claim 1 or 2, characterized in that the plasma spraying is effected with a power of over 30 kW.

4. A method as claimed in any of Claims 1 - 3, characterized in that the tungsten or the tungsten alloy to be sprayed is in the form of a powder having a particle size of not more than 45 μm.

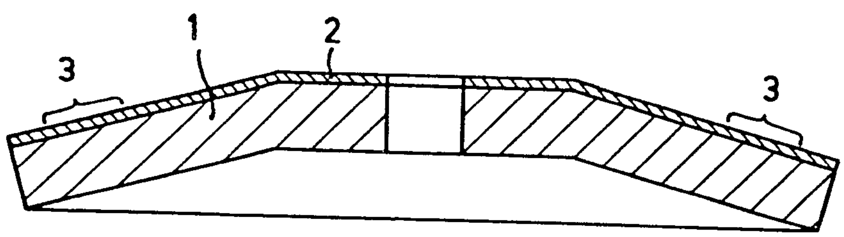
5. A method as claimed in any of Claims 1 - 4, characterized in that the plasma is sprayed with a spraying gun the nozzle of which during the spraying is more than 150 mm from the support.

6. A method as claimed in any of Claims 1 - 5, characterized in that the target layer is applied with a thickness of 0.5 - 2.0 mm.

7. A method as claimed in any of Claims 1 - 6, characterized in that the target layer consists of a tungsten alloy having 0 - 7 % by weight of Re and/or 0 - 4 % by weight of Ta and the support consists of a molybdenum alloy having 0.40 - 0.55 % by weight of Ti, 0.06 - 0.12 % by weight of Zr and 0.01 - 0.03 % by weight of C.

8. A rotary anode produced by a method as claimed in any of Claims 1 - 7.

9. An X-ray tube comprising a rotary anode as claimed in Claim 8.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EUROPEAN SEARCH REPORT

Application number
EP 80 20 0778

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	US - A - 3 243 636 (P.A. NINEUIL) * Column 2, lines 25-36; 60-64; figures * --	1,8,9
	FR - A - 2 204 041 (SIEMENS AKTIENGESELLSCHAFT) * Page 4, lines 11-20; figures 1-3 * & DE - B - 2 251 656 (cited by applicant) --	1,6-9
	US - A - 3 839 618 (E. MUEHLBERGER) * Column 2, lines 3-21; column 4, line 49 - column 5, line 7; column 7, lines 53-61; column 8, lines 13-15; column 9, lines 13-25; 55-57; column 11, lines 8-64; figure 1 * --	1-4,6
	US - A - 3 010 009 (A.C. DUCATI) * Column 4, line 69 - column 5, line 13; column 5, lines 21-44; column 6, lines 27-37; figures 1,2,4 * --	1,5,7
	FR - A - 2 210 009 (N.V. PHILIPS GLOEILAMPENFABRIEKEN) * Claims 1,2 * ----	1,7-9

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

H 01 J 35/10

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

H 01 J 35/10
H 01 J 35/08
H 05 H 1/42

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	05-12-1980	VILLEMIN