United States Patent

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[15] **3,689,795**

[45] **Sept. 5, 1972**

[54] **BORON-CONTAINING ROTATING X-RAY TARGET**

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[22] Filed: **May 27, 1971**

[21] Appl. No.: **147,615**

[30] **Foreign Application Priority Data**

June 2, 1970 Austria ....A 4945/70

[52] **U.S. Cl.**..................................**313/330,** 313/311

[51] **Int. Cl.**............................**H01j 35/10,** H01j 1/38

[58] **Field of Search**...............................313/311, 330

[56] **References Cited**

UNITED STATES PATENTS

1,625,427	4/1927	Rentschler	313/330
3,414,754	12/1968	Elsas	313/330
3,539,859	11/1970	Bouglé	313/311

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[57] **ABSTRACT**

This invention relates to an improvement in rotating X-ray targets involving incorporation of small quantities of boron into the molybdenum-containing base portion.

7 Claims, No Drawings

BORON-CONTAINING ROTATING X-RAY TARGET

X-ray equipment is in wide use for a variety of purposes. Various means are employed to bombard electrons onto a positively charged surface which is conveniently referred to either as an anode or as an X-ray target. There are various types of X-ray targets available on the market. These include stationary targets and rotating targets. In general, the X-rays are produced when the electrons hit the surface of the anode or target under appropriate X-ray generating conditions.

The portion of the surface of the target that is bombarded by electrons can be referred to as the focal track.

The focal track is frequently made of tungsten or of a tungsten alloy with another metal such as rhenium. Because of the expense of the materials used in the focal track, in commercial X-ray targets the entire target need not be made of the same alloy but, more usually, the target is a composite of a base and an outer layer or focal track intended for the bombardment of electrons. The focal track and the base are frequently made of different materials.

Molybdenum is a material frequently used in the base of rotating targets. Apart from cost, the use of molybdenum has the advantage that due to the lower specific gravity of molybdenum, the centrifugal forces generated during the rotation of the anode are reduced. Accordingly, higher speeds of rotation are possible. There are problems, however, with composites of molybdenum bases and tungsten alloy focal tracks. Under heavy duty operating conditions, cracks may develop in the molybdenum or at the molybdenum-tungsten interface because of the difference in thermal expansion between the molybdenum and the tungsten alloy.

In accordance with the present invention, it is possible to reduce the mechanical stresses caused by the differential thermal expansion. In this invention, the body or base upon which the focal track is imposed is comprised of a molybdenum alloy containing from 50 to 500 parts per million (by weight) of boron. Preferably, the molybdenum alloy will contain from 100 to 200 parts per million of boron. The presence of boron not only serves to reduce the stresses caused by differential thermal expansion, but it also serves to increase the high temperature strength and recrystallization of the body portion and also its cold ductility.

These small boron contents have a grain refining effect. Consequently, secondary grain growth is suppressed even at the elevated temperatures of formation and the tungsten alloy focal track will not differ to any great extent in grain size from the molybdenum base. All of these factors serve to equalize the internal stresses developed during cooling of the target thereby diminishing the risk of crack formation and increasing the service life of the target.

If desired, the high temperature strength of the body portion of the rotating target can be further increased by the addition of hafnium to the body portion in a quantity of up to about 2 percent by weight. Where hafnium is used, at least about 0.05 percent by weight should be present.

If desired, the molybdenum body or base can also contain alloying additions, i.e., up to about 10 percent by weight, of other refractory metals, for example, small amounts of tungsten, tantalum, niobium, rhenium or osmium, and may also contain small quantities, up to about 1.5 weight percent of titanium and up to about 0.5 weight percent of zirconium as well as small quantities of carbon.

A typical rotating X-ray target will have a molybdenum base of a thickness between about 2 and 8 mm., preferably about 6 mm.

The focal track of the rotating targets of this invention can cover the entire outer layer of the target or, more preferably, can just be present on that portion of the target that is intended to contact the bombarded electrons. The focal track can be made of pure tungsten, but is preferably made of tungsten alloyed with at least about 0.5 percent by weight, preferably from about 5 percent to 25 percent by weight, of rhenium. If desired, the focal track can also contain other alloying ingredients in addition to or in place of rhenium. For example, the tungsten alloy used in the focal track may contain from about 0.05 to about 5 percent by weight of platinum. Where platinum is employed, the tungsten-platinum alloy should contain from about 0.15 to about 1.5 percent by weight of platinum. The presence of platinum serves to increase the service life of the focal track by decreasing roughening. Optionally, the focal track may also contain amounts of up to 5 percent osmium and up to 2 percent iridium by weight for the purpose of improving target performance. Where osmium is employed, a minimum of about 0.1 percent by weight can be used and where iridium is employed, a minimum of about 0.05 percent by weight can be used.

The thickness of the tungsten or tungsten alloy layer of the focal track should be at least about 0.1 mm. Focal tracks of thicknesses in excess of about 2 mm. are generally not economically warranted.

The method of producing the alloy of the invention is conveniently carried out by powder metallurgical techniques. For example, powders of the various alloy components can be mixed together at an appropriate sintering temperature to cause alloy formation. The sintering temperature will generally be in the range of from about 1,600° to 2,400° C. Alternatively, the base can be formed either by powder metallurgical techniques or by any other convenient method and the base is then subjected to having the focal track sprayed on as by vapor deposition or any other convenient method.

The boron addition is preferably made to the molybdenum by use of molybdenum boride powder. However, powdered boron itself or another suitable compound of boron can also be employed. If hafnium addition is used, it is conveniently added in the form of powdered hafnium boride. In general, the powders employed in carrying out the powder metallurgical techniques will have particle sizes in the range of from 1 to 50 microns.

A convenient target for use in an X-ray tube can be made with the use of a cylindrical die which is slightly larger than the rotating target. The die is filled with molybdenum powder of a particle size range of from 2 to 10 microns and containing sufficient molybdenum boride powder of the same particle size range mixed therewith to bring the total boron content to 0.1 percent by weight based upon the combined weights of molybdenum and boron. If desired, the hafnium boride can be added at this point. These powders are filled to a thickness of approximately 10 mm. Thereafter, a second layer of a powder mixture of tungsten powder mixed with 10 percent by weight of rhenium powder is added to a thickness of about 2.5 mm. The powder within the cylinder is then compacted at a pressure of 4 tons per square centimeter into a circular compact. The compact is then sintered for 4 hours at 2,000° C. in a hydrogen atmosphere and then allowed to cool under hydrogen. Alternatively, sintering and cooling can be carried out in an atmosphere of an inert gas.

During the sintering, part of the boron may be oxidized by traces of oxygen contained in the powder and in the gaseous atmosphere. Such oxidized boron will be in the form of volatile boron trioxide. The residual boron content of the final sintered product may therefore be slightly lower than that of the original powder, and in this instance was 0.03 percent.

After sintering and cooling, the resultant product is then forged and ground to a product of the prescribed tolerance. Metallographic examination shows the existence of a good bond between the molybdenum alloy body and the tungsten alloy focal track. The boron contained in the molybdenum body which diffuses partly into the tungsten alloy serves to produce a fine grained transition between the two layers.

What is claimed is:

1. In a rotating X-ray target comprising a molybdenum-containing body and a tungsten-containing focal track, the improvement which serves to reduce the tendency towards cracking comprising the presence in the molybdenum-containing body of from 50 to 500 parts per million of boron.

2. The improvement of claim 1 in which boron is present in an amount of between about 100 to 200 parts per million.

3. The improvement of claim 1 in which the tungsten-containing focal track is comprised of an alloy of rhenium and tungsten.

4. The improvement of claim 1 in which the boron-containing molybdenum body also contains up to 2 percent by weight of hafnium.

5. The improvement of claim 4 in which the body also contains an alloying amount of a metal from the group consisting of tungsten, titanium or zirconium.

6. The improvement of claim 4 in which the focal track is comprised of an alloy of tungsten and rhenium.

7. The improvement of claim 6 in which the focal track contains an alloying addition of at least one metal of the group consisting of osmium and iridium.

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