Feb. 1, 1944. M. J. ZUNICK 2,340,500

ANODE STRUCTURE

Filed Nov. 16, 1942

Fig. 1.

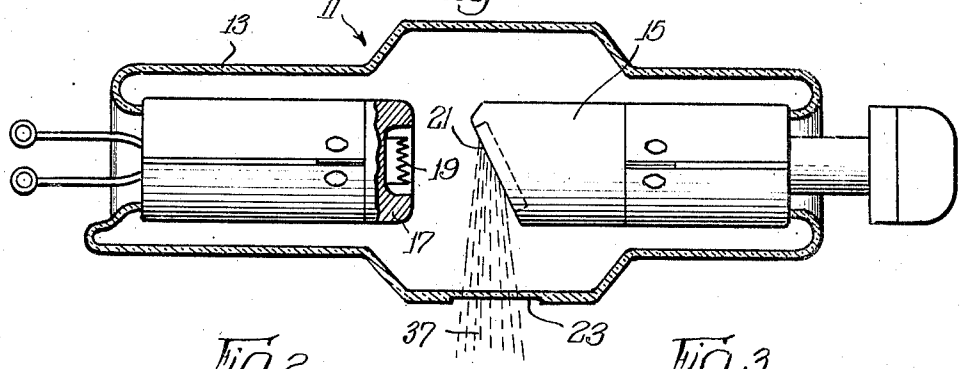


Fig. 2

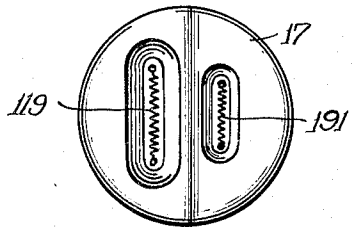


Fig. 3.

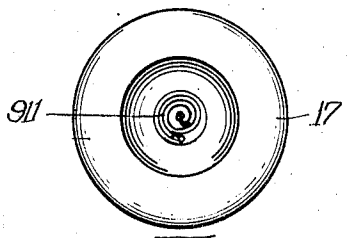


Fig. 4

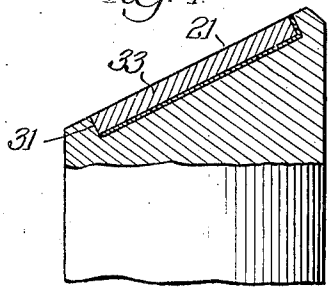


Fig. 5.

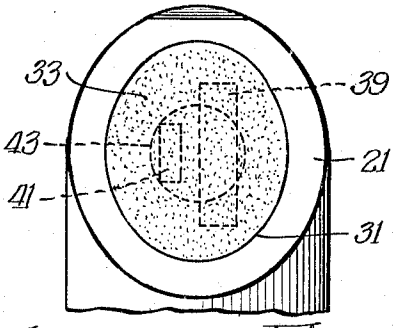


Fig. 6.

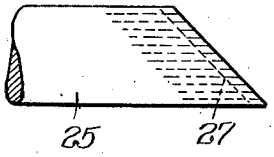


Fig. 7

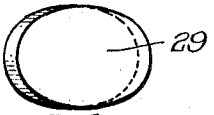


Fig. 8

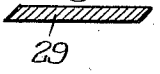


Fig. 9.

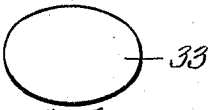
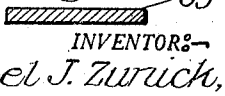


Fig. 10.



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UNITED STATES PATENT OFFICE

2,340,500

ANODE STRUCTURE

Michael J. Zunick, Columbus, Ohio, assignor to General Electric X-Ray Corporation, Chicago, Ill., a corporation of New York

Application November 16, 1942, Serial No. 465,716

1 Claim. (Cl. 250—149)

My invention relates in general to electronics and has more particular reference to an improved electrode construction particularly well suited for anodes of X-ray generators.

An X-ray generator comprises an electron emitting cathode and an anode at which X-rays are generated by impingement, upon a suitable target at the anode, of electrons emitted by the cathode. Such impingement on the target surface of the anode during operation of the tube results in grain growth in the anode material at the target surface due to heat, liberated in the anode through electron impingement thereon. Such grain growth results in deformation or curling of the anode at the target surface and consequent reduction in the X-ray output of the generator; and an important object of the present invention is to minimize such target deformation or curling through the provision of an improved anode structure presenting the anode material at the target surface in dense condition having a grain structure and other characteristics particularly well adapted to resist target deformation or curling.

Another object is to use metal in chemically pure condition for anode target purposes.

Another important object is to provide an anode for an X-ray generator having a target surface comprising material in which the crystalline structure of the material has a definite parallel grain arrangement; a further object being to utilize as an X-ray anode target a button in which the crystalline structure of the constituent material extends in parallel relationship throughout the button; a still further object being to form target buttons by first rolling a bar of target material longitudinally to impart a grain structure extending lengthwise of the bar and then cutting discs from the bar at a selected angle to provide buttons in which the grain structure extends at a desired angle with respect to the cut face of the button.

The foregoing and numerous other important objects, advantages, and inherent functions of the invention will be fully understood from the following description, which, taken in connection with the accompanying drawing, discloses a preferred embodiment of the invention.

Referring to the drawing:

Figure 1 is a sectional view taken through an X-ray generator fitted with an anode embodying the present invention;

Figure 2 is a plan view of the end of the cathode of the generator;

Figure 3 is a plan view of the face of a modified cathode that may be employed in the generator;

Figure 4 is an enlarged sectional view taken through the anode of the generator;

Figure 5 is a plan view of the face of the anode;

Figure 6 is a perspective view of a stock bar from which anode target buttons may be cut;

Figures 7 and 8, respectively, are plan and section views of a button blank as cut from the bar shown in Figure 6; and

Figures 9 and 10, respectively, are plan and section views of a finished target button.

To illustrate the invention the drawings show an X-ray generator 11 comprising a sealed envelope 13 containing an anode 15 and a cathode 17 embodying an electron emitting filament 19, the cathode and anode being mounted in coaxial spaced and facing relationship within the envelope 13. Suitable conductors for energizing the filament 19 and for applying operating potential between the filament and the anode from an electrical power source outwardly of the envelope, of course, are provided.

The filament 19 may be arranged in any preferred manner in the cathode, which comprises a suitable head, pocketed to receive the filament. As shown in Figure 2, the head may carry a pair of filaments 119 and 191 of different size, the filaments being shown as elongated or "line" electron sources. As shown in Figure 3, the filament may be arranged as a spiral 911.

The surface of the anode facing the electron emitting filament 19 forms a target surface 21, and the generator operates to produce X-rays at said target surface as a result of the impingement, on said surface, of electrons emitted at the filament 19 when electrically energized, said emitted electrons being impelled toward and caused to impinge upon the target surface under the influence of generator operating electrical potential applied between the filament and the anode.

As illustrated more particularly in Figure 1 of the drawing, X-rays may be generated at a target inclined with respect to the direction of travel of electrons between the electron source, it being usual to dispose the target in inclined position in generators for producing X-rays for radiographic and diagnostic purposes. The target, however, may for some purposes be disposed at right angles with respect to the path of impinging electrons, such right angle target arrangement being commonly utilized in X-ray generators for crystal analysis by X-ray diffraction principles, as discussed in United States Letters Patent No. 2,256,229. Furthermore, various metals may be

used as electron targets, tungsten being commonly employed in diagnostic and radiographic tubes, while copper and other metals may be used in generators for crystal analysis. The present invention, however, is not limited to any specific target material or to inclined targets but applies to right angle as well as inclined anode targets.

X-rays generated as a result of electron impingement on the target surface 21 may pass outwardly of the envelope in a radial direction through a transmitting window 23 formed in the envelope walls opposite the anode target. If desired, the envelope of the generator may be enclosed in a casing of X-ray opaque material provided with an X-ray transmitting window opposite the window 23.

When the generator is in operation for production of X-rays, a considerable amount of heat is developed at the target surface 21 as a result of electron impingement, such heat being dissipated through the body of the anode and thence outwardly of the envelope. The temperature at the target surface of the anode, however, may be of the order of the melting temperature of the target material, it being usual, in the interests of operating efficiency, to operate the generator so that its anode at the target surface functions at a temperature just short of the softening temperature of the anode material. When operated at such temperature there is a tendency for grain growth to occur in the anode material, such growth being evidenced by the peeling or curling of the anode material at the target surface and the consequent deformation of said surface from a desirable flat condition. Such peeling or curling of the anode surface, to some extent, impairs the production of X-rays at the target.

According to the present invention, the tendency of the target surface to peel or curl in service is minimized by forming the anode, more particularly at the target areas, to provide compact, uniform and chemically pure metal preferably having a grain structure characterized in that the grains of the material extend parallel with respect to each other. Preferably the target is arranged so that the grain structure thereof extends, in the body of the target, in a direction presenting the ends of the grains, at the target surface, toward the electron source 19. For convenience such grain structure may be designated "end grain." Electrons impinging on an end grain surface strike the ends of the crystals of material forming the anode target, which, because of the compact grain structure, tends to prevent peeling or lamination along grain boundaries.

While the entire anode may be formed of material having the desired parallel grain structure extending at a selected angle with respect to the target surface, it is not necessary to make the entire anode of the relatively expensive end grain target material; in fact, for the sake of economy, it is preferable to form the body 29 of the anode in any suitable or convenient manner, as by forming the same as a casting, preferably comprising vacuum melted copper.

The body of the anode, however, may be formed with a pocket 31 in the target surface thereof which faces the cathode, and a target button 33 may be fixed in said pocket, as by soldering the same in place, or the button may be cast in the anode during the formation of the anode body. Where the anode body comprises copper and the button comprises tungsten, or other metal having a substantially higher melting temperature than the material of the body, the anode may be formed by first making the button and then casting the body material on the button as described in United States Letters Patent No. 2,250,322. Where the button is of material having substantially the same melting temperature as the material of the body, as for example where both the button and the body comprise copper, it is of course not feasible to cast the material of the body on the preformed button. In such case the body may be formed separately and the button secured in the pocket as by soldering.

The button 33, in the illustrated embodiment, comprises a disc of metal having a parallel grain structure in which the grains extend at a selected angle with respect to the target surface 21 in order to present the grain ends, at the target surface, in position facing toward the electron source 19. Such granular structure may be accomplished by rolling or otherwise working a bar 25 of the target material in order to accomplish the desired parallel grain structure in a direction longitudinally of the bar, and then cutting the bar in sections at a selected angle to the grain direction, as shown at 27, in order to provide a target button blank 29, as shown in Figures 7 and 8. The marginal edges of the blank may then be trimmed at right angles to the face of the blank to produce the button 33, as shown in Figures 9 and 10.

Circular buttons may of course be made by cutting the bar 25 at right angles to its longitudinal axis. In such event the resulting button will have parallel grain structure extending at right angles to the target surface. The diagonal cutting shown in Figure 6, however, results in the production of target buttons of oval or elliptical shape adapted for use with a cathode comprising an elongated electron emitting element forming a "line" source of electrons. Such "line" source of electrons, in combination with an inclined face anode, is adapted to produce a usable X-ray beam 37 of desirable square sectional configuration for transmission through the window 23.

While it is preferable to orient the button on the anode so that the grains extend in the direction of the electron source, as shown in Figure 4, the button may be mounted in position turned end for end with the grains each extending in a direction at right angles to the direction of electron travel, since the principal advantages of the diagonal slicing of the bar 25 are the production of an elliptical target button economically by angularly slicing a cylindrical rod of diameter approximately two-thirds the long axis of the finished button 33, and the lengthening of the path along the grains between opposite faces of the button. At the same time, as a curl preventing expedient, it is equally important, if not more important, to employ pure metal as a target material. Metal of ordinary commercial purity is appreciably contaminated with foreign material and shows a very definite tendency to blister or peel when used as a target material, even if treated to provide parallel grain structure. Pure electrolytic metal, however, even in the absence of the desirable parallel end grain arrangement, provides a satisfactory dense and substantially non-curling target. Consequently, the broader aspects of the present invention are not necessarily limited to anodes having the particular grain structure herein described. The grain arrangement, however, is of appreciable value in producing sat-

isfactory anodes, and consequently the end grain structure and arrangement as herein disclosed forms a valuable phase of the present invention.

X-ray tube anodes made in accordance with the teachings of the present invention are characterized in that they are substantially immune to target surface deformation in service.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

The method of making elliptical target buttons for anodes which comprises preforming a cylindrical bar of target material with the grains of its constituent material extending longitudinally of the bar and then slicing button blanks from a cylindrical bar at an angle with respect to its longitudinal axis.

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