April 3, 1934. K. MATSUSHIMA 1,953,813

X-RAY TUBE

Filed Nov. 14, 1931

Fig. 1.

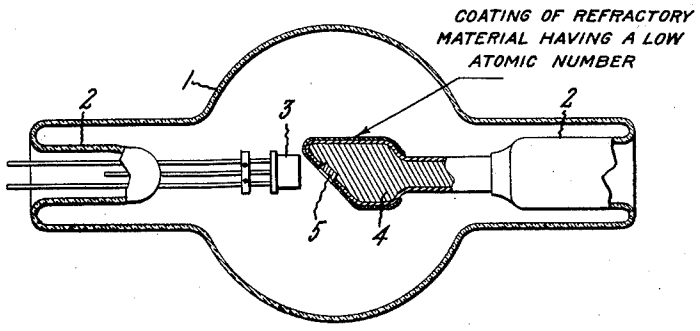


Fig. 2.

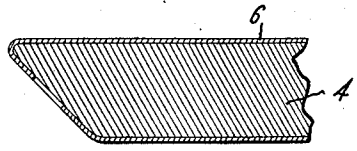
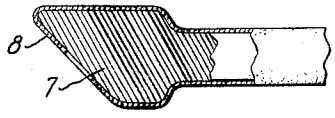


Fig. 3.



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Patented Apr. 3, 1934

1,953,813

UNITED STATES PATENT OFFICE

1,953,813

X-RAY TUBE

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Application November 14, 1931, Serial No. 575,063
In Japan November 29, 1930

3 Claims. (Cl. 250—35)

The present invention relates to X-ray tubes and more particularly to the anode structure of such devices. One of the objects of my invention is to reduce undesired X-ray radiation from the back of the target and thus to promote sharpness of definition in radiographs and fluoroscopic images.

In the operation of X-ray tubes, it has been found that notwithstanding the sharpness of focus by which cathode rays are directed onto a target member, secondary radiation is produced by electrons striking the various parts of the tube. The electrons radiated in this manner tend to impinge on portions of the anode to the rear of the target and cause the generation of undesired X-rays. These X-rays scatter in all directions from the anode and represent not only a loss in useful X-ray output but tend also to reduce the sharpness of image normally produced by the useful X-rays. The undesired X-rays may be due in part to the emanation of secondary rays by the elements of the tube and also in part to the primary rays reflected by such elements.

In accordance with the present invention, I propose to prevent the generation of these rays regardless of their origin. The invention, in brief, contemplates the use of a coating on the anode, except at the target member, of a material which precludes the production of X-rays, at least, rays of high frequency such as would deleteriously affect a radiographic plate. A material of this sort must be of refractory character, i. e. of a high melting point in order to preclude volatilization at the high temperatures necessary in denuding the anode of its occluded gas. Such a material has been found to be carbon which is applied preferably as a thin coat about the anode member. In some cases the carbon may be coated directly onto the anode, as for example when the latter constitutes a metal such as tungsten or molybdenum, while in other cases it is preferable to provide a covering or coat of suitable metal over the anode before the carbon is applied. The additional covering obviously must be such that carbon tenaciously adheres thereto. Thus in the case of copper of which an anode ordinarily is constituted, it may be desirable to plate the copper with nickel or to provide a layer of iron so that the carbon coating will have a foundation surface to which it can rigidly adhere.

The invention will be better understood when reference is made to the following description and the accompanying drawing in which Fig. 1 is a view, partly in cross section of an X-ray tube embodying my invention; Fig. 2 is a cross section of a casing or outer layer forming part of an improved anode, while Fig. 3 illustrates a modified form of anode.

Referring to Fig. 1, numeral 1 designates a bulbous envelope of an X-ray tube which terminates in two oppositely directed stems 2. One of these stems supports a combined cathode and focusing member 3 of ordinary type and the other stem carries an anode 4 and target 5. The usual form of anode is constituted of a block of copper in which is seated a target of refractory material. The latter is intended to be the origin of the useful X-rays generated in the tube by the impinging cathode rays. However, it has been found that notwithstanding the presence of the focusing device, the function of which is to converge the cathode rays on a small spot on the target, some of the rays scatter about the tube, traveling in all sorts of trajectories and impinging on various elements of the tube including the envelope and anode. These rays give rise, by reflection or otherwise, to undesired X-rays which have their origin at portions of the anode other than at the target. As stated hereinbefore, X-rays of this character which are usually of fairly short wave length, i. e. high frequency, preclude sharp definition in radiographs and fluoroscopic images. In accordance with my invention, I propose to coat the copper anode with a layer of carbon or other material having a relatively low atomic weight as compared to the metal of the anode. Other materials besides carbon will readily suggest themselves to those skilled in the art, since any material may be used which has a lower atomic number than the anode material and a higher melting point than the anode, also which lends itself to being coated. It is apparent, however, that the lower the atomic number of the coating material, the greater will be the protection afforded by the coat against the undesirable X-rays. Carbon, which has an atomic weight of approximately 12 whereas copper is 64 and tungsten 184, is particularly well suited for this purpose.

It has been found that in the case of an anode made of copper, the carbon does not adhere rigidly thereto and it may be necessary to provide an intermediate metal. Nickel may be used for this purpose in the form of a plating but I prefer to encase the anode in an iron sheath or casing. As shown in Fig. 2, the sheath 6 may take the skeleton form of an anode and the interior thereof filled with a block of copper and a tungsten insert positioned in place, after which all three

members may be fused into a solid mass at a high temperature. If desired, the composite body may be swaged to a particular form, such for example, as shown in Fig. 1. The anode may then be immersed in a furnace which contains a hydro-carbon vapor, and heated to a temperature sufficient to cause a carbon coat of even thickness to form on the exterior of the iron casing. The carbon settled on the tungsten insert may be removed by scraping or otherwise. A tube containing an anode fabricated in the manner described above may be treated to exhaust under heated conditions in the same way as if the carbon coat were not present. The carbon coat has a higher melting temperature than the copper base and consequently will not volatilize at the temperatures used in the gas denudation process. It has been found that an anode with a carbon coat may satisfactorily be used in high vacuum devices since the thinness of the carbon coat precludes the absorption of much gas and its denudation is a relatively simple matter.

In the case where anodes of solid tungsten are employed, it has been found unnecessary to provide the intermediate layer. The carbon coat may be applied directly to the tungsten surface to which it adheres tenaciously. This modification is shown in Fig. 3 in which an anode of solid tungsten or molybdenum is designated by reference character 7, swaged or turned to form; the carbon coat is identified by character 8. The carbon may be removed over a small area on the chamfered face of the anode to form a target portion on which the cathode rays impinge.

When the carbon-coated anodes are employed in X-ray tubes, it has been found that the cathode rays give rise to X-rays of the highest frequency, hence of the type useful for diagnostic and radiographic purposes, only at that portion of the anode which is not covered by the carbon, i. e. at the target. The stray cathode rays which also impinge on the anode, particularly at the back of the target, are precluded from producing X-rays of this character and such X-rays that are produced fail to impair the diagnostic or therapeutic effect of the useful rays.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. An anode for X-ray tubes, said anode comprising a nickel-plated copper member provided with a target of refractory metal and coated with a material having an atomic number less than that of copper.

2. An anode for X-ray tubes, said anode comprising a copper body provided with a target of refractory metal, a layer of carbon encasing said copper body, and an intermediate layer of metal for binding the carbon to the copper.

3. An anode for X-ray tubes, said anode comprising a copper body provided with a target of refractory metal, a layer of carbon encasing said copper body, and an intermediate layer of metal for binding the carbon to the copper, said intermediate layer constituting iron.

KIYOSHI MATSUSHIMA.