May 28, 1929. W. D. COOLIDGE 1,714,975

X-RAY ANODE

Filed Dec. 10, 1923

Fig. 1.

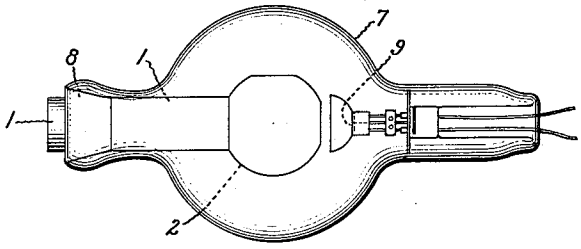


Fig. 2.

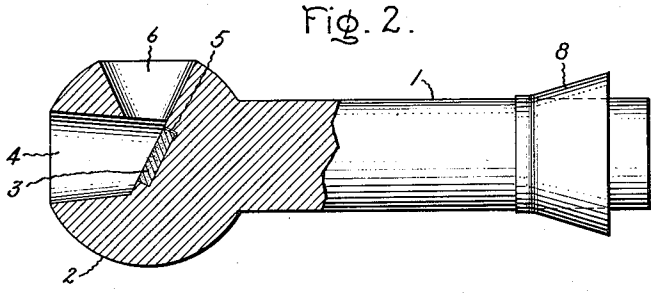
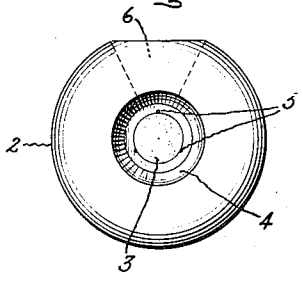


Fig. 3.



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UNITED STATES PATENT OFFICE.

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X-RAY ANODE.

Application filed December 10, 1923. Serial No. 679,525.

The present invention comprises an improved new target for X-ray tubes, which is capable of increasing the energy capacity of an X-ray tube, and which confines the emission of X-rays to a restricted zone so as to protect the operator.

In my prior Patent 1,211,092 of January 2, 1917, I have described an X-ray tube containing an anode which is provided with a shield or hood surrounding the face of the anode upon which X-rays are generated, the hood being provided with openings for the entry of an electron beam and the emergence of X-rays. This hood consists of a refractory metal, such as tungsten or molybdenum.

This construction is useful in many ways, for example, it reduces X-ray emission from the surface of the anode outside the focal spot and intercepts undesired X-rays. Other advantages are set forth in the above prior patent.

It is the object of my present improvement to increase the effectiveness and operating range of this type of anode by providing an anode consisting of a knob-shaped mass of metal constructed to accomplish the same shielding action as this hooded cathode but having a higher thermal capacity for a given size, offering better facilities for distribution of heat, and having less tendency to emit secondary X-rays than the composite anode described in my prior patent.

In accordance with my invention, I have provided an anode which is constructed as later explained, to enable X-rays to be generated at or near the center of the mass of the head which acts both as a heat reservoir and as a shield.

The accompanying drawing shows in Fig. 1 in outline an X-ray tube containing an anode embodying my invention; Fig. 2 shows my improved anode partly in longitudinal section; and Fig. 3 is an end view of the same.

As best shown in Fig. 2, my improved anode comprises a knob-shaped mass of metal which in the specific embodiment illustrated comprises a relatively thick cylindrical stem 1 and a substantially spherical head 2, although of course, these exact geometric configurations are not essential. These portions of the anode preferably consist of a metal of good heat conductivity, for example, copper, or even silver. These metals have atomic numbers 29 and 47 respectively, and hence are poorer generators of X-rays when struck by electrons. A plate or disc 3, consisting of a highly refractory metal of high atomic number, such for example, as tungsten, is embedded at or near the center of the head. A good metallic union is insured by casting copper about the tungsten plate, as described in my prior Patent 1,162,339 of November 30, 1915. The plate 3 may be held temporarily by small molybdenum or tungsten wires upon a plug of graphite (not shown) which when removed after casting leaves the passage 4 in the anode head. The wires may remain in the anode as shown at 5. The plate 3, which may be termed the "target" on which X-rays are generated, is preferably placed at an angle to the longitudinal axis of the anode, as illustrated. The passageway 4 extends from the exterior to the target plate 3 substantially in line with the longitudinal axis of the anode. A second passage 6 extends substantially at right angles to the passage 4. This passage also may be formed by a graphite plug suitably positioned in the mold.

The anode is mounted in a bulb 7 (Fig. 1) by sealing the cone-shaped flange 8, which consists of platinum, or other suitable material into the arm of the glass bulb. The stem 1 projects out of the bulb and serves to carry heat to the exterior where it may be dissipated either by a radiator (not shown) or by a surrounding body of oil. The cathode which is of the usual construction, as described for example in my prior Patent 1,211,092, is mounted opposite the anode. The bulb is exhausted by well-known methods.

During the operation of the X-ray tube electrons are projected from the cathode under the influence of the impressed voltage into the passage 4, upon the target plate 3. The useful beam of X-rays passes out through the passage 6, the remaining undesired X-rays being intercepted by the anode head and by the oppositely located cathode structure 9. Secondary electrons are to a large extent intercepted by the metal walls of the anode. The secondary electrons not only are forced to overcome the repulsive effect of their own electric and magnetic fields when passing through the passageways 4 or 6,

but also tend to strike the side walls of the passageways where the X-rays which are generated by their impact are largely shielded from the X-ray subject and operator. As already indicated, copper is a less effective generator of X-rays than tungsten, hence this factor also renders the present construction superior to my former construction, as shown in my Patent 1,211,092. By making the main body of the anode, that is, the stem 1 and the head 2, a jointless continuous mass of metal, maximum heat distribution, and heat storage is obtained for an anode of given weight and size. During the time of operation of the X-ray tube, the heat is generated at the centre of a mass of metal, which is substantially of spherical shape so that heat can flow with equal readiness in substantially all directions.

Certain changes, of course, may be made within the spirit of my invention. For example, instead of two passages, or a right-angled passage in the anode, a single passage may serve both for the entry of electrons and the emergence of X-rays.

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

1. The combination in an X-ray tube of a cathode structure and an anode, said anode comprising a knob-shaped mass of metal of good heat conductivity, said mass having a passage extending from the exterior to a substantially central portion thereof, a plate of refractory metal located at the end of said passage and in alignment with the direction of electron flow from said cathode, said cathode structure being located closely adjacent to said anode whereby it may act as a shield for undesired X-rays.

2. The combination in an X-ray tube of a cathode structure and an anode, said anode comprising a knob-shaped mass of metal of good heat conductivity, said mass having a passage extending from the exterior to a substantially central portion of said mass, a plate of refractory metal located at the end of said passage and in alignment with the direction of electron flow from said cathode, a second passage at right angles to said first mentioned passage said plate being adapted to emit electrons through said second passage, said cathode structure being closely adjacent to said anode whereby it may act as a shield for undesired X-rays.

3. An X-ray anode comprising an integral, substantially spherical mass of copper having a passage extending from the exterior to a substantially central portion thereof, a plate of refractory metal located at the end of said passage, an integral solid stem in alignment with said passage, and a second passage substantially at right angles to and intersecting said first mentioned passage substantially at the center of mass of said anode whereby X-rays emitted from said refractory plate may pass through said second passage.

4. An anode for X-ray tubes comprising an integral substantially spherical mass of cupreous metal having a passage extending from the exterior to a substantially central portion and a plate of refractory metal located at the end of said passage.

5. An anode for X-ray tubes comprising an integral substantially knob-shaped mass of metal of good heat conductivity, said mass having an atomic number not substantially greater than 47 nor substantially less than 29 and having passages substantially at right angles to one another and extending to approximately the center of mass of said anode, a disc of highly refractory metal held in good heat conductive relation with said knob-shaped mass in position in one passage to receive an electron discharge and to emit X-rays through another of said passages and a solid stem of relatively large diameter integrally united with said knob-shaped mass of metal.

6. An anode for X-ray tubes comprising an integral, substantially spherical mass of metal of good heat conductivity, said spherical mass having an atomic number not appreciably greater than 47 and not appreciably less than 29 and having a passage extending from the exterior to a substantially central portion thereof, a plate of refractory metal located at the end of said passage and a solid stem of relatively large diameter integrally united with said spherical mass.

In witness whereof, I have hereunto set my hand this 7th day of December, 1923.

WILLIAM D. COOLIDGE.