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[54] **X-RAY TUBE**

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[51] **Int. Cl.** **H01j 35/10**

[58] **Field of Search** 313/32, 60

[56] **References Cited**

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[57] **ABSTRACT**

An x-ray tube with an anode which is located in a high vacuum chamber connectable to a vacuum pump and is passed through by cooling fluid. The anode which comprises a peripheral mantle surface and lateral surfaces which are approximately parallel to each other is disengageably connected to a rotatable hollow shaft for rotation therewith and has its peripheral mantle surface located within the region of the electron beams emitted by the cathode. The x-ray tube furthermore comprises a distributing member for distributing the cooling fluid, which distributing member is arranged in the interior of and coaxially with the rotatable anode. The peripheral mantle surface is formed by the central peripheral portion of a ring which has a U-shaped cross section and the legs of which are detachably connected to the lateral surfaces of the anode, O-rings being provided for sealing purposes between the legs of the ring and the lateral surfaces of the anode.

7 Claims, 3 Drawing Figures

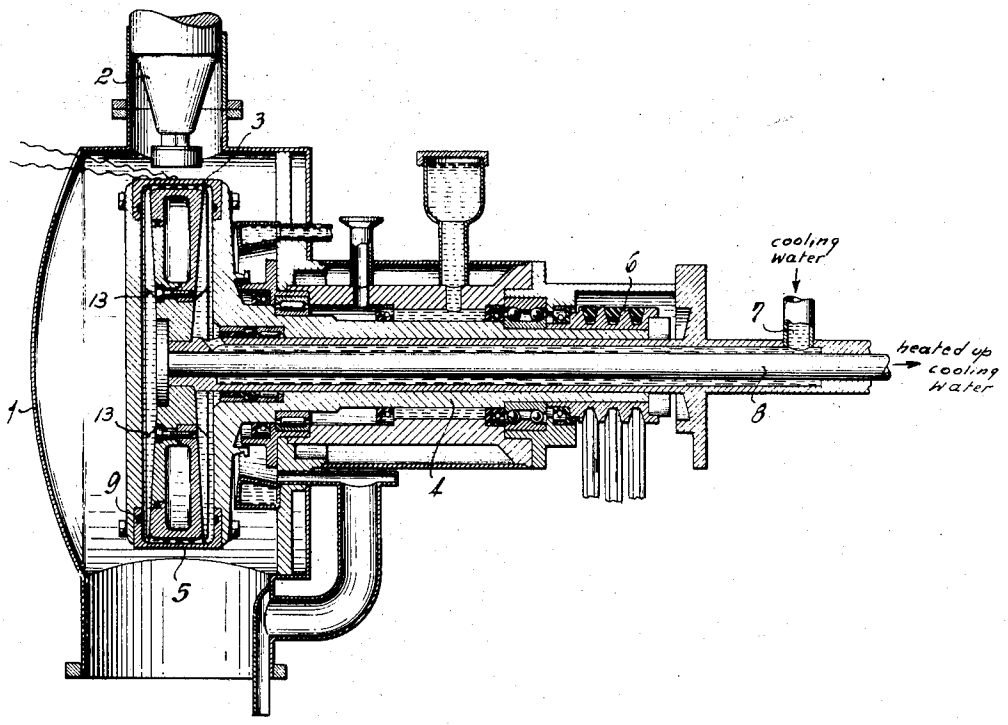
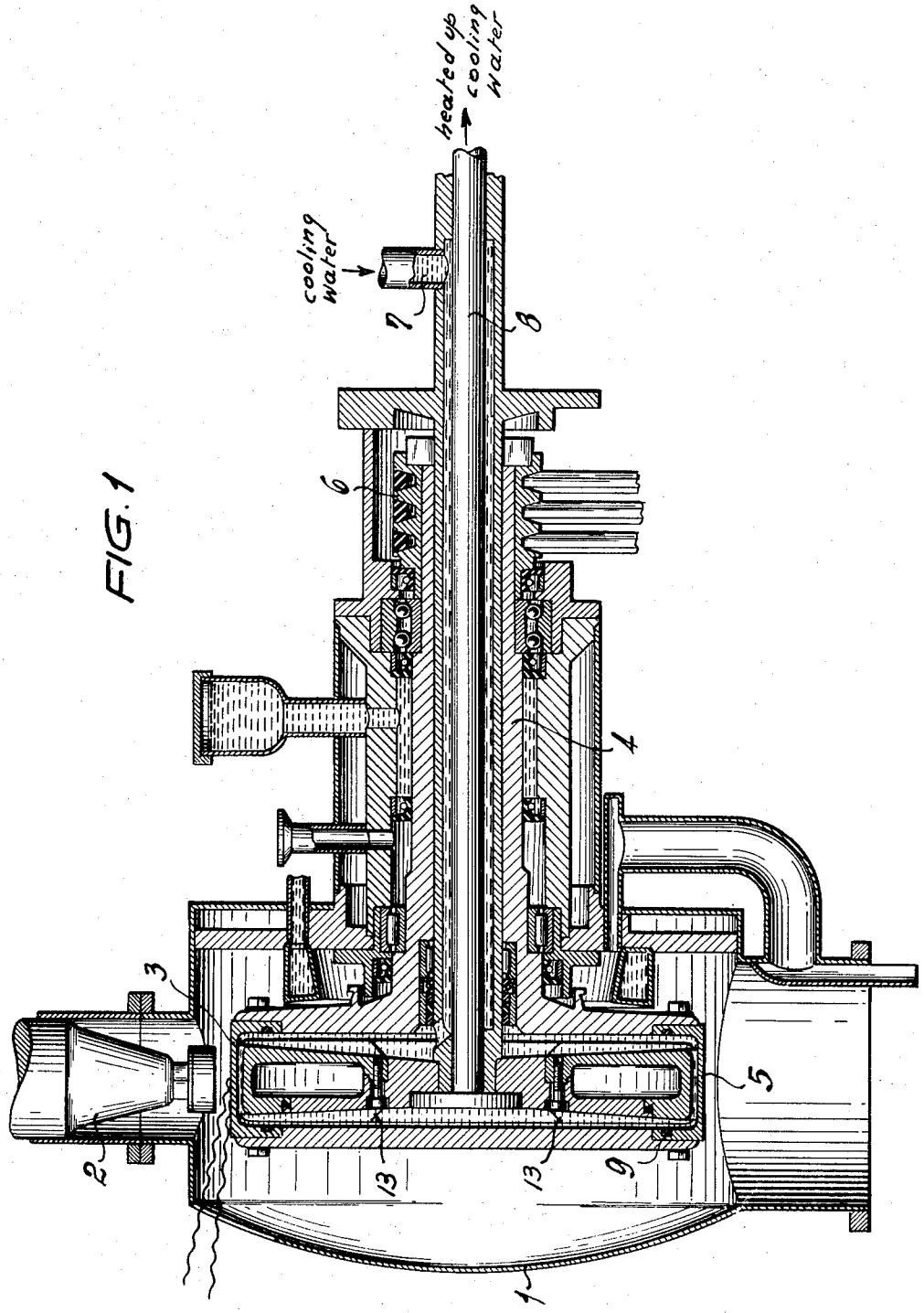


FIG. 1



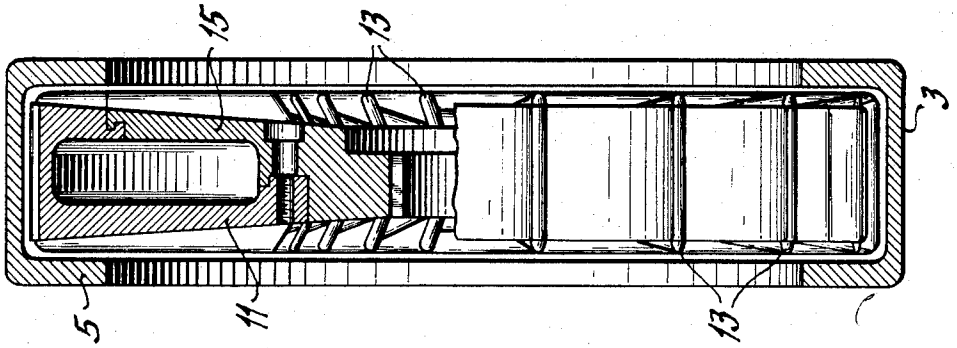


FIG.3

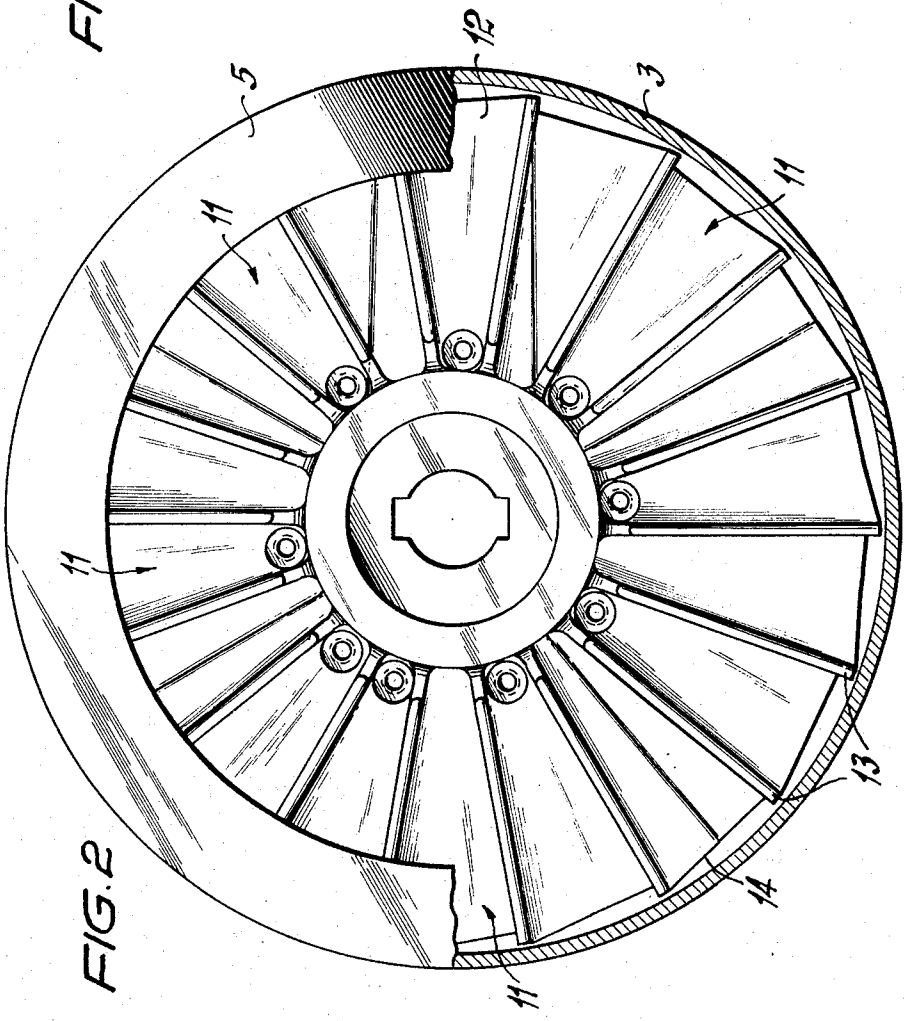


FIG.2

X-RAY TUBE

The present invention relates to an x-ray tube with an anode which is passed through by cooling water and while being detachably connected to a driven hollow shaft is rotatably journalled. This anode is arranged in an evacuated chamber which is connected to a vacuum pump. The anode is rotation symmetric and has two parallel or nearly parallel lateral surfaces and a mantel while extending through the housing of the x-ray tube. The mantle surface of said anode is located within the region of the electron beams emitted by the cathode while for controlling the cooling means a distributor body is arranged within the rotatable anode coaxially therewith.

X-ray tubes are known in which for purposes of reducing the heating up thereof, the anode is designed as a driven body of rotation so that continuously other areas of the anode are exposed to the impacting electron beam. With a heretofore known x-ray tube having a rotatable anode for increasing the speed of the cooling means introduced for cooling the rotatable anode, a cooling means distributor was arranged within the rotatable anode. This cooling means distributor was so arranged within the anode that the driven anode rotated about the stationary cooling means distributor. Since as far as possible thin walled structural elements have to be employed for the rotatable anode, there was encountered the drawback that the necessary mechanical stability was not sufficiently assured when the x-ray tube was subjected to high stresses. In order to assure a safe mounting of the anode at high rotational speeds of the anode as they occur with x-ray tubes having a high thermal loadability, it was suggested with this heretofore known x-ray tube to provide one bearing each for the cooling water distributor on the hollow shaft and also on that lateral surface of the rotatable anode which faces away from the hollow shaft. As a result thereof, deformations of the mantle surface occurred in view of the forces which were generated by the unsymmetric water inflow and sometimes also in view of unbalances and were exerted upon the relatively thin cylinder wall of the anode. The rotation of the rotatable anode therefore was non-uniform. Undesired movements of the focal spot of the electron beam occurred. This in turn occasionally brought about the destruction of the anode. Furthermore, with one embodiment of heretofore known x-ray tubes having rotatable anodes it was necessary to mount the mantle surface of the rotatable anode in the form of a ring connected at the edges to the lateral surfaces, because only in this way it was possible to insert the cooling water distributor into the rotatable anode.

It is an object of the present invention to provide an x-ray tube with high output in which in spite of the uniform cooling of the rotatable anode a proper operation will be assured.

It is another object of this invention to provide an x-ray tube as set forth in the preceding paragraph in which, in order to permit the respective required characteristic radiation, the parts determining the same can be exchanged in a simple manner.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 represents a longitudinal section through an x-ray tube according to the invention while the radiation protective mantle has been removed.

FIG. 2 illustrates on a larger scale than that of FIG. 1 a top view and cross section vertical to the axis through the rotatable anode of the x-ray tube of FIG. 1.

FIG. 3 is a side view and a cross section taken parallel to the axis through the rotatable anode of the x-ray tube of FIG. 1.

The x-ray tube according to the invention is characterized primarily in that the rotatable anode 5 comprises a ring which has a U-shaped cross sectional profile and has an intermediate web which forms the mantle surface 3 of the rotatable anode 5 and comprises lateral surfaces which are detachably connected to the lateral webs of the U-shaped ring while for purposes of effecting a seal between the webs of the U-shaped ring and the lateral surfaces of the anode, O-rings are provided. Expediently, at leat the ring-shaped part of the wall of the anode consists of highly pure vacuum cast electrolyte copper or of another suitable highly pure vacuum cast metal. In order to permit the simple installation of the distributor body in the rotatable anode for the cooling means with high degrees of efficiency, an advantageous design of the x-ray tube according to the invention consists in that the axial symmetrically designed distributor body is composed of a plurality of parts which are connected to a rotation symmetric body that is arranged coaxially with regard to the axis of the rotatable anode. These parts are at their radial surface and/or two surfaces guided parallel to each other and equally spaced from the axis of the distributor body while contacting each other. The lateral surfaces of said parts have from the inside to the outer circumference such an inclination that the intermediate space formed by the lateral surfaces of the distributor body and the inner surfaces of the lateral walls of the rotatable anode decreases from the inside to the outside in such a way that when considering that the outer circumference increases in radial direction, a uniform speed profile forms of the cooling means which flows in and out in the vicinity of the axis. On the lateral surfaces of the distributor body there are arranged radially extending ribs while the outer circumference of the distributor body is formed by one or more inclined planes which are arranged between each two ribs and ascend in the direction of rotation of the rotatable anode in such a way that at those areas where the distributor body has its greatest dimensions, only a very slight distance from the inner surface of the cylindrical mantle of the rotatable anode exists.

Experience has shown that an x-ray tube with the features of the present invention, which was operated at a rotational speed of the anode of 3,000 rpm and with the diameter of the rotatable anode amounting to 25 cm while the ring of U-shaped cross section of the rotatable anode consisted of highly pure vacuum cast electrolyte copper, was able to produce an electric output of 100 kw while the vacuum amounting to 10^{-5} torr.

Referring now to the drawings in detail, the electron beam emitted by the cathode 2 through the passage provided in the housing 1 impacts in a focal spot upon the mantle surface 3 of a rotatable anode 5 arranged at one end of a hollow shaft 4. The rotatable anode preferably comprises highly pure vacuum cast electrolyte

copper. However, if the need should occur, the rotatable anode also may consist of a material of another suitable highly pure vacuum cast material. The driven hollow shaft is driven by means of the drive **6.** The cooling water inflow **7** and the cooling water return flow **8** for cooling the rotatable anode **5** are arranged within the hollow shaft **4.**

As will be evident from the drawing, the rotatable anode is formed by a ring of U-shaped cross sectional profile and by two lateral surfaces arranged perpendicularly with regard to the axis of the hollow shaft, one of said lateral surfaces being connected to the hollow shaft **4.** The ring is detachably connected to the detachable surfaces of the rotatable anode **5** for instance by screw connections. The intermediate web of the ring simultaneously forms the mantle surface of the rotatable anode **5.** For sealing purposes, O-rings **9** are provided between the lateral webs of the ring and the lateral surfaces of the anode **5.**

As will be evident from FIGs. **2** and **3,** the distributor body is axially symmetrically designed and is composed of a plurality of parts **11** which engage each other at their radial surfaces. For purposes of facilitating the insertion of the parts **11** into the rotatable anode **5,** one of the parts **12** which form the distributor body as well as the parts **11** adjacent to the part **12** comprise two surfaces which are parallely guided toward each other and are equally spaced from the axis of the distributing body. The parts **11** of the distributor body and the parts **12** are, as will be evident from the drawing, detachably connected to a rotation symmetric body for instance by means of screw connections, said rotation symmetric body being coaxial with regard to the axis of the rotatable anode **5.** The lateral surfaces of the parts **11** and of the part **12** of the distributor body are so inclined that the intermediate space defined by the outer surfaces of the distributor body and the inner surface of the lateral walls of the rotatable anode **5** decreases from the inside toward the outside in such a way that the cooling liquid which in the vicinity of the axis flows in and out and is intended for the rotatable anode **5** has a uniform speed profile when considering the outer circumference of the distributor body which outer circumference increases in radial direction. The lateral surfaces of the distributor body are furthermore provided with radially extending fins **13.** The outer circumference of the distributor body is, as evident from the drawing, formed by inclined planes **14** provided between each two fins **13.** The inclined planes **14** ascend in the direction of rotation of the rotatable anode. The spacing of the inner surface of the cylindrical mantle **3** of the rotatable anode **5** from the outer curcumference of the distributor body is rather small. Due to the fact that the intermediate space between the inner surface of the mantle **3** of the rotatable anode **5** and that surface of the distributor body which faces said inner surface of the mantle **3** is particularly small at those areas where the distributor body in radial direction has the greatest dimensions, it will be appreciated in view of the thus obtained turbulent flow, that a very effective cooling of that part of the rotatable anode **5** will be obtained which is most strongly exposed to thermal stresses. This brings about a considerable increase in the degree of efficiency of the x-ray tube according to the invention.

It is, of course, to be understood that the present invention is, by no means, limited to the particular showing in the drawings but also comprises any modifications within the scope of the appended claims.

What we claim is:

1. An X-ray tube which includes: a high vacuum chamber connectable to a vacuum pump, a rotation-symmetric rotatable anode having a hollow space therein and being rotatably arranged in said high vacuum chamber, a rotatable hollow shaft disengageably connected to said anote for rotating the same, conduit means associated with said hollow shaft and communicating with the hollow space of said anode for respectively conveying cooling fluid to and from said anode, a rotatable distributing member arranged within said hollow space of said anode and coaxially therewith and being rotatably connected to said anode including lateral wall means and ring means of a U-shaped cross section the central portion of which forms the peripheral mantle surface of said anode and the legs of which have said lateral wall means detachably connected thereto, sealing means interposed between said legs and said lateral wall means, and a cathode arranged relative to said anode so that said mantle surface of said anode is within the region of the electron beams emitted by said cathode.

2. An X-ray tube according to claim **1,** in which at least that portion of said anode which is formed by said ring means is made of a suitable highly pure vacuum cast material.

3. An X-ray tube according to claim **1,** in which at least that portion of said anode which is formed by said ring means is made of highly pure vacuum cast electrolyte copper.

4. An X-ray tube according to claim **1,** in which said distributing member includes a rotation-symmetric body and a plurality of elements connected to said rotation symmetric body and having lateral surfaces inclined from their inner circumference to their outer circumference in such a manner that the distance between the lateral surfaces of said distributing member and the inner surfaces of the lateral walls of said rotatable anode decreases in radial outward direction of said distributing member in such a way that when considering the radially increasing outer circumference a substantially uniform speed profile of the cooling fluid flowing in and out of said anode in the vicinity of its axis of rotation is obtained, and fin means arranged on the outer lateral surfaces of said distributing member, the outer circumference of said distributing member being formed by at least one inclined edge each between each two adjacent fin means with each of said edges ascending in the direction or rotation of said anode in such a way that at the areas of greatest dimensions of said distributing member the latter is only slightly spaced from the inner mantle surface of said anode.

5. An X-ray tube according to claim **3,** in which said elements are flat surface parts with radially extending surfaces engaging each other.

6. An X-ray tube according to claim **3,** in which each of said elements has two surfaces which are parallel to each other at the same distance from the axis of rotation of the distributing member, and in which said two surfaces of each of said elements engage corresponding surfaces of the respective adjacent elements.

7. An X-ray tube according to claim **3,** in which the outer circumference of the distributing member has a rather slight distance from the inner surface of the outer peripheral wall of said rotatable anode.

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