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A. TAYLOR

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DEMOUNTABLE X-RAY TUBE CONSTRUCTION

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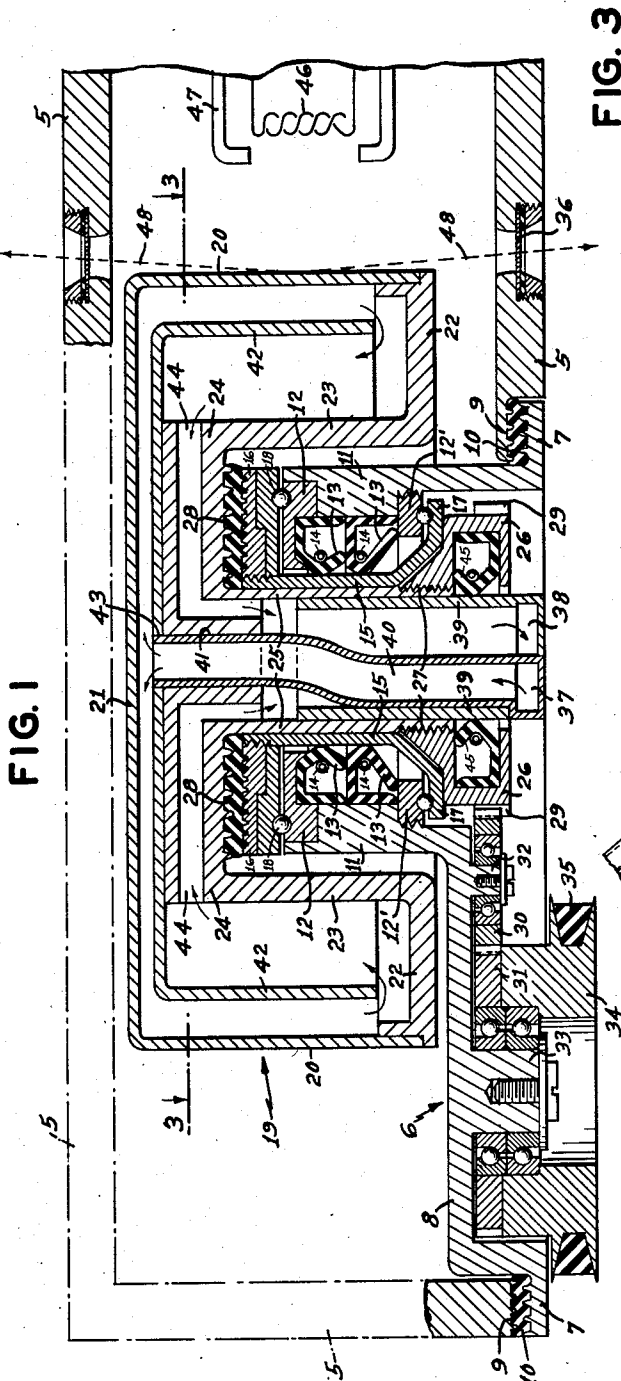
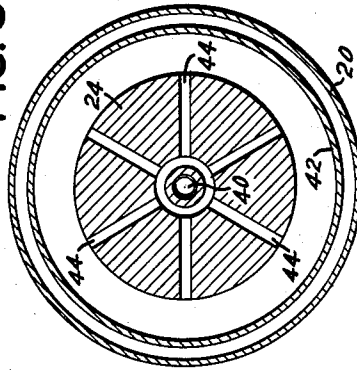
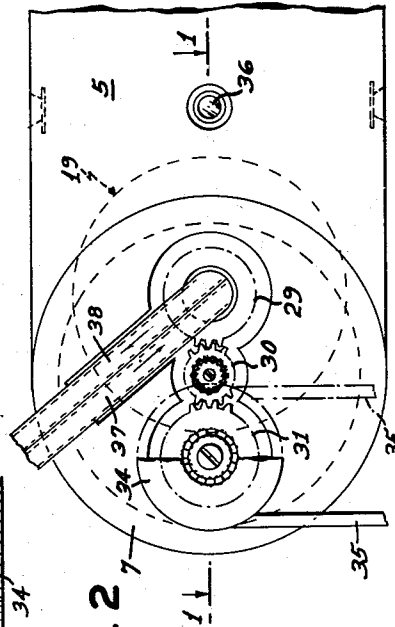


FIG. 3



INVENTOR.
Abraham Taylor

BY

Plim, Edmund, Norton, Curran & Taylor
ATTORNEYS

UNITED STATES PATENT OFFICE

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DEMOUNTABLE X-RAY TUBE
CONSTRUCTION

Abraham Taylor, Cleveland, Ohio, assignor to
Horizons Incorporated, Princeton, N. J., a cor-
poration of New Jersey

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This invention relates to demountable X-ray tubes and, more particularly, to a rotating water-cooled cylindrical anode assembly for such tubes.

It is well known that the continuous output of an X-ray tube can be considerably increased if the heat generated at the focal spot of the electron beam striking the anode is effectively dissipated. The conventional procedure for dissipating and distributing this heat over a relatively large anode area is to rotate or oscillate the anode, and the removal of the heat thus distributed over the large anode area is generally removed by auxiliary cooling with circulating water or the like. Of course, movement of the anode should be such as to maintain the focal spot of the electron beam at a fixed position with respect to the tube geometry, and this focal spot, comprising the source of the X-ray beam, should be positioned as close as possible to the windows of the tube envelope in order to obtain a high value of emergent X-ray energy.

A characteristic construction of rotating anode assemblies for demountable X-ray tubes, that is, tubes provided with an auxiliary vacuum pumping system, includes a hollow shaft mounted in the tube envelope, rotation of the anode being provided by rotation of the shaft and cooling of the anode being provided by circulation of water through the hollow shaft. The driving means for rotating the anode shaft is positioned exteriorly of the tube envelope, and such driving means has generally been positioned so close to the emergent X-ray beam as to limit the useful area around the emergent beam adjacent the tube window. As a result, the utility of such an X-ray tube is considerably restricted, particularly if the tube is to be used with an X-ray diffraction camera which occupies a relatively large area adjacent the X-ray tube envelope.

The rotating water-cooled anode assembly of the present invention is characterized by its compactness and arrangement of the anode driving mechanism. These features increase the accessibility, and hence the utility, of the X-ray beam emerging from a window of a demountable-type tube positioned adjacent the same side of the tube as the anode driving mechanism. The anode assembly of my invention comprises an anode supporting frame adapted to be mounted in an opening in a side wall of the X-ray tube envelope, the supporting frame being provided with an eccentrically positioned bearing assembly projecting in the direction of the interior of the tube, an anode driving sleeve positioned within the bearing assembly, and sealing means

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for maintaining a substantially gas-tight seal between the anode supporting frame and the anode driving sleeve. A cylindrical anode drum is mounted on the anode driving sleeve, one face of the drum being provided with an annular recess adapted to receive the driving sleeve, and connecting means are provided for securing the anode driving sleeve to the anode drum in substantially gas-tight relationship. An anode driving gear train is mounted on the anode supporting frame in engagement with the external end of the anode driving sleeve, and water supply and discharge lines are mounted in communication with the interior of the anode drum through the anode driving sleeve. The resulting structure comprises a water-cooled cylindrical anode assembly characterized by unimpeded access to all tube windows positioned peripherally thereof in the plane of emission of X-rays from the cylindrical drum surface.

These and other features of my invention will be more fully understood by reference to the accompanying drawing in which

Fig. 1 is a cross-sectional view of the anode assembly of the invention mounted in an X-ray tube envelope, the section being taken along line 1—1 in Fig. 2;

Fig. 2 is an exterior plan view of the anode assembly shown in Fig. 1; and

Fig. 3 is a section taken along line 3—3 in Fig. 1.

The anode assembly, particularly as shown in Figs. 1 and 2, is mounted in one end portion of an envelope 5 of a conventional demountable type X-ray tube. The anode assembly includes an anode supporting frame 6 having a peripheral flange portion 7 and an inwardly recessed body portion 8. The flange portion 7 is shaped to conform to the outline of the tube opening 9 which receives the anode assembly, the joint between the flange 7 and the edge of the tube opening 9 being completed by any appropriate sealing material such as a soft gasket 10. Inasmuch as the anode supporting frame and its associated structure functions as a cover plate for the tube envelope opening 9, the supporting frame can be held tightly against the tube opening by the maintenance of a vacuum within the tube. It will be seen, accordingly, that a gas-tight seal may be provided between the envelope 5 of the X-ray tube and the main body portion 8 of the anode supporting frame without any extraneous clamping structure.

The body portion of the anode supporting frame, as clearly shown in Fig. 1, is provided ec-

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centrically thereof with a bearing assembly projecting in the direction of the interior of the tube. The bearing assembly is composed of an inwardly projecting annular body portion 11 provided internally adjacent its extremities with vacuum seal retaining rings 12 and 12'. Within the space defined by the annular body portion 11 and the two retaining rings 12 and 12' there is mounted a suitable vacuum seal device such as the greased chevron rings 13 which are urged radially towards their axis by compression springs 14. The vacuum seal rings 13 are thus urged against the outer surface of an axially positioned anode supporting sleeve 15 mounted within the annular body portion 11 of the anode bearing assembly. The supporting sleeve 15 is provided with a radially outwardly projecting flange 16 threaded onto its inner extremity and is provided adjacent its outer extremity with a similarly disposed but integrally formed flange 17. The flanges 16 and 17 thus embrace the inwardly projecting retaining rings 12 and 12' on the body portion 11 of the bearing assembly, and ball bearings 18 are mounted therebetween so that the anode sleeve 15 may be rotated freely within the body portion of the anode bearing assembly. Accordingly, the rotatable sleeve 15 is adapted to carry an anode drum so that the drum may be rotated by driving the sleeve 15.

The anode drum 19 comprises a cylindrical shell 20 one peripheral edge of which is formed integrally with or soldered to a face plate 21. The other peripheral edge of the cylindrical anode shell 20 has mounted thereon, preferably by soldering or the like, a face plate 22 provided with an inwardly recessed portion or well 23. The base of the recessed portion 23 is closed by a relatively thick body portion 24 which is provided axially thereof with an up-struck sleeve portion 25 so proportioned as to extend within and throughout the full length of the bearing sleeve 15. The outer end of the anode drum sleeve 25 is provided with a threaded portion 27 onto which a threaded drive cap assembly 26 is screwed. By tightening the drive cap assembly on the sleeve 25, the body portion 24 of the recessed anode drum face is forced against the innermost bearing flange 16 so as to compress a gasket 28 of rubber or the like therebetween and thus form a gas-tight seal. Corrugation of these parts which engage the gasket 28, and the absence of relative rotation of these parts as they are being brought together, further enhances the efficacy and durability of the seal.

It will be clearly apparent, accordingly, that maintenance of a vacuum within the tube envelope 5 is insured by the gasket 28 which seals the joint between the recessed face of the anode drum and the anode bearing sleeve 15, by the vacuum seal 13 provided between the anode sleeve 15 and the body portion 11 of the bearing assembly of the anode supporting frame, and by the sealed engagement of the flange 7 of the anode supporting frame with the tube envelope 5. Thus, a suitably high vacuum may be maintained by an active vacuum pump system associated with the tube envelope while rotating the anode drum 19 by driving the rotatable anode sleeve 15.

The driving mechanism for the anode sleeve comprises a gear train engaging gear teeth 29 provided on the drive cap 26 secured to the end of the anode drum sleeve 25. The frictional contact between the drive cap and the outer flange 17 of the anode driving sleeve 15 provides a positive driving connection between the cap and the

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sleeve. The gear train may comprise any appropriate number and combination of sizes of gears positioned within the recessed body portion 8 of the anode supporting frame, and the gear train is advantageously, though not necessarily, driven in such direction as to turn the drive cap 26 in the direction of tightening its grip on the sleeve threads 27. In the embodiment of the invention shown in the drawing, the gear train comprises two gears 30 and 31 mounted on bosses 32 and 33, respectively, struck up from the body portion 8 of the anode supporting frame. The driving gear 31 is, in turn, connected to the drive pulley 34 which is driven by a conventional belt 35, or the like. It can be seen clearly in Figs. 1 and 2 that the position of the drive pulley 34, which is the only part of the anode assembly that extends outwardly beyond the face of the tube envelope in the modification shown in the drawings, is sufficiently removed from the adjacent tube window 36 as to leave completely accessible a large area surrounding the window. If desired, a portion of the anode supporting frame flange 7 and a corresponding portion of the tube envelope 5 may be recessed to accommodate the drive belt 35 and thus permit the drive pulley to be mounted in the supporting frame flush with or inside the plane of the tube envelope. In this latter modification of the anode assembly of my invention, no part of the assembly will extend beyond the contour of the tube envelope itself. In all modifications of the anode assembly of the invention, the assembly is characterized by an anode supporting frame having a raised peripheral flange adapted to engage the tube wall opening and with all elements of the anode assembly, with the possible exception of the drive pulley 34, positioned inwardly of the tube with respect to the plane of said peripheral flange.

Although the water-cooling connections for the anode drum are mounted axially of the drum assembly, the positioning of the drive pulley 34 away from the drum axis leaves available for the water connection a recessed portion of the complete assembly. Accordingly, water supply and discharge lines 37 and 38, respectively, are brought into the axis of the drum within the recess space provided by the plane of the anode supporting frame flange 7 and the outermost surface of the drive cap 26. The water connections to the interior of the drum are provided by a stationary union composed of a cylindrical sleeve 39 having a tube portion 40 mounted therewithin. The water supply line 37 communicates with the outer extremity of the sleeve 39 and the water discharge line 38 is connected to the outer extremity of the tube 40. The inner extremity of the tube 40 extends through an axial opening 41 in the body portion 24 of the recessed anode drum face. A dish-shaped baffle 42 provided with an axial opening 43, and mounted securely on the inner face of the body portion 24 of the recessed anode drum face, provides a partition within the anode drum through which cooling water may flow. Thus, cooling water from the supply line 37 flows inwardly through the tube 40, thence between the face of the baffle plate 42 and the inner surface of the drum face 21 of the anode, through the outer chamber of the anode drum where it passes in direct contact with the cylindrical shell 20 of the anode drum. The cooling water thence flows into the inner chamber of the drum and through a plurality of radial openings 44 drilled or otherwise formed in the body portion 24 of the recessed anode drum face, six such radial

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openings being provided in the modification shown in Figs. 2 and 3. The water issuing from the inner ends of the openings 44 passes into the cylindrical sleeve 39 of the water coupling and thence through the discharge line 38. A packing gland 45 positioned within the drive cap assembly 26 maintains a water seal between the anode driving sleeve and the stationary water supply union.

In operation of the apparatus of my invention, the pulley 34 is driven so as to drive the gear train and the anode driving sleeve 15 and thus rotate the anode drum 19. A stream of high velocity electrons from a conventional incandescent cathode 46, focused by the externally adjustable shield 47, impinges on the cylindrical anode shell 20 of the drum, and the resulting X-ray beam 48 leaves the drum surface at a low angle of incidence (approximately 5°) and passes through the tube windows. The absence of any obstruction beyond the plane of the tube envelope 5 adjacent that portion of the anode supporting frame nearest the tube window 36 makes this window as completely useful as all other windows which may be provided peripherally about the tube envelope. Of course, the characteristics of the emergent X-ray beam may be modified by interchanging anode drums having cylindrical shells 20 formed of metals which will provide the desired X-ray beam characteristics. Thus, although a conventional copper anode surface may be provided by forming the shell 20 of copper or of a copper plated base metal, other metals may be used in lieu of copper. If desired, a variety of X-ray beam characteristics may be obtained by plating, or otherwise positioning, on the surface of the drum 20 a plurality of segments composed of a variety of other metals. By limiting rotation of the anode drum by an angular oscillation equal to the angular extent of each such segment, the tube may be operated to supply at will the characteristic X-ray radiation of the metal of such segment while nevertheless taking advantage of the other virtues of my novel anode assembly structure. Accordingly, the term "rotating" as used herein and in the claims, includes continuous uninterrupted rotation in a single direction as well as oscillatory rotation of either a multiple or a fraction of a complete revolution.

It will be appreciated that the rotating anode assembly of my invention is relatively simple in construction and that it is readily amenable to disassembly and removal from the tube envelope. The compactness of the anode assembly makes it a particularly valuable adjunct to a demountable X-ray tube, and its substantially flush outer contour enhances the utility of such a tube embodying this anode assembly.

I claim:

1. A rotating water-cooled cylindrical anode assembly for demountable X-ray tubes characterized by unimpeded access to all tube windows positioned peripherally thereof in the plane of emission of X-rays from the cylindrical wall surface of the drum and comprising an anode supporting frame adapted to be mounted in an opening in a side wall of an X-ray tube envelope, the supporting frame being provided with an eccentrically positioned bearing assembly projecting in the direction of the interior of the tube, an anode driving sleeve positioned within said bearing assembly, sealing means providing a substantially gas-tight seal between the anode supporting frame and the anode driving sleeve, a cylindrical anode drum mounted for rotation in a plane par-

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allel to the plane of the anode supporting frame, one face of the drum being provided with an annular recess adapted to receive the anode driving sleeve, connecting means for securing the anode driving sleeve to the annular recess in the anode drum in substantially gas-tight relationship, an anode driving gear train mounted on the anode supporting frame in engagement with the anode driving sleeve, and water supply and discharge lines communicating with the interior of the anode drum through said anode driving sleeve.

2. A rotating water-cooled cylindrical anode assembly for demountable X-ray tubes characterized by unimpeded access to all tube windows positioned peripherally thereof in the plane of emission of X-rays from the cylindrical wall surface of the drum and comprising an anode supporting frame having a main body portion and a raised peripheral flange adapted to be mounted in an opening in a side wall of an X-ray tube envelope, the supporting frame being provided with an eccentrically positioned bearing assembly projecting in the direction of the interior of the tube, an anode driving sleeve positioned within said bearing assembly, sealing means providing a substantially gas-tight seal between the anode supporting frame and the anode driving sleeve, a cylindrical anode drum one face of which is provided with an annular recess adapted to receive the anode driving sleeve, connecting means for securing the anode driving sleeve to the annular recess in the anode drum in substantially gas-tight relationship, an anode driving gear train mounted on the anode supporting frame in engagement with the anode driving sleeve, and water supply and discharge lines communicating with the interior of the anode drum through said anode driving sleeve, all previously recited elements of the assembly being positioned inwardly of the tube with respect to the plane of the peripheral flange of the anode supporting frame.

3. A rotating water-cooled cylindrical anode assembly for demountable X-ray tubes characterized by unimpeded access to all tube windows positioned peripherally thereof in the plane of emission of X-rays from the cylindrical wall surface of the drum and comprising an anode supporting frame adapted to be mounted in an opening in a side wall of an X-ray tube envelope, the supporting frame being provided with an inwardly recessed main body portion in which there is mounted an eccentrically positioned bearing assembly projecting in the direction of the interior of the tube, an anode driving sleeve positioned within said bearing assembly, sealing means providing a substantially gas-tight seal between the anode supporting frame and the anode driving sleeve, a cylindrical anode drum one face of which is provided with an annular recess adapted to receive the anode driving sleeve, connecting means for securing the anode driving sleeve to the annular recess in the anode drum in substantially gas-tight relationship, an anode driving gear train mounted on the anode supporting frame in engagement with the anode driving sleeve, and water supply and discharge lines communicating with the interior of the anode drum through said anode driving sleeve.

4. A rotating water-cooled cylindrical anode assembly for demountable X-ray tubes characterized by unimpeded access to all tube windows positioned peripherally thereof in the plane of emission of X-rays from the cylindrical wall surface of the drum and comprising an anode sup-

porting frame adapted to be mounted in an opening in a side wall of an X-ray tube envelope, the supporting frame being provided with an inwardly recessed main body portion in which there is mounted an eccentrically positioned bearing assembly projecting in the direction of the interior of the tube, an anode driving sleeve positioned within said bearing assembly, sealing means providing a substantially gas-tight seal between the anode supporting frame and the anode driving sleeve, a cylindrical anode drum one face of which is provided with an annular recess adapted to receive the anode driving sleeve, connecting means for securing the anode driving sleeve to the annular recess in the anode drum in substantially gas-tight relationship, an anode driving gear train mounted on the anode supporting frame in engagement with the anode driving sleeve and positioned within the recessed body portion of said supporting frame, and water supply and discharge lines communicating with the interior of the anode drum through said anode driving sleeve.

5. A rotating water-cooled cylindrical anode assembly for demountable X-ray tubes characterized by unimpeded access to all tube windows positioned peripherally thereof in the plane of emission of X-rays from the cylindrical wall surface of the drum and comprising an anode supporting frame adapted to be mounted in an opening in a side wall of an X-ray tube envelope, the supporting frame being provided with an inwardly recessed main body portion in which there is

mounted an eccentrically positioned bearing assembly projecting in the direction of the interior of the tube, an anode driving sleeve positioned within said bearing assembly, sealing means providing a substantially gas-tight seal between the anode supporting frame and the anode driving sleeve, a cylindrical anode drum one face of which is provided with an annular recess adapted to receive the anode driving sleeve, connecting means for securing the anode driving sleeve to the annular recess in the anode drum in substantially gas-tight relationship, an anode driving gear train mounted on the anode supporting frame in engagement with the anode driving sleeve and positioned within the recessed body portion of said supporting frame, and water supply and discharge lines communicating with the interior of the anode drum through said anode driving sleeve, the water supply and discharge lines being connected to the anode driving sleeve within the recess provided by the recessed body portion of the anode supporting frame.

ABRAHAM TAYLOR.

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