

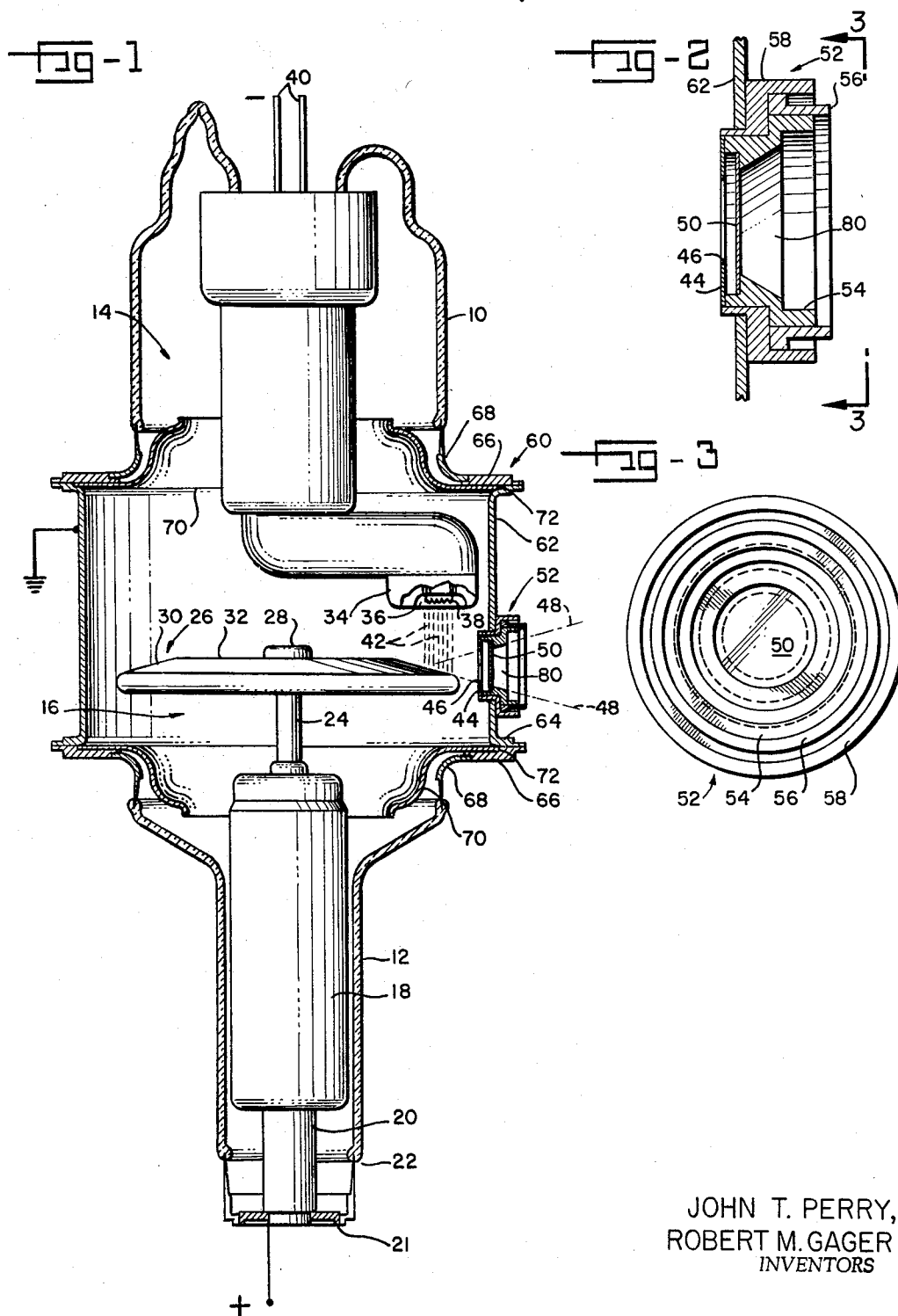
March 10, 1970

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3,500,097

X-RAY GENERATOR

Filed March 6, 1967



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3,500,097

X-RAY GENERATOR

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Filed Mar. 6, 1967, Ser. No. 620,969

Int. Cl. M01j 35/10

U.S. Cl. 313—59

1 Claim

ABSTRACT OF THE DISCLOSURE

A rotating anode X-ray tube provided with a cylindrical metal center section and a window assembly depending from the center section, such window assembly including an X-ray diaphragm disposed in close proximity to the rotating anode. The center section is electrically grounded while the tube's anode and cathode may be at high positive and negative voltages with respect to ground. The center section is welded to metal sleeves which are in turn sealed to glass envelope portions at either end of the tube.

BACKGROUND OF THE INVENTION

In order to overcome heating problems associated with high voltage X-rays, certain X-ray tubes employ rotating anodes whereby the surface of the anode subjected to electron bombardment continually changes. While use of rotating anodes has aided in solving the problem of overheating, attempts to improve picture definition have been hindered. In the operation of a high voltage X-ray tube, some electrons are diverted from their desired path and strike the anode at locations outside the desired focal area of the electron beam. As a result, undesirably large quantities of spurious X-rays are generally produced from a relatively large area of the anode. These spurious X-rays cause a general loss of detail on the radiographic image produced by the tube. This loss of detail may be materially reduced by utilization of an apertured diaphragm in close proximity to the X-ray source, that is, adjacent the rotating anode. Heretofore, diaphragms have been mounted relatively close to the anode by mounting the diaphragm on the anode structure itself. A disadvantage of this solution is the excessive heating encountered in the diaphragm structure, and the position of the diaphragm at an inaccessible fixed location inside the tube envelope. In other instances diaphragms have been mounted on the X-ray tube's glass envelope. In the latter case, a problem arises in protecting the glass-to-metal seal from punctures due to charge buildup on the relatively close adjacent glass. Moreover, metal from the rotating anode tends to deposit on the nearby glass surfaces, deleteriously affecting the tube's characteristics. It therefore has frequently been necessary to place the diaphragm farther away from the rotating anode than would be desired.

Greater control over the X-ray beam could also be attained with a variable or movable diaphragm placed closely adjacent the source of X-rays. However, construction heretofore employed has required the placement of such controllable or movable diaphragm relatively far from the X-ray source.

SUMMARY OF THE INVENTION

According to the present invention, a high voltage X-ray tube includes a glass envelope having a grounded cylindrical metal center section substantially surrounding a rotating anode and adjacent cathode.

A grounded window assembly located in the sidewall of the cylindrical metal center section includes an apertured diaphragm at the inward end thereof which is closely positioned relative to the rotating anode. The center section, being metal, is not subject to puncture, nor is it

subject to charge buildup since it is grounded. Also because the cylindrical metal center section and window assembly are grounded, only one-half the total voltage need be withstood between the window assembly and the X-ray tube electrodes, whereby close spacing of the diaphragm and anode is further facilitated.

Moreover, the metal center section provides overall electrical stability for the tube, and this stability does not deteriorate with time inasmuch as metal evaporated onto the metal center section has no effect upon the electrical field configuration within the tube as would be the case in the instance of the usual glass tube. The metal center section is joined to the glass envelope by means of sleeves welded to the center section and sealed to the glass envelope. Shields supported from between the cylindrical metal center section and such sleeves extend toward the opposite ends of the tube acting to shield glass-to-metal seals from the anode-cathode area of the tube. The construction provides ease of manufacture of the glass and metal construction of the X-ray tube.

Accordingly, an object of the present invention is to provide an improved X-ray tube for providing a source of X-rays of effectively small area by diaphragming such source close to a rotating anode.

It is another object of the present invention to provide an improved X-ray tube producing a controlled X-ray beam wherein such tube is rugged in construction and stable in operation.

It is another object of the present invention to provide an improved X-ray tube for producing a controlled X-ray beam wherein such tube is easy to assemble.

DRAWINGS

FIG. 1 is a cross section of an X-ray tube embodying the present invention;

FIG. 2 is an enlarged cross-sectional view of a window assembly included in X-ray tube of FIG. 1; and

FIG. 3 is an end view of the window assembly of FIG. 2.

DETAILED DESCRIPTION

Referring to the drawings the X-ray tube illustrated therein comprises an envelope including end portions 10 and 12 formed of glass or similar insulating material having a cathode 14 mounted at one end and an anode 16 mounted at the other. The anode 16 is of the rotary type and comprises a rotor body 18 suitably supported by bearing structure (not shown) upon a stem or spindle 20 which is supported from the envelope by an end plate 21 connected to the envelope by a conventional glass-to-metal seal 22. Extending from the rotor body 18 toward the cathode 14 is a shaft 24 which supports a target member or disk 26 secured to the shaft by a cap nut 28. The target disk 26 is preferably formed of tungsten or another metal of high atomic number, and the nut 28 and shaft 24 are preferably of molybdenum or another suitable metal having high strength at high temperatures. As will be noted, the target disk 26 is formed with a peripheral bevel or frustoconical surface portion 30, and a flat center portion 32 which extends at right angles to shaft 24. The anode is suitably connected to a high positive potential. The anode is suitably maintained at a voltage of approximately 170 kvp. with respect to the cathode.

The cathode 14 is provided with a head portion 34 having a focusing cup recess 36 provided therein and in which is mounted a filament 38 adapted to be energized via leads 40 from a source of filament power. One of these leads is also suitably connected to a high negative potential. The filament 38 and cup 36 are designed to generate and focus a beam of electrons indicated at 42 upon the target surface portion 30 of the rotating anode. The beam 42 is preferably of approximately rectangular

crosssection with its longer axis extending radially of the tube. The beam 42 is focused to impinge on the target portion 30 of target disk 26 over a predetermined focal area. Preferably the angle of inclination of the target portion 30 is such that as viewed at right angles to the beam 42, such focal area is substantially square. In addition to the electrons striking the desired focal area, primary and secondary electrons strike portions of the anode surface other than the desired focal area. Therefore, spurious X-rays may be generated. However, use is made of a diaphragm 44 capable of screening spurious X-rays. This diaphragm suitably comprises a sheet of molybdenum which is substantially opaque to X-rays. The diaphragm is provided with a central aperture 46 of a size such as to provide a sight of substantially only the desired focal area of the target from a point within a predetermined useful field of the X-rays generated at the focal area. This useful field may be defined by an imaginary cone of X-rays indicated at 48, diverging from the target. The X-rays then pass through a window 50 formed of a material of low atomic number, e.g., beryllium or titanium, each of which is substantially transparent to X-rays. The diaphragm 44 and window 50 are supported in a window assembly 52 including a window support 54, a window support flange 56, and a window flange 58. These window assembly elements are suitably formed of Monel metal and are joined as illustrated to provide a vacuum-tight structure.

In accordance with an important feature of the present invention, window assembly 52 extends through and is supported by a cylindrical metal center section 60 of the tube. The cylindrical metal center section 60 comprises a central cylinder 62 which may be formed of Kovar and which is provided with an outwardly turned axial flange 64 at either end thereof. Window flange 58 of assembly 52 is brazed into a matching aperture located in cylinder 62 opposite the beveled portion of target disk 26 to form a vacuum tight seal with the cylinder 62. Sleeve means join the metal center section to the glass envelope, such means comprising an annular disk sleeve support 66 joined to each flange 64, and a curved sleeve 68 joined as by brazing to each support 66. Both sleeve support 66 and sleeve 68 are suitably Kovar. Sleeves 68 are joined to glass end portions 10 and 12 in the usual manner to provide a glass-to-metal seal therebetween.

Metal shields 70, which may be formed of Monel metal or titanium, are supported between sleeve supports 66 and flanges 64 and extend radially inwardly past sleeves 68 and then curve longitudinally of the tube toward the respective end portions thereof. The shields 70 are positioned between the electrode portion of the tube and the glass-to-metal seals joining sleeve 68 and end portions 10 and 12, to protect these seals and end portions from possible radiation and puncture during high voltage tube operation. Titanium is desirably used for the shields 70 since at moderate temperatures which such shields attain from heat radiating from the anode and electron bombardment, the titanium acts as a getter to help maintain a high vacuum within the envelope.

The structure of the present tube makes possible simplified construction and assembly thereof. No glasswork need be performed on large brazed assemblies, nor is brazing required after glasswork. The glass-to-metal seal between end portions 10 and 12 and the respective sleeves 68 may be entirely formed with the sleeve means substantially detached from the remainder of the assembly. This greatly simplifies the cleaning of the structure subsequent to glasswork. The sleeve supports 66 are welded, e.g., employing heliarc welding, to flanges 64 around the periphery thereof, with the shields 70 positioned in place. It is noted the shields 70 are received within an annular recess 72 in sleeve support 66 where the latter joins to flange 64. The shields can be polished, cleaned and fired independently with respect to the glass and metal seals and also independently of the metal center section.

The foregoing construction also imparts improved mechanical properties and ruggedness as well as improved thermal radiation properties to the high voltage rotating anode tube. The tube is evacuated, sealed, and gettered in the usual manner.

Metal center section 60 positions the window assembly 52 and particularly diaphragm 44 thereof in close proximity to the electron bombarded area or focal area of the target from which the X-rays originate, the window assembly 52 providing a re-entrant structure for the diaphragm with respect to the metal center section. The spacing between the diaphragm 44 and target disk 26 in a typical construction may be on the order of half an inch, while the cylindrical metal center section itself is suitably positioned on the order of about five-eighths of an inch from the peripheral edge of target 26 providing a compact structure. Placement of the diaphragm close to the target provides enhanced radiation collimation of an X-ray beam and results in improved quality radiographs. This close spacing is made possible because the metal center section is not subject to charge buildup as would be the case if the center section were glass. Moreover, although metal tends to become deposited upon the inner side of metal center section 60 because of tungsten evaporation from the filament and focal area, this deposition does not affect the tube's electrical characteristics. Since the metal center section comprises a conducting surface, the deposit of metal thereon has no effect on the electric field configuration surrounding the tube's electrodes.

The metal center section is suitably grounded electrically as indicated, while the cathode and anode, during operation of the tube, are preferably maintained at substantially equal but opposite high voltages on either side of ground. Since the tube center section, including window structure, is electrically grounded, only approximately half the total operating voltage of the tube need be withstood, and therefore the window structure, and particularly diaphragm 44, can be spaced close to the anode without encountering the danger of electrical breakdown.

As an additional advantage of the construction according to the present invention, close placement of diaphragm 44 with respect to the anode makes possible the close spacing of additional external diaphragm means relative thereto. The window structure of the tube according to the present invention is re-entrant providing an apertured well 80 accessible from outside the X-ray tube for receiving variable diaphragm means or the like, such variable diaphragm means forming no part of the present invention. The forward or small end of the variable diaphragm means may then be conveniently insertable within well 80 so as to locate such variable diaphragming means as close as possible to the source of X-rays, thereby enabling enhanced control thereover.

While we have shown and described a preferred embodiment of our invention, it will be apparent to those skilled in the art that many changes and modifications may be made without departing from our invention in its broader aspects. We therefore intend the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

We claim:

1. An X-ray tube comprising:

an envelope comprising opposite end sections of glass and a facing rotary anode and cathode in said envelope said cathode being mounted in one of said sections and said anode mounted in the other of said sections,

a cylindrical metal center section joined to said glass envelope sections and surrounding the facing ends of said anode and cathode in overlapping relation to each,

means for electrically grounding said metal section, said metal section having an outwardly turned flange on each of its opposite ends,

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- a pair of metal sleeve means joined at one end thereof one to each of said glass envelope sections by a glass-to-metal seal, said sleeve means being flared outwardly from the said one end thereof and the opposite end of each having a flange thereon mating with and joined to said flanges of said metal section in vacuum tight relation,
- a pair of annular steel shields within said envelope, said shields having outwardly extending flanges supported immediately between the flanges of said metal center section and the flanges of said metal sleeve means, said shields each curving inwardly and toward the corresponding adjacent end of the envelope and over the adjacent glass-to-metal seal thereby to protect said glass-to-metal seals from bombardment from electrons emanating from said anode and cathode,
- a metal window assembly supported by and extending through the outer wall of said cylindrical metal center section adjacent said rotary anode, said window assembly being provided with a diaphragm comprising a body of material substantially opaque to X-rays, said diaphragm having an aperture therein for the passage of X-rays, said window assembly posi-

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tioning said apertured diaphragm inwardly from the inner wall of said metal center section toward said rotary anode,

and a window of material relatively transparent to X-rays sealed across said window assembly spaced outwardly from said diaphragm on the side of said diaphragm remote from said rotary anode.

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U.S. Cl. X.R.

313—58, 60

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,500,097 Dated March 10, 1970

Inventor(s) John T. Perry and Robert M. Gager

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

┌ In the heading the assignee should be Picker Corporation;
column 2, line 18, change "The" to -- This --; column 3,
line 27, change "poined" to --joined-- and column 5, line 8,
change "steel" to --metal--.

SIGNED AND
SEALED
JAN 19 1971

(SEAL)

Attest:

Edward M. Fletcher, Jr.
Attesting Officer

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Commissioner of Patents