Jan. 23, 1962 Z. J. ATLEE 3,018,398

X-RAY GENERATOR

Filed Oct. 27, 1958 3 Sheets-Sheet 1

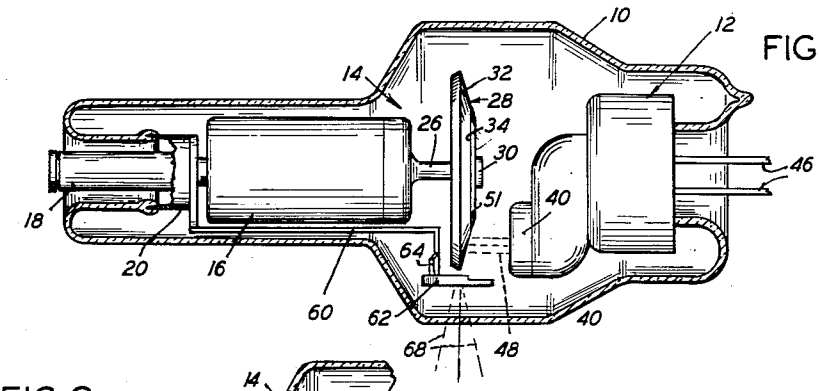


FIG. 1

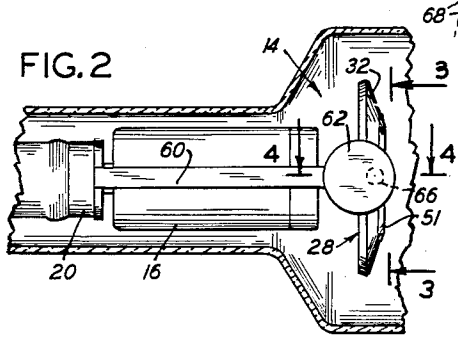


FIG. 2

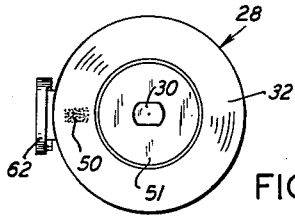


FIG. 3

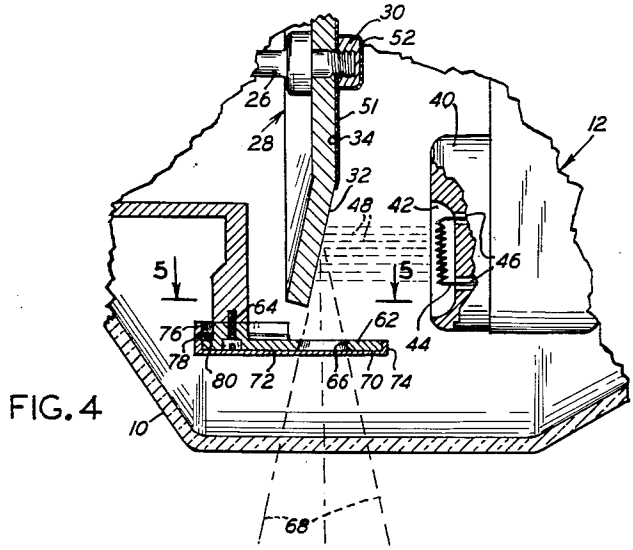


FIG. 4

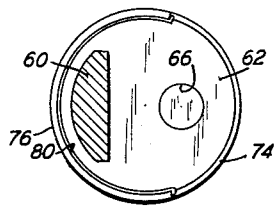


FIG. 5

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X-RAY GENERATOR

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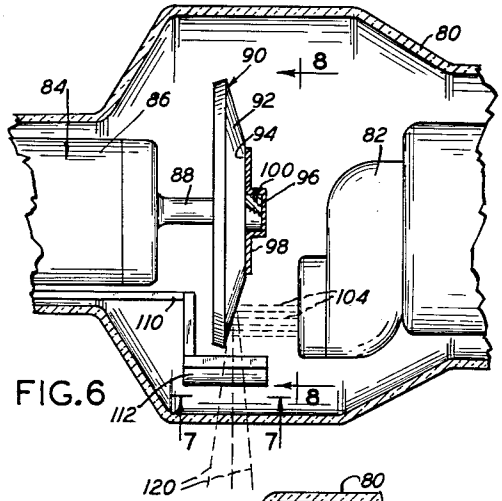


FIG.6

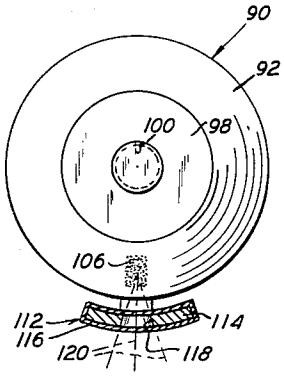


FIG.8

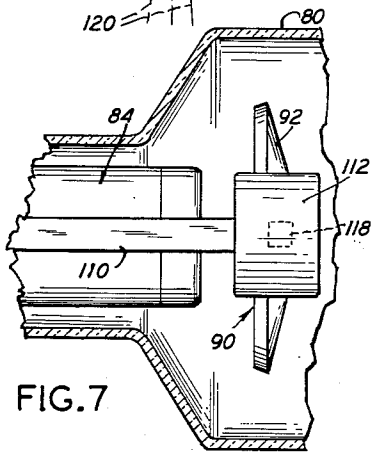


FIG.7

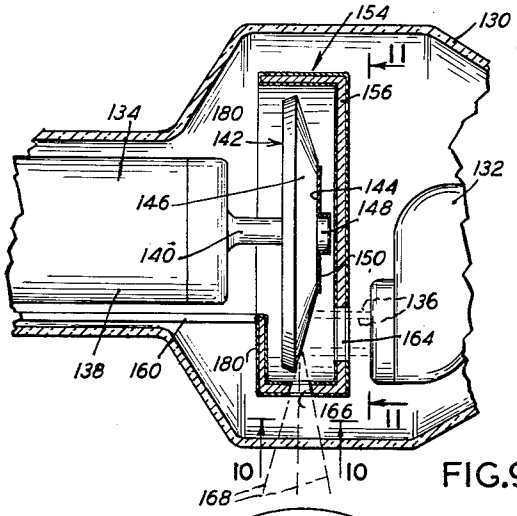


FIG.9

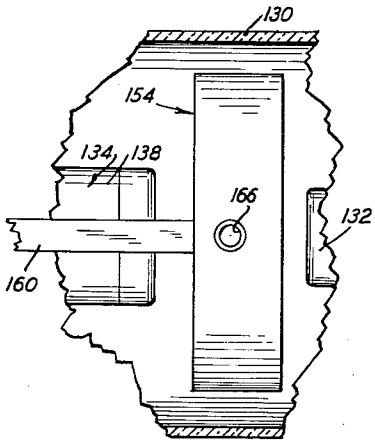


FIG.10

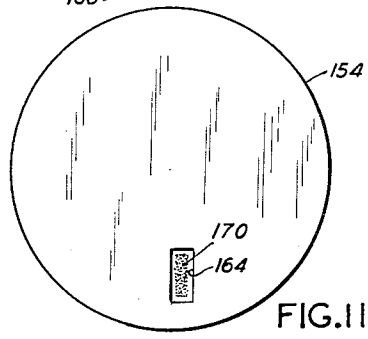


FIG.11

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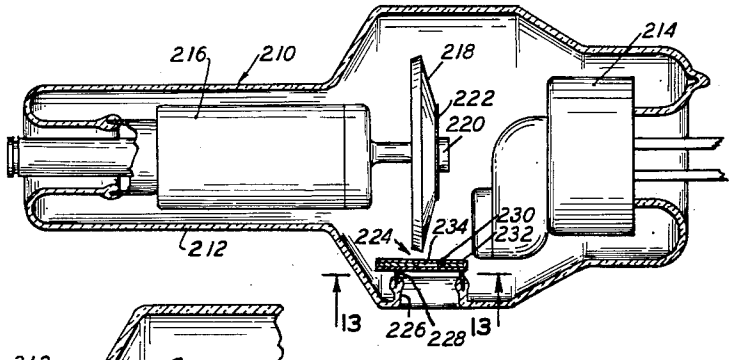
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X-RAY GENERATOR

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FIG. 12



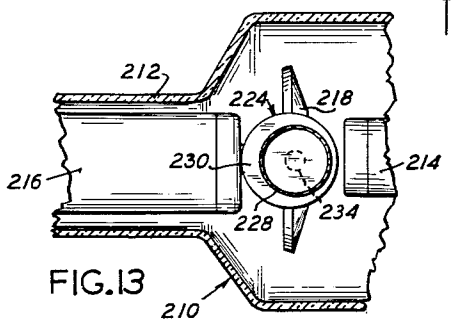


FIG. 13

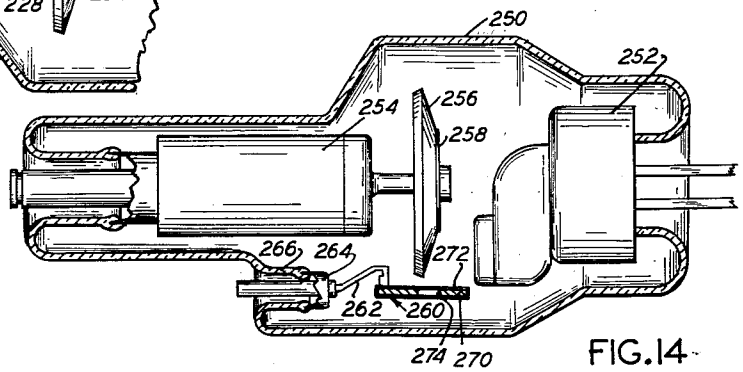


FIG. 14

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X-RAY GENERATOR

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Filed Oct. 27, 1958, Ser. No. 769,651
11 Claims. (Cl. 313—59)

The present invention relates to X-ray generators and more particularly to construction of X-ray generators permitting better definition in the X-ray pictures taken therewith.

To overcome some of the problems attendant with the heating of the anode target in the operation of an X-ray generator, rotating anodes have been used. While such anodes have helped solve the problem of overheating, they have raised an additional problem in trying to secure X-ray pictures of good definition. In the operation of an X-ray generator, some of the primary electrons generated at the cathode are diverted from the desired path and will strike the anode at portions other than within the desired focal area of the electron beam upon the anode to generate undesirably large quantities of spurious X-rays if the material hit is of high atomic number. Also, the heated portions of the generator will give rise to secondary electron emission which will also strike various portions of the anode target giving rise to generation of spurious X-rays. Obviously, to secure the best possible shadow picture of an object being X-rayed, it is desirable to have the source of X-rays as small as possible, a pinpoint source theoretically being the most desirable, but, being, of course, impractical to obtain in an X-ray generator under the present state of knowledge. However, it is possible to form a reasonably small focal area on an X-ray generator target member so that a picture of superior definition could be obtained if the X-rays striking the X-ray sensitive medium were restricted to those from such focal area. Heretofore, however, the spurious X-rays generated by the diverted primary electrons and the secondary electrons as mentioned above have been essentially unrestricted and have been permitted to pass freely from the tube with the result that the definition of the picture being taken has been lessened by reason of the various spurious X-rays striking the X-ray sensitive medium.

It is, therefore, an object of the present invention to provide an X-ray generator in which the X-rays leaving the generator in the direction of an object being X-rayed are limited essentially to those arising from the desired focal area on the anode target.

It is a more specific object of the invention to shield an object being X-rayed from X-rays generated at the target of an X-ray generator other than from those X-rays generated at the desired focal area of the target.

Another specific object of the invention is to provide an X-ray generator with means to shield the anode target member from the diverted primary and secondary electrons so as to prevent origination of spurious X-rays outside of the target area.

Other objects and advantages of the invention will become more apparent hereinafter.

In accordance with an illustrated embodiment of the present invention, a rotating anode type X-ray generator is provided with a diaphragm positioned about the path of the useful beam of X-rays desired to be emitted from the generator. The diaphragm is comprised of a material of high atomic number so that it is substantially opaque to X-rays and is provided with an aperture through which the useful beam of X-rays may pass. Portions of the diaphragm exposed to a view of the object being X-rayed are preferably provided with a lamina or coating of material of low atomic number, such as beryllium, so that such surfaces are shielded from secondary

electrons thus to minimize rise of spurious X-rays from such surfaces. Portions of the anode target member other than that forming the focal area for the electrons preferably are also provided with a coating of low atomic number again to prevent such portions from being a source of spurious X-rays.

For a more detailed description of the invention, reference is made to the following specifications and accompanying drawings wherein:

FIG. 1 is a side elevation partially in section of an X-ray generator made in accordance with the invention;

FIG. 2 is a bottom view of the anode portion of the generator;

FIG. 3 is an end view of the anode target member looking in the direction of the arrows 3—3 of FIG. 2;

FIG. 4 is an enlarged fragmentary sectional view taken substantially along line 4—4 of FIG. 2;

FIG. 5 is a view of the diaphragm member taken along line 5—5 of FIG. 4;

FIG. 6 is a fragmentary side elevation of a modified embodiment of the invention shown partly in section;

FIG. 7 is a fragmentary bottom view of the anode portion of the generator looking in the direction of the arrows 7—7 of FIG. 6;

FIG. 8 is an end view of the target member of the embodiment of FIG. 6 looking in the direction of the arrows 8—8 of FIG. 6;

FIG. 9 is a fragmentary side elevation partially in section of still another embodiment of the invention;

FIG. 10 is a fragmentary elevation of the anode portion of the generator shown in FIG. 9;

FIG. 11 is an end view of the anode taken in the direction of the arrows 11—11 of FIG. 9;

FIG. 12 is a side elevation partially in section of a further embodiment of the invention;

FIG. 13 is a sectional view taken substantially along line 13—13 of FIG. 12; and

FIG. 14 is a side elevation partially in section of still another embodiment of the invention.

Referring first to FIGS. 1 to 5, inclusive, the X-ray generator shown therein comprises an envelope 10 of glass or other suitable material having a cathode 12 mounted at one end thereof and an anode 14 mounted in the other end thereof. The anode 14 is of the rotary type and comprises a rotor body 16 suitably supported by bearing structure (not shown) upon a stem or spindle 18 which extends outwardly of the envelope through a conventional glass-to-metal seal structure 20. Extending from the rotor 16 towards the cathode 12 is a shaft 26 wich supports a target member 28 secured to the shaft by a cap nut 30. The target disc 28 is preferably of tungsten or other metal of high atomic number and the nut 30 and shaft 26 are preferably of molybdenum or other suitable metal having high strength at high temperatures. As will be noted, the target 28 is formed with a peripheral frusto-conical target surface portion 32 and a flat center portion 34 which extends at right angles to the shaft 26.

The cathode 12 is provided with a head portion 40 having a focussing cup recess 42 provided therein in which is mounted a filament 44 adapted to be energized through leads 46 from a suitable source of electrical energy. The filament 44 and cup 42 are designed to generate and focus a beam of electrons indicated at 48, upon the target portion 32 of the anode target 28. The beam 48 is preferably of rectangular cross-section with its longer axis extending vertically as the generator is shown in FIG. 1. The beam 48 is focussed to impinge upon the target area 32 of the rotor 28 over a focal area 50. Preferably, the angle of inclination of the target portion 32 is such that as viewed at right angles to the beam 48, the focal spot 50 is square. This is, of course, utilization of the conventional line-focus principle.

As will be recognized by those skilled in the art, the structure described heretofore is that of a more or less conventional rotating anode X-ray generator or tube. In such tubes, secondary electrons are generated from many sources and strike portions of the anode surface other than the focal area **50**. These secondary electrons give rise to X-rays, some of which will be emitted toward the object being X-rayed. Also, electrons are deflected from the primary beam **48** and strike the anode outside of the target area **50**. It will be apparent that in taking an X-ray picture, the definition of the picture obtained will be dependent upon the smallness of the focal area from which X-rays are emitted. The spurious X-rays generated outside of the focal area in a conventional rotating anode tube, such as from the surface portion **34** and nut **30** of the target and also from the portions of the target immediately adjacent the focal spot **50**, in effect cause an enlargement of the focal area so that the picture obtained loses some of its definition. The X-ray generator of the invention is provided with means to shield the object being X-rayed and the X-ray film from X-rays other than those generated at the focal area so that pictures of improved definition may be obtained.

In accordance with the invention, the surface portion **34** of the target **32** is preferably protected from electron bombardment by a coating **51** of a high temperature material of low atomic number, such as, for example, graphite. The nut **30** is likewise provided with a coating **52** of such low atomic number material. Low atomic number materials, it will be recognized, are poor sources of X-rays so that relatively few X-rays will be generated by electrons which may strike such materials. Furthermore, the coatings serve to stop any electrons impinging thereon to prevent the electrons from reaching the heavy metal beneath the coating. Thus, such coatings substantially eliminate the coated surfaces as sources of X-rays which might otherwise be emitted therefrom.

The generator is also provided wiht a diaphragm means capable of screening off X-rays generated by secondary and diverted electrons on portions of the target surface **32** adjacent the focal area **50**. In the presently described embodiment of the invention, the diaphragm means includes a support arm **60** suitably secured to the stem **18** adjacent the glass-to-metal seal **20**. The arm **60** extends along the rotor body **16** to a point just rearwardly of the target disc **28** at which point it is turned downwardly as the tube is shown in FIG. 1. To the end of the arm **60** is secured a diaphragm disc **62** which consists of a sheet of material of high atomic number, such as tungsten, which is substantially opaque to X-rays. The disc **62** is illustrated as secured to the end of the arm **60** by means of screws **64**, though other suitable means can be used. To provide an aperture through the disc **62** for the X-rays generated at the focal spot **50**, an opening **66** is provided in the disc and which opening is preferably of a size such as to provide a sight of substantially only the focal spot **50** from any point within a predetermined useful field of the X-rays generated at the focal spot **50**. It will be understood that this useful field is defined by an imaginary cone of X-rays, indicated at **68**, diverging from the target focal spot **50**, as shown in FIG. 4. Preferably, the opening **66** is frusto-conical and defines the outline of the useful field **68**. Preferably, a layer or coating of a material of low atomic number is positioned over the face of the disc **62** facing away from the anode target **28** so that secondary electrons cannot reach such surface of the disc and generate interfering X-rays therefrom. In the illustrated embodiment of the invention, the disc **62** is provided with a cover or jacket **70** of a material of low atomic number, such as, for example, beryllium, and which jacket includes a bottom portion **72** which engages against the bottom of the disc **62** and a side wall portion **74** which surrounds the peripheral edge of the disc so as to prevent any access of electrons to the bottom surface of the disc. The jacket may be secured to the disc in any

suitable manner. In the illustrated embodiment, the peripheral edge **74** is provided with an upstanding flange **76** extending about two-thirds of the distance about the periphery and which flange defines a groove **78** for receiving a snap ring **80** which extends over the upper edge of the disc **62** to hold the jacket in position.

Preferably, the diameter of the disc **62** is such as to mask the anode surface from points within the useful field of the generator for a substantial distance around the focal spot **50**. Thus, X-rays from the areas surrounding the focal spot **50** will be cut off with the result that X-ray shadow pictures of superior definition can be obtained.

FIGS. 6, 7 and 8 illustrate a modified embodiment of the invention comprising an envelope **80** in which is mounted in any suitable manner a cathode **82** and a rotary anode **84**. The cathode **82** may be of a construction similar to the cathode **12** described above. The anode **84** comprises a suitably supported rotor **86** from which extends a shaft **88** upon which is mounted a target member **90** of tungsten or like metal of high atomic number capable of producing X-rays when struck with electrons. The target member **90** is formed with a peripheral frusto-conical target portion **92** and a flat center portion **94** which extends at right angles to the shaft **88**. The target member **90** is suitably secured to the shaft **88** as by means of a nut **96**. Mounted on the target member and covering the center portion **94** and the nut **96** thereof is a hat-like covering member **98** formed of graphite or other suitable high temperature material of low atomic number. The hat **98** is suitably secured in position as by a pin **100** extending through the hat into an aperture provided therefor in the nut **96**.

The cathode **82** may be constructed in substantially the same manner as the cathode **12** described above and is provided with means to generate and focus a beam of electrons **104** upon the target portion **92** of the anode target member **90**. The beam **104** is preferably of rectangular cross section with its longer axis extending vertically of the generator as shown in FIG. 6 so as to form a rectangular focal area **106** on the target member as indicated in FIG. 8.

Diaphragm means are provided in the generator including a support arm **110** suitably secured to a stationary portion of the generator and upon which is mounted a diaphragm element **112** which is curved arcuately concentrically of the axis of rotation of the target member **90**. The diaphragm element **112** comprises a sheet-like core **114** of X-ray opaque material such as, for example, tungsten, encapsulated in a material of low atomic number, such as beryllium, graphite, boron or other poor X-ray generating material, indicated at **116**. The core **114** is provided with an aperture **118** to permit the transmission of a useful field of X-rays from the focal area **106** of the anode, such field being indicated by the dotted lines **120**. While the aperture **118** may be circular in outline, as shown in the previously described embodiment and which shape facilitates manufacture, preferably, the aperture is square in outline as indicated in FIG. 7 so as to conform to the projected shape of the focal spot **106**.

As will be apparent, the hat **98** will shield the center portion **94** and the nut **96** of the anode from electrons so as substantially to eliminate such portions as sources of spurious X-rays. The diaphragm element **112** will in turn screen off portions of the target member adjacent the focal area **106** from the sight of the useful field, thus to secure better definition in the resulting picture as described hereinabove. The curved configuration of the diaphragm **112** is of advantage in maintaining a more uniform electrical field within the tube so as to cause less deflection of electrons from the electron beam **104** and substantially to eliminate arcing between the diaphragm and the envelope **80**. The curved diaphragm also increases the area of X-ray protection which is extremely desirable from a safety standpoint.

Reference is now made to FIGS. 9, 10 and 11 which

illustrate a still further embodiment of the invention. In these views, there is shown an X-ray tube comprising an envelope **130** having a cathode **132** suitably supported at one end and a rotary anode **134** in the opposite end thereof. The cathode **132** is provided with a focussing cup and electron generating filament of the type described above for generating and focussing a beam of electrons **136** upon the target member of the anode **134**. The anode **134** includes a rotor body **138** from which extends a shaft **140** for supporting a target member **142** of tungsten or like material capable of generating X-rays efficiently when bombarded with electrons. The target member **142** is formed with a flat center portion **144** which is normal to the axis of rotation of the target member and with a surrounding frusto-conical target portion **146** upon which the electron beam **136** is focussed. The target portion **146** extends obliquely with respect to the axis of the beam **136** so as to utilize the line-focus principle. The target member **142** is secured to the shaft **140** by means of a cap nut **148**. The surface of the center portion **144** and the nut **148** preferably are provided with a coating **150** of a high temperature material of relatively low atomic number having relatively poor X-ray generating efficiency, an example of such material being graphite. Other suitable materials will be apparent to those skilled in the art. Disposed about the target member **142** is a hood means **154** comprising a cup-shaped body **156** of material, such as, for example, tungsten, relatively opaque to X-rays. The body **156** is mounted coaxially of the target member **142** with the closed end of the body facing the cathode **132**. The body **156** is supported on an arm **160** suitably secured to a stationary portion of the tube structure, such as, for example, in the manner of the support of the arm **60** in the first described embodiment. The body **156** is provided with an opening **164** through which the electron beam **136** may pass and is also provided with an aperture **166** for the passage of a useful beam of X-rays **168** generated at the focal spot **170** of the electron beam **136** on the target portion **146**. Preferably, the aperture **166** is of a size not substantially greater than that necessary to provide a sight of the focal spot **170** from any point within the desired useful field of the tube. This field is, of course, as mentioned above defined by an imaginary cone diverging from the focal spot **170** in the direction at right angles to the electron beam **136**.

To prevent the generation of X-rays from the exterior surface of the hood **156** from those portions visible from the useful field of the tube, such surface portions preferably are provided with a coating of a material of low atomic number, such as beryllium, graphite or boron. Preferably, as in the illustrated embodiment the entire hood is encapsulated in such low atomic number material, the encapsulating coating being indicated in FIG. 8 at **180**.

The hood **154** will, of course, afford more complete X-ray protection for personnel. In addition, the hood will more completely shield the X-ray field of the tube from all portions of the target member except that viewed through the aperture **166** with the result that better definition will be secured. Further, better voltage gradients are formed in the tube and which is of particular concern in higher voltage ranges.

Illustrated in FIGS. 12 and 13 is a tube **210** comprising an evacuated envelope **212** of glass or other suitable material within which is mounted a cathode **214** and a rotary anode **216** comprising a target member **218** constructed substantially as those hereinbefore described. The flat center portion of the target member and the securing nut **220** preferably are provided with a coating **222** of graphite or other suitable high temperature material of low atomic number.

Mounted in the path of the useful X-ray beam from the target member **218** is a diaphragm element **224** defining a window in the envelope **212**. As best shown in FIG. 12, the envelope **210** is formed with an inwardly turned cylindrical neck **226** to which is secured by a suitable glass-to-metal seal a mounting ring **228** of suitable metal, such as Kovar. The diaphragm element **224** comprises a disc **230** of X-ray opaque material, such as, for example, tungsten encapsulated in a vacuum tight envelope **232** of an X-ray transparent material of low atomic number, such as, for example, beryllium. The disc **230** is provided with an aperture **234** to permit the transmission of a useful field of X-rays from the focal area of the target member **218**. The diaphragm element **224** is secured to the mounting ring **228** by suitable means such as brazing so as to provide a vacuum tight seal. As will be observed, the aperture **234** is positioned in off center relation with respect to the disc **230** and the diaphragm element **224** is mounted in off center relation with respect to the ring **228** with respect to which the aperture **234** is centered, so that the diaphragm element extends rearwardly of the target member **218** a substantial distance. This construction is preferred to provide a maximum amount of X-ray protection with a disc of given diameter while maintaining the disc in spaced relation with respect to the cathode **214** and which is desired, of course, by the voltage differences between the cathode and anode.

As will be apparent, the coating **222** will minimize the generation of X-rays from the central portion of the target member while the diaphragm element **224** will screen off substantially all of the X-rays generated at portions of the target surface other than at the focal area.

Still another arrangement for supporting a diaphragm element in accordance with the invention is shown in FIG. 14. The tube therein illustrated comprises an envelope **250** of glass or other suitable material within which is suitably mounted a cathode **252** and rotary anode **254** having a target member **256** which may be provided with a protective coating **258** of low atomic number over its central portion as previously described to minimize X-ray generation from such portion. Mounted in the path of the useful X-ray beam is a diaphragm element **260** supported upon an arm **262** secured to and supported by the envelope through means of a glass-to-metal seal **264** fixed to a neck **266** in the envelope wall. The diaphragm element includes a disc **270** of X-ray opaque material such as tungsten which preferably is encapsulated within an outer layer **272** of a poor X-ray generating material of low atomic number such as, for example, beryllium, graphite or boron. The disc **270** is provided with an aperture **274** to permit the transmission through the diaphragm of a useful beam of X-rays. As will be apparent, the cap **258** will minimize the number of X-rays generated at the center portion of the target and the diaphragm element **260** will screen off substantially all of the X-rays generated from the target surface at portions other than the focal area.

Having illustrated and described the preferred embodiments of the invention, it should be apparent to those skilled in the art that the invention permits of modifications in arrangement and detail. I claim as my invention all such modifications as come within the true spirit and scope of the appended claims.

I claim:

1. An X-ray tube comprising an envelope, a cathode and a rotary anode mounted in opposite ends of said envelope, diaphragm means spaced from said anode and disposed in the path of the useful X-ray beam from said anode, said diaphragm means comprising a body of a material substantially opaque to X-rays having an aperture therethrough for the passage of said X-ray beam, said aperture being of a size such as to provide a sight of substantially only the focal spot of said anode from any point from within a predetermined useful field of the X-rays generated at said focal spot, said body extending radially of such opening by a distance such as to obscure substantially all of the remainder of said target

portion from any point within said useful field, means supporting said body with said aperture concentric of said X-ray beam, and means for shielding the surface of said body facing away from said anode from bombardment by secondary electrons comprising a lamina of a material of low atomic number disposed adjacent to and covering said body surface.

2. In an X-ray tube comprising an envelope, a cathode and an anode mounted in opposite ends of said envelope, diaphragm means disposed in the path of the useful X-ray beam from said anode, said diaphragm means comprising a flat disc of a material substantially opaque to X-rays having an aperture therethrough for the passage of said X-ray beam, means supporting said disc with the same disposed substantially at right angles to the axis of said X-ray beam and with said aperture concentric of said X-ray beam, and means for shielding the surface of said disc facing away from said anode and the peripheral edge thereof from bombardment by secondary electrons comprising a cup-shaped jacket of a material of low atomic number, said jacket including a bottom portion engaging said disc surface and a side wall portion surrounding said disc peripheral edge, means securing said disc and jacket together.

3. An X-ray tube comprising a rotary anode and a cathode, said cathode having means for generating and focussing an electron beam of rectangular cross section upon said anode, said anode comprising a target portion extending obliquely with respect to said electron beam axis at such an angle that a substantially square projection of the target focal spot is obtained at right angles to the direction of said beam, and diaphragm means disposed adjacent but spaced from said target member and defining an aperture square in outline symmetrically disposed about said projection, said diaphragm means comprising a body of material relatively opaque to X-rays, said aperture being of a size such as to provide a sight of substantially only said focal spot from any point within a predetermined useful field of the X-rays generated at said focal spot, said body extending radially of such opening by a distance such as to obscure substantially all of the remainder of said target portion from any point within said useful field, said diaphragm means comprising a lamina of a material of low atomic number on the surface of said body facing an object being X-rayed.

4. In an X-ray tube, a cathode for generating a beam of electrons, an anode comprising a target member supported for rotation about an axis parallel to but displaced from the longitudinal axis of said electron beam, said target member including a center portion presenting a surface normal to said axis of rotation and a surrounding frusto-conical target portion extending into the path of said electron beam, said target portion extending obliquely with respect to said electron beam axis, said target member comprising a body of metal of relatively high atomic number having relatively high X-ray generating efficiency, said center portion having a coating thereon of a material of relatively low atomic number having relatively poor X-ray generating efficiency, and diaphragm means disposed closely adjacent said target member, said diaphragm means comprising a body of material relatively opaque to X-rays and provided with an aperture for the passage of a useful beam of X-rays from the focal spot on said target portion, said aperture being of a size not substantially greater than that necessary to provide a sight of said focal spot from the normal useful field of said tube, said diaphragm means having a lamina of a material of low atomic number on the surface of said body facing an object being X-rayed.

5. In an X-ray tube, a cathode for generating a beam of electrons, an anode comprising a target member supported for rotation about an axis parallel to but displaced from the longitudinal axis of said electron beam, and hood means disposed about said target member, said hood means comprising a cup-shaped body of material relatively opaque to X-rays mounted coaxially of said target member with the closed end of said body facing said cathode, said closed end being provided with an opening for said electron beam, the side wall of said cup being provided with an aperture for the passage of a useful beam of X-rays, said aperture being of a size not substantially greater than that necessary to provide a sight of the focal spot of said electron beam on said target portion from the predetermined useful field of said tube, said hood body having a lamina of a material of low atomic number on the surface portions thereof in sight from said useful field.

6. In an X-ray tube, a cathode for generating a beam of electrons, an anode comprising a target member supported for rotation about an axis parallel to but displaced from the longitudinal axis of said electron beam, said target member including a center portion presenting a surface normal to said axis of rotation and a surrounding frusto-conical target portion extending into the path of said electron beam, said target portion extending obliquely with respect to said electron beam axis, said target member comprising a body of metal of relatively high atomic number having relatively high X-ray generating efficiency, said center portion having a coating thereon of a material of relatively low atomic number having relatively poor X-ray generating efficiency, and hood means disposed about said target member, said hood means comprising a cup-shaped body of material relatively opaque to X-rays mounted coaxially of said target member with the closed end of said body facing said cathode, said closed end being provided with an opening for said electron beam, the side wall of said cup being provided with an aperture for the passage of a useful beam of X-rays, said aperture being of a size not substantially greater than that necessary to provide a sight of the focal spot of said electron beam on said target portion from the predetermined useful field of said tube, said hood body having a lamina of a material of low atomic number on the surface portions thereof in sight from said useful field.

7. In an X-ray tube, a cathode for generating a beam of electrons, an anode comprising a target member supported for rotation about an axis parallel to but displaced from the longitudinal axis of said electron beam, said target member including a center portion presenting a surface normal to said axis of rotation and a surrounding frusto-conical target portion extending into the path of said electron beam, said target portion extending obliquely with respect to said electron beam axis, said target member comprising a body of metal of relatively high atomic number having relatively high X-ray generating efficiency, said center portion having a coating thereon of a material of relatively low atomic number having relatively poor X-ray generating efficiency, and hood means disposed about said target member, said hood means comprising a cup-shaped body of material relatively opaque to X-rays mounted coaxially of said target member with the closed end of said body facing said cathode, said closed end being provided with an opening for said electron beam, the side wall of said cup being provided with an aperture for the passage of a useful beam of X-rays, said aperture being of a size not substantially greater than that necessary to provide a sight of the focal spot of said electron beam on said target portion from the predetermined useful field of said tube, said hood body being encapsulated in a material of low atomic number.

8. An X-ray tube comprising a rotary anode and a cathode, said cathode having means for generating and focussing an electron beam of rectangular cross section upon said anode, said anode comprising a target portion extending obliquely with respect to said electron beam axis at such an angle that a substantially square projection of the target focal spot is obtained at right angles to the direction of said beam, and diaphragm means disposed adjacent said target member and defining an aperture symmetrically disposed about said projection, said diaphragm means comprising a body of material rela-

tively opaque to X-rays, said aperture being of a size such as to provide a sight on said anode of substantially only said focal spot from any point within the useful field of the X-rays generated at said focal spot, said diaphragm body being disposed concentrically with respect to the axis of rotation of said anode, the surface portions of said body within sight of said useful field being provided with a lamina of a material of low atomic number so as to shield such surface portions from impinging electrons.

9. An X-ray tube as set forth in claim 1 wherein said rotary anode includes a supporting spindle fixedly sealed to said envelope, and said means supporting said diaphragm means comprises an arm secured at one end to said spindle and at its other end to said diaphragm means.

10. An X-ray generator comprising a sealed envelope, a rotary anode and a cathode within said envelope, said envelope comprising a tubular glass portion surrounding said anode, said portion having an opening therein surrounding the path of the useful beam of X-rays from said anode, a metal mounting ring sealed to said envelope about said opening and extending from the envelope toward said anode, and diaphragm means sealed to the end of said ring adjacent said anode, said diaphragm means comprising a disc of a material of high atomic number

and relatively opaque to X-rays, said disc being encapsulated in a vacuum tight envelope of low atomic number and relatively transparent to X-rays, said disc having an aperture therethrough for the passage of a useful beam of X-rays.

11. An X-ray generator as set forth in claim 1 wherein said envelope comprises a tubular glass portion having an opening therein adjacent the path of the useful beam of X-rays from said anode, a metal arm extending through said opening, a metal mounting ring sealed to said envelope about said opening and to said arm and supporting said arm, and diaphragm means secured to said arm and supported thereby in the path of the said useful beam of X-rays.

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