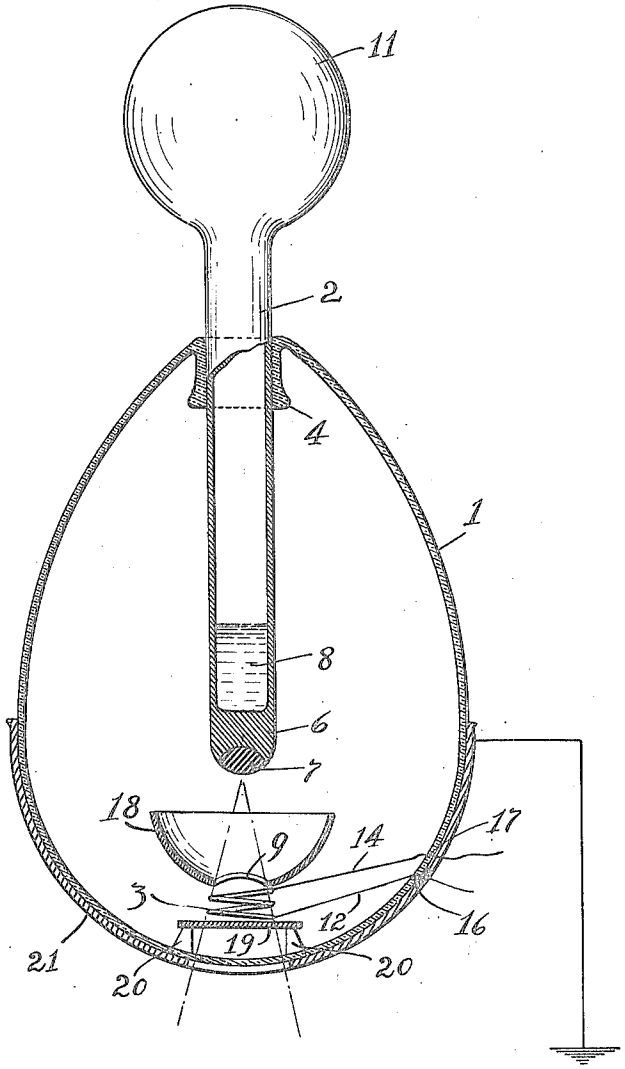
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M. MORRISON

X-RAY TUBE

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INVENTOR

MONTFORD MORRISON

BY

J. F. Elwork

ATTORNEY

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MONTFORD MORRISON, OF NEW YORK, N. Y.

X-RAY TUBE.

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The present invention relates to vacuum devices and more particularly to certain improvements in apparatus for the generation of Roentgen or X-rays.

An object of the invention herein described is the provision of a more powerful X-ray apparatus.

Another object of the present invention is the provision of an X-ray device which will afford safety both to an operator of the device and to a patient exposed to the action of the same.

Another object of the present invention is the provision of an X-ray device which will produce clear definition in a radiograph.

A further object of this invention is the provision of a more durable X-ray tube.

Other objects of this invention will be apparent from the following description.

In the continuous advance of the X-ray art it is desirable to construct increasingly more powerful X-ray generating units. Previous X-ray devices have been limited in voltage by reason of the excessive stresses set up by electrostatic fields resulting from the very high voltages required in modern high powered X-ray tubes. These stresses result in strains which finally end in a puncturing of the enclosing envelope and thereby terminate the usefulness of the device. The failure of an X-ray tube in such manner is not only uneconomical but may prove injurious to persons in the vicinity of the tube.

In the past, accidents of a serious and even fatal nature have resulted from an improper construction of X-ray tubes. This applies particularly to patients in the process of being subjected to X-rays. In the use of a tube of the present invention, such dangers are materially reduced.

X-ray tubes of the prior art have been objectionable, especially for therapeutic purposes, in that the X-radiation therefrom has been heterogeneous. It is known that radiation from an X-ray tube contains rays of different hardness, that is to say, rays of varying penetrative power. For certain purposes, the hard rays alone are necessary and desirable; in such cases it is highly desirable to eliminate the soft rays. An instance of such a requirement may be cited as being existant in the therapeutic use of X-rays where it is desirable to treat deep-seated tissue, in which case hard rays are necessary; however, a simultaneous generation of the softer rays reach the more superficial layers of tissue and it is known that these have a burning action on the same.

It will, therefore, at once be appreciated that these softer rays should be eliminated and it will be apparent from the following description that I have devised means for preventing the prejudicial action of the same. This and other novel features and benefits of my invention will be explained in connection with the description of the accompanying drawing, the single figure of which is a sectional side elevation of an X-ray tube embodying my invention.

Referring to the drawing, the X-ray tube shown is provided with an evacuated sealed envelope 1 consisting, for example, of glass suitable both from the mechanical standpoint and for the transmission of X-rays and into which are sealed a high-tension electrode 2 and a cathode 3 having their vertical axes coincident with the corresponding axis of the envelope. The form of the envelope provided for the X-ray tube of the present invention is a novel feature in X-ray devices, and valuable results are obtained by the use of such an envelope. The bulb is of such configuration that its surfaces substantially conform to the lines of force representing the electric field in which it is disposed and, by possessing properly proportioned radii of curvature and being symmetrical with respect to the vertical axis and to the electrodes (as shown), it avoids the concentration of such field at a point and the consequent liability of the glass to puncture. When made in such manner, higher voltages may be used, whereby more powerful X-rays may be generated than in prior devices. Further, a smaller bulb may be used for an X-ray tube of given input and this affords advantages and economies over devices of the prior art.

It will be apparent that the form of the bulb, preferably being substantially that of an ovoid, with all outer surfaces convex and its axis in line with the electrodes, will vary somewhat with different conditions of use and it is to be understood that the exact form of the bulb is not confined to the outline shown in the drawing, which is illustrative only.

The position of the anti-cathode 2, which is preferably a hollow cylinder of refractory material, such as tungsten or molybdenum, and which is sealed into the envelope 1 by means of the press 4, is a feature of the present X-ray tube; being directed away from the object of the X-rays, there is little dan-

ger of personal injury resulting from contact with a high-potential electrode. The anti-cathode 2 is further characterized by the novel form of its lower end 6 which forms a target where X-rays are generated. The form of target provided in a tube of the present invention and hereinafter described, overcomes a defect in previous X-ray targets by which a portion thereof was in danger of melting when the X-ray tube was run at an over load. This liability of fusion occurred particularly at the thin edge of the anti-cathode which resulted from truncation of this member at an angle to its longitudinal axis. The surface of the target 6, from which X-rays originate, is given, according to the present invention, a convex surface which may be hemispherical. That is to say, the surface connecting the body of the anti-cathode with its target is preferably continuous so as to be free from sharp angles. Integrally affixed to the target 6 is a body of refractory metal 7, such as tungsten, which constitutes the focal spot or point of origin of the major portion of X-rays. Preferably, the focal body 7 is inset so that its surface forms part of the hemispherical surface of the target.

As stated above, the electrode 2 may be a hollow cylinder, and it is so formed for the purpose of cooling the target which may become excessively hot when the tube is in operation. Cooling of the target may be effected by means of a circulation of water or a fluid such as a gas or a vapor contained in the cylinder, whereby heat is dissipated from the target by convection currents of the fluid. As one form of such heat-dissipating means, I may introduce into the cylinder a quantity of mercury 8, vapor from which ascends to the portion of the electrode which is outside the bulb and is condensed in a radiator 11. The radiator has sufficient surface to remain, during the operation of the X-ray tube, at a temperature sufficiently low to condense the vaporized mercury, which, after condensation, falls back into the pool of liquid mercury 8.

Opposite the target 6 and having its axis coincident with the vertical axis of the X-ray tube, is a filamentary electron-emitting element 3 adapted to be heated electrically and consisting, in this case, of a helix (3) of tungsten, tantalum or other material. It is connected to lead-in wires 12 and 14, either one of which may be grounded, and which are sealed respectively into the envelope 1 at 16 and 17. The wires 12 and 14 are connected to a source of current such as a battery or a transformer.

Interposed between the target 6 and the cathode 3 is a focusing cup 18 disposed with its concave surface facing the electrode 2 and provided with an aperture 9, the center of which is in alignment with the axis of the helical cathode 3 to permit the free passage of X-rays emanating from the focal spot 7. The focusing cup may be supported in any desirable manner obvious to those skilled in the art. In the present embodiment of this invention, the perimeter of the opening 9 is less than the inner circumference of the helix 3. The position and size of the opening are such that only the rays originating in the focal spot pass through, while rays generated in other portions of the target are substantially intercepted by the focusing cup. This elimination of the rays coming from parts of the target other than the focal spot is a highly desirable improvement in that clearer images are secured of the object radiographed. The focusing cup 18, as a secondary function, also serves as a shield to prevent metallic particles which are emitted from the target 6 from being thrown against the glass envelope to cause the possible puncture of the same. The focusing device 18, which may be of molybdenum, may assume various forms and the particular form shown, namely a hemispherical shell, is illustrative only, and it may or may not be electrically connected to the cathode 3 in addition, the focusing device intercepts stray electrons emanating from the anti-cathode.

As above explained, it is frequently desirable to secure X-radiations of uniform intensity and this may be attained by absorbing the softer rays before they reach the object of such rays. To this end I place in the path a screen capable of eliminating the undesirable rays. Such screen is shown at 19 and it may consist of a metallic plate of a material such as aluminum and may be supported in any practical manner such, for example, as by supporting means 20. The ray screen or filter 19 serves an additional function in preventing sputtered metallic particles from coming into contact with the glass envelope to the possible damage of the latter.

Interposed between the high-tension electrode 2 and the object of the X-rays, and preferably attached to the lower portion of envelope 1, is a metallic shield or coating 21 shown as a dished plate, preferably conforming substantially to the envelope, in this embodiment, being shown substantially hemispherical and having an opening 22 to permit a free passage of the X-radiation coming from the focal spot. The shield is electrically grounded and performs the function of a protective device for personal safety. And it has further utility in that the tube may be mechanically associated with its auxiliary apparatus by means of attachment to said shield, thus avoiding the previous rather dangerous method of supporting the tube from a high-potential electrode by which the electrostatic lines of force were diverted and thereby caused excessive strains in the envelope. The present method of supporting

the device is such that the lines of force are not interfered with and the liability of the tube to puncture is thus materially lessened.

The lead 12 to the cathode 3 is shown passing through an aperture in the shield 21 and being insulated therefrom by a suitable bushing. The lead 14 to the cathode may be grounded in some other way, but preferably passes through the shield 21 in electrical contact therewith, as shown.

While I have herein illustrated and described one embodiment of my invention, it is apparent that many modifications thereof may be devised without the exercise of the inventive faculty and such modifications are to be considered as part of this invention, as set forth in the appended claims.

What is claimed is:

1. An X-ray device comprising an envelope of ovoidal configuration, an anti-cathode sealed in the small portion of said envelope and a cathode and focusing device disposed in the larger portion of said envelope, the shape of said envelope conforming substantially to the lines of force representing the electrical field between the cathode, focusing device and anti-cathode.

2. An X-ray device comprising an evacuated envelope enclosing a cathode and a target, common means affording personal protection and support for the envelope which consists of a grounded electro-conductive shield associated as a coating on the envelope and electrically connected to the cathode.

3. An X-ray device comprising an envelope, a target formed with a convex surface, a cooperating electron-emitting cathode, means for focusing the electron stream, means for absorbing undesirable portions of the X-radiation and a grounded electro-conductive shield conforming to the shape of the bulbous portion of the envelope.

4. An X-ray device comprising an envelope having such radii of curvature that excessive electrostatic strains are avoided, an electron-emitting cathode, an anode for emitting X-rays, means for focusing the electron stream between the cathode and the anode, means for absorbing undesirable X-rays and a grounded electro-conductive shield conforming to the shape of the bulbous portion of the envelope and serving to afford personal protection and to support the device.

5. An X-ray device comprising an envelope, an electron-emitting cathode, an X-ray-emitting target provided with a convex working surface, a heat conductive stem in one end of which said target is secured, the exposed surface of said target and the end of said stem merging to form a rounded surface, means for focusing the electron stream and means for absorbing undesirable X-rays, and both disposed in the path of the useful X-rays.

6. An X-ray device comprising an envelope enclosing a cathode and an anode, an X-ray target mounted in one end of said anode, said anode end and the exposed surface of said target merging and being rounded.

7. An X-ray device comprising an envelope, a thermionic electron-emitting cathode and a cooperating anti-cathode, a substantially hemispherical focusing device for the electrons, said focusing device being positioned with respect to said anticathode as to extend to each side thereof to such a distance as to prevent sputtered particles from the anticathode striking the envelope.

8. An X-ray device comprising an envelope, an electron-emitting cathode formed as a helix having an opening of substantial size therethrough and a cooperating X-ray-emitting anode, generating useful X-rays which pass through the electron-emitting cathode, substantially along the axis thereof.

9. An X-ray device comprising a substantially ovoid envelope enclosing electrodes and conforming to the electrical field between said electrodes, the longitudinal axes of which substantially coincide with the axis of the envelope, one of said electrodes serving to emit X-rays, and a substantially hemispherical focusing device located between the electrodes and extending beyond the sides of the X-ray emitting electrode to such an extent as to prevent sputtered material therefrom striking the walls of the envelope.

10. An X-ray device comprising an envelope in substantially the form of an ovoid with its axis vertical, a substantially helical electron-emitting cathode, the axis of which substantially coincides with the axis of the envelope, a target mounted opposite the cathode and presenting a convex surface toward the cathode and a focusing device so disposed with respect to said target as to shield the envelope from sputtered electrode material.

11. An X-ray device comprising an evacuated envelope ovoid in shape, an electron-emitting cathode formed as a helix, an X-ray emitting target located along the axis of the cathode and discharging useful X-rays along said axis and through the cathode, a curved shield between the anode and cathode serving to focus the electron stream and a curved shield conforming in shape to the envelope, closely embracing the lower portion thereof, serving as a support therefor and provided with an opening in its lower portion for allowing useful X-rays to pass therethrough.

12. An X-ray device comprising an evacuated envelope, an electron-emitting cathode, an X-ray-emitting target located along the axis of the cathode and sending useful X-rays along said axis and through an aperture in the cathode and a shield between the anode and cathode serving to focus the electron stream from the cathode and a shield conforming substantially in shape to the envelope at the lower portion thereof and serving as a support therefor.

13. An X-ray device comprising an evacuated envelope, an electron-emitting cathode formed with an aperture therethrough, an X-ray-emitting target located so that it will discharge useful X-rays along the line between said cathode and target, a shield between the anode and cathode presenting a concave surface toward the anode and electrically-connected to the cathode so that it serves to focus the electron stream and a curved shield closely embracing the lower portion of the envelope when in a normal position and provided with an opening at its lower portion for allowing useful X-rays to pass therethrough, said shield being grounded for the protection of persons using the device.

14. An X-ray device comprising an evacuated envelope substantially symmetrical in shape with respect to its longitudinal axis and with all surfaces of large radii of curvature, an electron-emitting cathode therein, an X-ray emitting cathode therein located on the longitudinal axis of the envelope, an X-ray-emitting target located on said axis and emitting the bulk of the X-rays generated along said axis so that they pass through the cathode, a focusing shield between the anode and cathode presenting a concave surface toward the anode and adapted to protect the envelope from sputtered material and a grounded shield substantially conforming in shape to the lower part of said envelope on the exterior thereof and serving as a support for the same, said shield being provided with an aperture in line with the longitudinal axis of the tube for allowing useful X-rays to pass therethrough.

15. An X-ray device comprising an envelope, an X-ray emitting anode and a filamentary electron-emitting cathode therein, said cathode being substantially circular in form and having an opening in the center of sufficient size and disposed with respect to said anode in such manner as to permit a solid beam of X-rays to pass therethrough.

16. An X-ray device comprising an envelope, and X-ray emitting anode and a filamentary electron-emitting cathode therein, said cathode being composed of at least one turn of wire and so arranged with respect to said anode as to permit a solid beam of X-rays to pass therethrough.

17. An X-ray device comprising an envelope, an X-ray emitting anode and an electron-emitting cathode, said cathode comprising a plurality of turns of wire in the form of a helix having an opening between the turns thereof through which a solid beam of X-rays is permitted to pass.

18. An X-ray device comprising an envelope, an X-ray emitting anode and a filamentary electron-emitting cathode, the longitudinal axis of said anode and cathode being coincident, said cathode being substantially circular in form and having an opening of sufficient size to permit a solid beam of X-rays to pass therethrough.

19. In an X-ray tube, an anti-cathode comprising a body of metal and a target of good X-ray emitting material in the end thereof, the end of the anticathode being rounded and the exposed surface of the target forming a part of said rounded end.

20. In an X-ray tube, an anti-cathode comprising a body of metal and a target of good X-ray emitting material inset in the end thereof, the surface of said target being convex and merging with the surface of said body so as to form a continuous unbroken surface.

21. In an X-ray tube, an electron-emitting cathode and an X-ray emitting anode, said anode being composed of a body of suitable target material embedded in a second body of material of higher heat conductivity and said second body having a form free from sharp angles, whereby the tendency of said second body to soften in restricted parts is reduced.

22. An X-ray device comprising an envelope, means for generating X-rays including electrodes, means for absorbing undesirable portions of the X-rays and a grounded electro-conductive curved shield mechanically and conductively connected with one of said electrodes so as to be at the same potential thereof, said shield being fitted around and in close proximity to that portion of the envelope containing the electrode to which said shield is connected.

23. An X-ray device having a cooperating cathode and anode producing an ovoidal field, comprising an envelope shaped substantially as an ovoid, the major axis of which substantially coincides with the axis of the electrodes.

24. An X-ray device comprising an envelope, a thermionic cathode, a cooperating anticathode, and a substantially hemispherical shell-like focussing device, said focussing device being of large diameter and extending beyond the sides of said anti-cathode to such an extent as to prevent stray electron bombardment of the walls of the envelope.

25. An X-ray device comprising an envelope having a shape conforming substantially to the shape of the electrical field therein, an electron-emitting cathode, a target generating X-rays by cooperation with said electron-emitting cathode, which cathode encircles the useful X-rays generated and means for focusing the electron stream comprising an annular member between the target and the cathode.

In testimony whereof, I have hereunto subscribed my name June 7, 1921.

MONTFORD MORRISON.