Aug. 4, 1942. B. CASSEN 2,291,948

HIGH VOLTAGE X-RAY TUBE SHIELD

Filed June 27, 1940

Fig. 1.

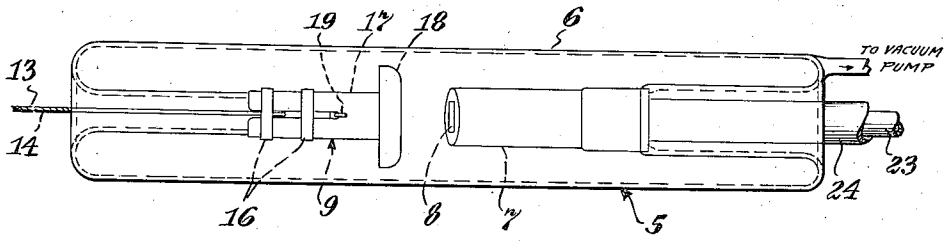


Fig. 2.

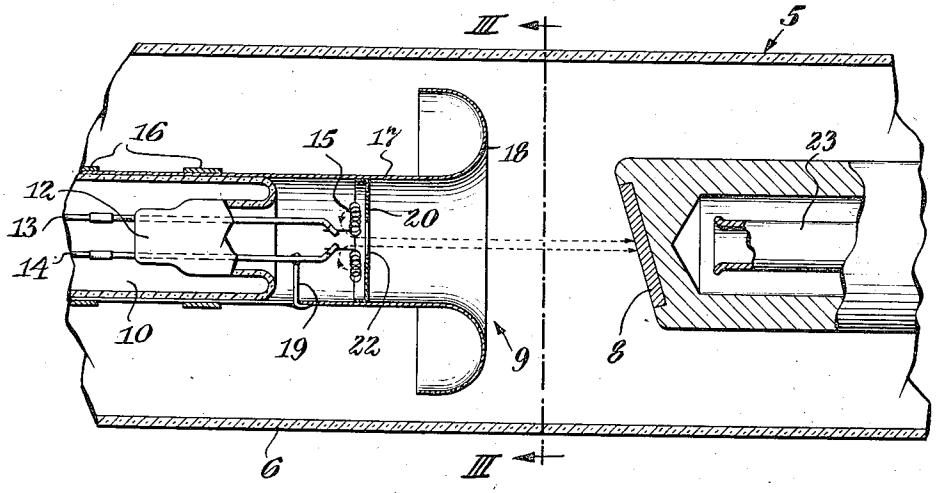
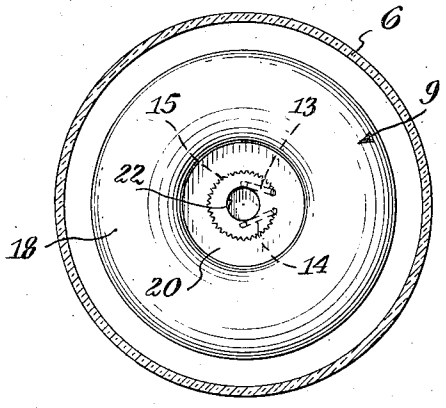


Fig. 3.



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HIGH VOLTAGE X-RAY TUBE SHIELD

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4 Claims. (Cl. 250—145)

The present invention relates to X-ray tubes and particularly to such tubes operable at exceedingly high voltages.

High voltage X-ray tubes are being used more and more extensively by the medical profession for therapeutical treatments. Although there appears to be two schools of thought as to the therapeutical value of high voltage X-rays for therapeutical treatment, nevertheless one theory is that the higher the voltage, the greater the therapeutical effect since the X-rays have a greater degree of penetration.

To this end the voltages applied to X-ray tubes now approximate one million volts and higher. When tubes are operated at this voltage, they must be connected to a vacuum pump so that evacuation of the tube continues during operation, since occluded gases are liberated by the metallic parts of the tube under the stress of this exceedingly high voltage. Although connected to a vacuum pump for the purpose of evacuating occluded gases, nevertheless the filamentary cathode has heretofore been subjected to a certain amount of positive ion bombardment, which in many instances causes destruction of the cathode and, in any event, considerably shortens the life thereof.

It is accordingly an object of the present invention to provide a cathode electrode for a high voltage X-ray tube wherein such cathode is shielded from positive ion bombardment.

Another object of the present invention is the provision of a cathode electrode for a high voltage X-ray tube wherein the cathode is shielded from positive ion bombardment and wherein the electrical fields generated within the tube cause the emission of electrons from the filament which bombard the anode to produce X-rays of high penetrative power.

Still further objects of the present invention will become obvious to those skilled in the art by reference to the accompanying drawing wherein:

Fig. 1 is an elevational view of an X-ray tube employing a cathode in accordance with the present invention.

Fig. 2 is a cross-sectional view on an enlarged scale of the X-ray tube as shown in Fig. 1 and showing more in detail the novel construction of the cathode electrode, and

Fig. 3 is a sectional view taken on the line III—III of Fig. 2.

Referring now to the drawing in detail, in Fig. 1 an X-ray tube 5 is shown which, for the sake of simplicity, is more or less of the conventional type. It should be understood, however, that X-ray tubes operable at voltages of one million volts or more naturally do not conform to the conventional type illustrated, but the spacing between the electrodes is much greater and various other precautions must be taken in the way of insulation, etc., between parts of opposite instantaneous polarity. However, since the present invention is more concerned with the cathode construction, it is believed unnecessary that an X-ray tube as now known to the art, operable at one million volts or more, be illustrated.

As in the usual construction, the X-ray tube comprises an enclosure or envelope 6 provided with an anode 7 having a target 8 of refractory metal, such as tungsten or the like, and disposed adjacent thereto is a cathode electrode assembly 9. As shown more in detail in Fig. 2, the cathode assembly comprises a reentrant portion 10 having a press 12 through which a pair of leading-in conductors 13 and 14 are sealed which carry heating current for a circular filamentary cathode 15.

Secured to the reentrant stem 10, such as by means of bands or clamps 16, is a metallic focusing cup 17 with a flared or mushroom head 18 having a large radii of curvature, adjacent the oppositely disposed anode. The focusing cup is connected to the filamentary cathode in any suitable manner, such for example as a conductor 19, so that both are at the same polarity during operation and a diaphragm 20 is disposed in the cylindrical part of the focusing cup a short distance from the circular filamentary cathode.

This diaphragm is provided with an aperture 22 having a diameter less than the inner diameter of the circular filamentary cathode, as can be more readily appreciated from Fig. 3, so that there is no straight line flow of electrons from the cathode to the anode; and by the same token, the diaphragm 20 prevents the flow of positive ions which would otherwise bombard the filamentary cathode.

Due to the position of the filamentary cathode just behind the edge of the aperture in the diaphragm, the lines of force generated by the electrical field pass through the aperture and bend around, ending on the filament 15. The electrons thus pulled from the filament are started with a backward component of velocity, but are slowed down in a short distance due to the field and are then accelerated in the forward direction at high velocity where they bombard

the target 8, producing X-rays of great penetrative power.

Moreover, due to the depth of the diaphragm 20 with its aperture 22 within the focusing cup 18 and the resulting electrostatic field, substantially all of the electrons after passing through the aperture, flow in a straight line to the oppositely disposed anode. Consequently, these electrons do not impinge upon the walls of the envelope or housing, which would otherwise result in the building up of a high negative charge on the walls of the envelope. Moreover, any X-rays given off substantially normal to the surface of the target 8 have no harmful effect on the tube since they simply pass through the aperture 22, as shown by the arrow in Fig. 2, and are absorbed by the customary shields or the like.

During operation of the X-ray tube at the high voltage of one million or more volts, the envelope or housing 6 is connected to a suitable vacuum pump, as shown by the legend in Fig. 1. In addition, as is customary in tubes of such high voltage, the anode electrode may be cooled by the circulation of a cooling medium through an intake conduit 23 and a concentric outlet conduit 24. By the provision of such cooling means, the target 8 may be of lower melting point material than tungsten, if desired.

It thus becomes obvious to those skilled in the art that an X-ray tube operable at voltages approximating one million volts is herein provided wherein a cathode electrode is employed which is completely shielded from positive ion bombardment resulting from gases liberated from the metallic parts of the tube during its operation. Moreover, despite the complete shielding of the filamentary cathode, the electrical field is such that substantially all of the electrons are caused to flow from the thermionic cathode to the anode for the production of X-rays.

Although one specific embodiment of the present invention has been herein shown and described, it is to be understood that still further modifications may be made without departing from the spirit and scope of the appended claims.

I claim:

1. A high voltage X-ray tube comprising an enclosing envelope provided with a reentrant press, an anode in said envelope, a focusing cup provided with an end of large radii to prevent formation of intense electric fields and surrounding said reentrant press and supported thereby in longitudinal spaced relation to said anode, a filamentary cathode in the form of an annulus disposed within said focusing cup and longitudinally spaced relative to said anode, and a shield positioned well within said focusing cup adjacent said cathode and electrically and mechanically connected to said focusing cup, and said shield having an aperture therein to prevent a straight line flow of electrons from said cathode to said anode and the impingement of said cathode by positive ion bombardment during operation of said tube and to cause the flow of electrons only in an arcuate path through said aperture from said cathode to said anode.

2. A high voltage X-ray tube comprising an enclosing envelope, an anode in said envelope, a focusing cup spaced opposite said anode and of large radii of curvature to prevent formation of intense electric field, a filamentary cathode in the form of an annulus adapted to be heated to an electron emitting temperature and disposed within said focusing cup and longitudinally spaced relative to said anode, and a shield positioned adjacent said cathode and electrically and mcehanically connected to said focusing cup, and said shield closing said focusing cup except for an aperture therein of less diameter than the diameter of said annular cathode to prevent the flow of electrons from said cathode to said anode except in an arcuate path through said aperture and to prevent positive ion bombardment of said cathode during operation of said tube.

3. A high voltage X-ray tube comprising an enclosing envelope, an anode in said envelope, a filamentary cathode in said envelope of annular form and disposed opposite said anode in longitudinal spaced relation thereto, a cylindrical focusing cup spaced longitudinally from said anode and surrounding said cathode and projecting in the direction of said anode well beyond the limits of said cathode to form a relatively deep recess for the latter, and a diaphragm disposed in said recess adjacent said cathode and electrically and mechanically connected to said focusing cup, and said diaphragm forming a closure for said focusing cup except for an aperture therein to prevent a straight line flow of electrons from said annular cathode to said anode and the impingement of said cathode by positive ion bombardment during operation of said tube, and to allow the flow of electrons only in an arcuate path through said aperture from said cathode to said anode.

4. A high voltage X-ray tube comprising an enclosing envelope, an anode in said envelope having a refractory metal target, an annular filamentary cathode in said envelope disposed opposite said anode in longitudinal spaced relation thereto, a cylindrical focusing cup spaced longitudinally from said anode and projecting in the direction of said anode well beyond the limits of said cathode to form a relatively deep recess for the latter, and a diaphragm supported by said focusing cup adjacent said cathode and electrically connected thereto, and said diaphragm forming a closure for said cylindrical focusing cup and have an aperture therein of less diameter than that of said annular filamentary cathode to prevent the flow of electrons from said cathode to said anode except in an arcuate path through said aperture and to prevent positive ion bombardment of said cathode during operation of said tube.

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