

March 9, 1954

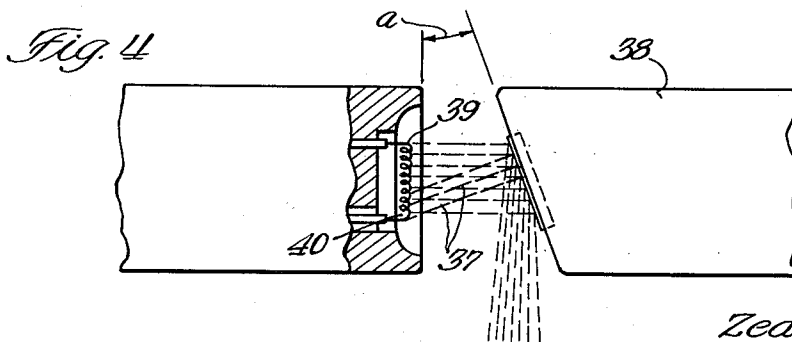
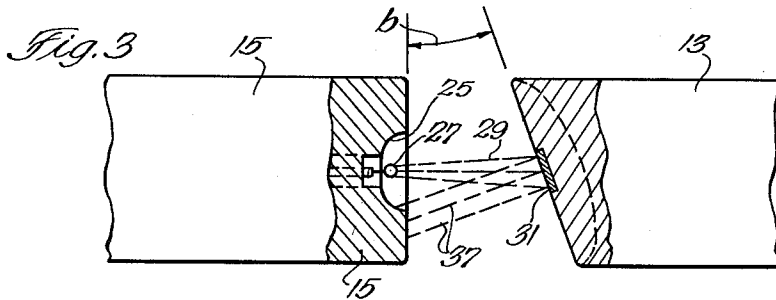
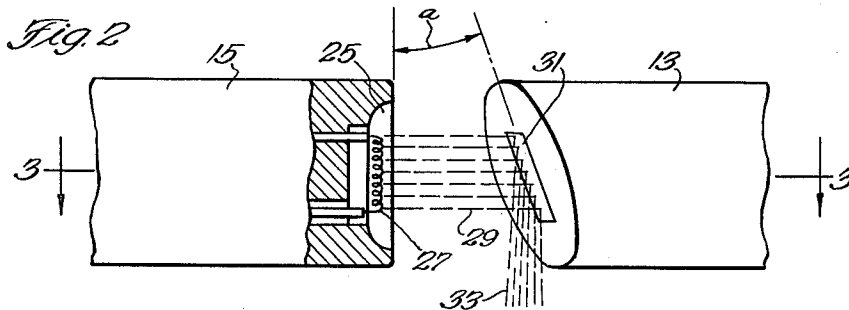
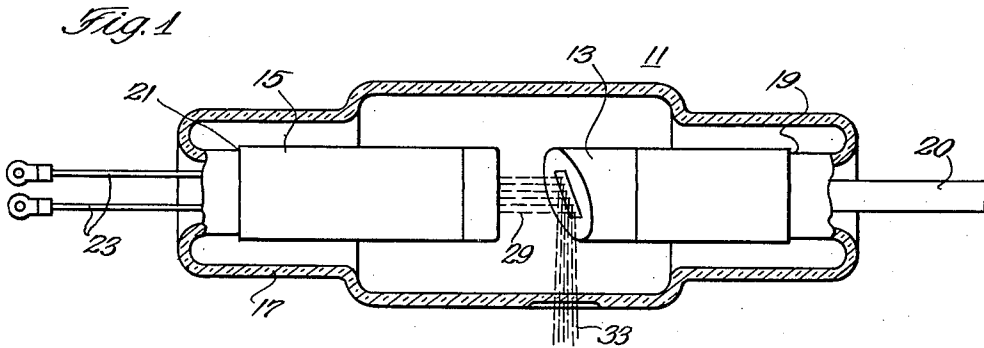
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2,671,867

ELECTRODE STRUCTURE FOR X-RAY TUBES

Filed Nov. 24, 1950

3 Sheets-Sheet 1



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ELECTRODE STRUCTURE FOR X-RAY TUBES

Filed Nov. 24, 1950

3 Sheets-Sheet 2

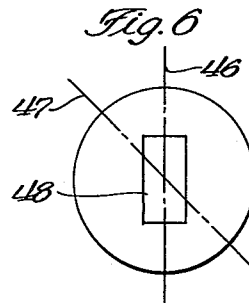
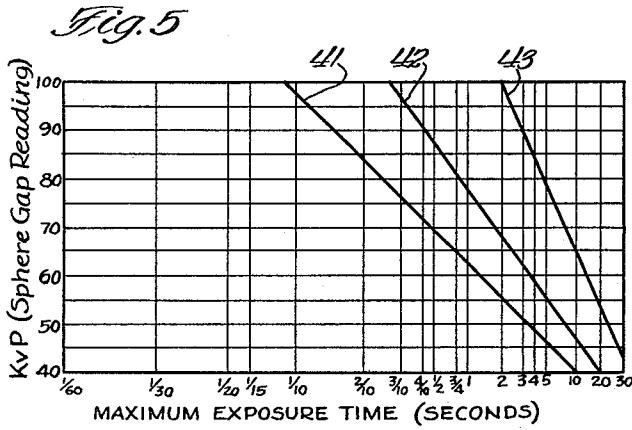


Fig. 7



Fig. 8



Fig. 9

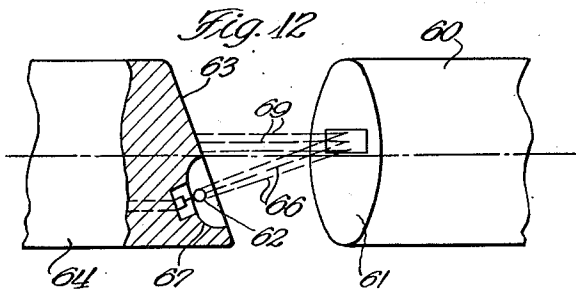
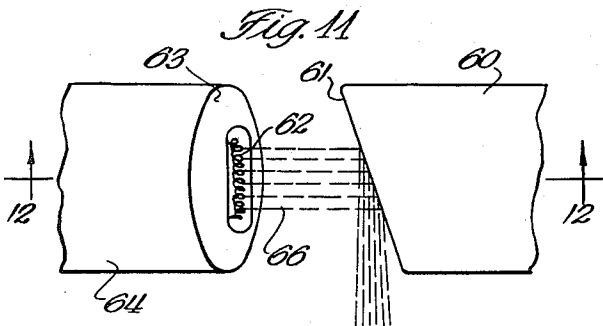
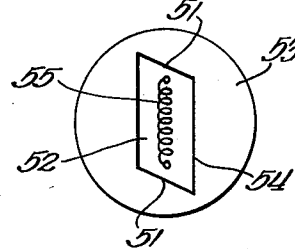
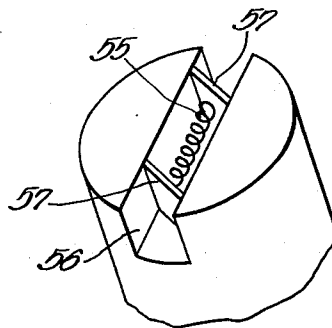


Fig. 10



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ELECTRODE STRUCTURE FOR X-RAY TUBES

Filed Nov. 24, 1950

3 Sheets-Sheet 3

Fig. 13

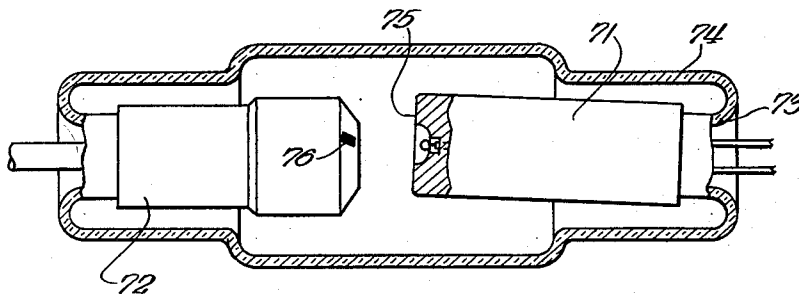


Fig. 14

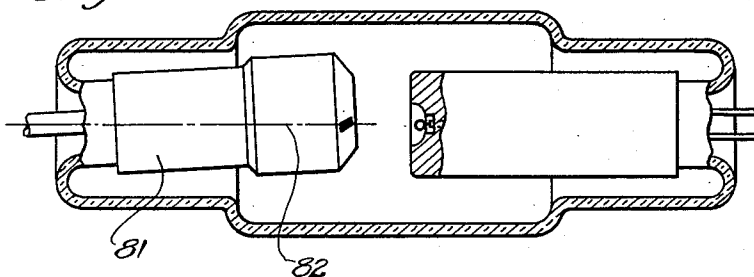


Fig. 15

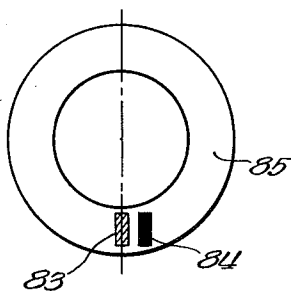
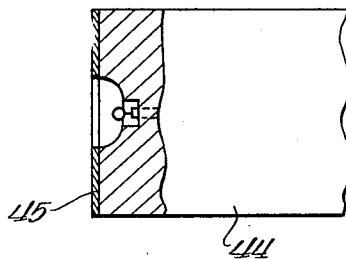


Fig. 16



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UNITED STATES PATENT OFFICE

2,671,867

ELECTRODE STRUCTURE FOR X-RAY TUBES

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Application November 24, 1950, Serial No. 197,441

13 Claims. (Cl. 313—57)

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The present invention relates to X-ray tubes and, more particularly, to relative arrangements of the anode and cathode units thereof.

X-ray tubes are frequently designed so that they may be used either self-rectified or in conjunction with half-wave or full-wave rectifying equipment. The ratings for conventional tubes when operated self-rectified are ordinarily less than half the rating for the same tube when used with a half-wave rectifier. The half-wave rectified rating is in turn less than the rating of the tube when used with full-wave rectified equipment. In accordance with the present invention, such a tube, as considered above, may be operated self-rectified while the rating thereof approximates that of the tube operated with full-wave rectification. It is a general object of the present invention, therefore, to provide an X-ray tube which may be operated self-rectified at ratings approximating those of a similar conventional tube operated with full-wave rectified equipment.

A further object of the invention is to provide an X-ray tube in which the cathode filament is protected against destructive inverse electron emission from the anode. A still further object of the invention is to provide a new and improved X-ray tube in which the cathode filament is so disposed with respect to the anode target that the inverse emission from the anode target will not impinge upon the filament.

A more specific object of the present invention is to provide a new and improved X-ray tube in which the relative angular relation between the facing ends of the anode and cathode units is such that the inverse electron emission from the anode target is directed in a laterally displaced relation with respect to the location of the cathode filament.

By many observations, I have determined that the inverse electron beam flowing from the anode to the cathode always flows in the direction perpendicular to the plane of the anode surface at the focal spot and in the usual X-ray tube structure, the cathode filament, or some portion thereof, is in line with such perpendicular. The inverse electron beam may be deflected out of such a perpendicular flow path by some such means as a permanent magnet imbedded in the body of the anode structure with the pole faces thereof at the surface of the anode on each of the opposite sides of the focal spot. The magnetic field thus produced would have no appreciable effect upon the high speed electron beam emitted by the cathode filament but

would tend to deflect the relatively slow inverse electron beam emitted from the anode surface so that instead of leaving such surface perpendicularly it would leave following more or less of an arcuate path with an effective angle of inclination so as to miss the cathode filament. Such a structure would be relatively costly to make as compared with the structural alternatives disclosed herein.

In accordance with one form of the present invention, the target face of the anode is provided in a direction longitudinally of the cathode filament and, in addition, a second angle of inclination in the direction at right angles with respect to the first angle, the second angle of inclination being such that inverse electron emission from the focal spot on the target and leaving the anode target in the direction normal to the surface thereof, impinge harmlessly against the cathode structure in a laterally displaced relation with respect to the filament. With the cathode filament thus protected from the destructive effects of the inverse emission, the tube may be operated under conditions approximating those normally considered safe only when the tube is used with half- or full-wave rectified current.

For a consideration of what is believed novel and inventive, attention is directed to the following description taken in connection with the accompanying drawings, while the features of novelty will be pointed out with greater particularity in the appended claims.

In the drawings,

Fig. 1 is a section view taken through an X-ray tube embodying the present invention;

Fig. 2 is an enlarged sectional view taken through the anode and cathode comprising the parts of the tube shown in Fig. 1;

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 2;

Fig. 4 is a sectional view corresponding to Fig. 2 but showing a conventional anode and cathode arrangement;

Fig. 5 is a set of curves illustrating comparative operational characteristics of a conventional X-ray tube and of a tube of the present invention;

Fig. 6 is an end view showing the face of an anode unit as viewed along the axis thereof;

Fig. 7 is an enlarged diagrammatic view illustrating the configuration of a typical anode projected focal spot at right angles to the main axis of the tube;

Fig. 8 is an enlarged diagrammatic view illustrating a distorted anode focal spot;

Fig. 9 is an end view of a cathode head unit illustrating in particular the configuration of a focusing cup designed to eliminate distortion of the anode focal spot;

Fig. 10 is a detail perspective view of a cathode head unit illustrating a focusing cup structure in accordance with a further modification of the invention;

Fig. 11 is a fragmentary view illustrating a cathode and anode unit according to a further modification of the invention;

Fig. 12 is a view of the arrangement shown in Fig. 11 but at right angles thereto, a portion of the head of the cathode unit being shown in section taken along the line 12—12 of Fig. 11;

Fig. 13 is a longitudinal view illustrating a rotating anode type of tube constructed in accordance with a further modification of the invention;

Fig. 14 is another view of a rotating anode type X-ray tube constructed in accordance with an alternative modification;

Fig. 15 is an enlarged end view of the anode unit of a rotating anode tube and illustrating in particular the shift in position of the focal spot thereupon in accordance with the present invention; and

Fig. 16 is an enlarged fragmentary view, partially in section, of a portion of a cathode head unit constructed in accordance with a further modification of the invention.

To illustrate the invention, the drawing in Fig. 1 shows an X-ray generator or tube 11 comprising spaced anode and cathode electrodes 13 and 15 sealed within an enclosing, preferably glass, envelope 17.

The anode 13 may be of any suitable or preferred construction and is suitably mounted in the envelope 17 and sealed therein at one end of the envelope by a glass-to-metal seal 19 through which a portion 20 of the anode extends outwardly of the envelope to provide for cooling the anode.

The cathode 15 is likewise sealed in the envelope, preferably by a glass-to-metal seal 21 at the end of the envelope remote from the seal 19, the cathode being connected within the envelope to conductors 23 extending outwardly of the envelope through the seal 21 for the purpose of energizing the cathode from a suitable source of cathode energizing current outwardly of the envelope. In the tube shown, the anode and cathode are supported in coaxial spaced apart alignment in the envelope and having facing heads.

As is well known, X-ray generators function to produce X-rays in response to the activation of the anode as an X-ray source by impingement on the head of the anode of electrons emitted by and from the cathode. The cathode head facing the anode is formed with an elongated recess or cup 25 in which is disposed an electron emitting filament 27. The filament 27 is connected with the conductors 23 and may be constituted as an electron emitting element when energized by the passage therethrough of current supplied through the conductors 23. By applying an electrical potential between the filament 27 and the facing head of the anode, as by contacting one of the conductors 23 and the outwardly extending portion 20 of the anode with a suitable source of electrical potential, electrons emitted by the filament 27 may be caused to travel from the filament as an electron stream 29 and impinge upon a portion

of the head of the anode forming a target area 31. The recess of cup 25 serves to focus the electrons comprising the stream 29 upon the target zone 31.

It will be observed that the head of the anode may be inclined in the direction longitudinally of the filament 27 by an angle indicated by the angle α , ordinarily of the order of 20° , so that X-rays generated in the target area may be transmitted therefrom as an X-ray beam 33 directed outwardly of the envelope through a portion of the side wall thereof normally referred to as the window area. During the operation of the X-ray generator a considerable amount of heat is developed in the anode and which may be dissipated outwardly of the envelope by radiation from the anode through the envelope walls and by conduction through the anode and its outwardly extending portion 20.

If the generator is operated in an overloaded condition, the focal spot 31 may, and frequently does, reach a temperature at which the focal spot itself becomes an electron emitting source of electrons which may pass therefrom as a primary beam of electrons focused upon a portion of the cathode structure. I have discovered that the electrons thus emitted from the anode target leave the surface thereof in a direction normal to the plane of the target face. Referring to Fig. 4, which illustrates a conventional coaxial cathode and anode arrangement and in which the anode face is inclined by the angle α in only one direction, it will be observed that the beam 37 of inverse electrons emitted from the focal spot on the face of the anode 38, may impinge upon the lower end 40 of the cathode filament 39. Such impingement of emission electrons upon the filament 39 causes localized increased heating of the filament at the point of impingement and which results in increased emission of electrons from the filament. Increased electron emission from the filament results in still greater heating of the focal spot on the anode target thereby further increasing electron emission from the anode target and consequent still further increase of heating of the cathode filament. This condition of runaway increases with such rapidity that the cathode filament is quickly destroyed.

The likelihood of destruction of the cathode filament due to overheating of the anode occurs only when operating the tube on alternating current potential or in a self-rectified manner. Under such conditions emission from the anode during the inverse half-cycle is apt to be particularly severe. For this reason the ratings for conventional tubes when operated self-rectified are very much less than when the tube is operated with one-half of the alternating current wave rectified. Referring, for example, to the graph of Fig. 5, the curve 41 illustrates a typical rating for a tube having a focal spot of 4.2 mm. This curve is plotted showing the applied voltage or kilovolts potential (sphere gap reading) against maximum exposure time. With a maximum applied voltage of 100 kv. the exposure time must be limited to below .1 second. Curve 42 illustrates the rating characteristic for the same tube when operated with one-half of the alternating current wave rectified and from which it will be noted that with an applied potential of 100 kv. the maximum exposure time may be increased to between .2 and .3 second.

In accordance with the present invention, I effectively protect the cathode filament against bombardment by inverse emission of electrons

from the anode target by the simple expedient of providing a second relative angle of inclination to the anode face with respect to the cathode head and which is illustrated more clearly in the view of Fig. 3 which is a view taken at right angles with respect to the view of Fig. 2. Referring to Fig. 3, it will be observed that the anode face is further inclined at an angle with respect to the head of the cathode unit 15 by an angle b in a plane at right angles to the plane of the angle a . The angle b is not critical but it must be sufficient so that the emission electron beam indicated at 37 leaving the anode target 31 perpendicularly with respect to the surface thereof, will be laterally displaced with respect to the cathode filament 27. It will be observed that the closer the spacing between the adjacent ends of the cathode and anode units, the greater this angle must be. In most instances, however, I have found that if the angle of inclination in the direction laterally of the filament is the same as the angle of inclination a , in the direction longitudinally of the filament, that the beam 37 of inverse electrons will be dis-

elements being relatively inefficient in producing X-rays as compared with elements of high atomic number.

An X-ray tube constructed in accordance with the present invention and supplied with non-rectified alternating current potential may safely be operated at ratings considerably greater than the half-wave rectified ratings for the comparable conventional tube. Referring again to Fig. 5, curve 43 illustrates the rating characteristic for the X-ray tube of the present invention when operated self-rectified. At an applied voltage of 100 kvp., the maximum exposure time is two seconds and which corresponds substantially to the rating for a comparable conventional tube when energized with a full-wave rectified potential.

The various curves of Fig. 5 are for a large focal spot of 4.2 mm. and the following chart sets forth comparative ratings of the present tube as compared with ratings of conventional tubes for different smaller focal spot sizes. In both cases, the ratings given are for self-rectified operation of the tube.

Focal Spot Size Needed Before	Focal Spot Size Now Possible	Self-Rectified Rating of New Tube	Rating of Conventional Tube
5.2 mm. 20° target.....	4.2 mm. 20° target.....	100 kvp.-100 ma., 2 Sec.....	85 kvp.-100 ma., $\frac{3}{10}$ Sec.
4.5 mm. 20° target.....			
4.2 mm. 20° target.....			
3.8 mm. 20° target.....	3.2 mm. 20° target.....	80 kvp.-75 ma., 2 Sec.....	85 kvp.-75 ma., $\frac{1}{10}$ Sec.
3.5 mm. 20° target.....			
3.2 mm. 20° target.....			
2.8 mm. 20° target.....	2.4 mm. 20° target.....	80 kvp.-50 ma., 2 Sec.....	80 kvp.-50 ma., $\frac{2}{10}$ Sec.
2.4 mm. 20° target.....			
2.0 mm. 20° target.....			
1.5 mm. 20° target.....	1.5 mm. 20° target.....	75 kvp.-30 ma., 1 Sec.....	55 kvp.-30 ma., $\frac{1}{10}$ Sec.
1.2 mm. 20° target.....			
	1.0 mm. 20° target.....	85 kvp.-5 ma., Continuous..	

placed laterally of the cathode filament sufficiently to avoid destructive impingement of the inverse emission of electrons upon the cathode filament.

With the inverse electron beam thus focused to one side of the cathode filament they fall more or less harmlessly against the side walls of the focusing cup or upon the end face of the peripheral portion of the cathode head. Of course, in an extremely overloaded condition the inverse emission electron beam may cause melting of the metal forming the cathode head with deleterious effects upon the tube and which should be avoided. Such accidental melting of the surface of the cathode head may be minimized by covering the face surface of the cathode head with a layer of high melting point material, such as molybdenum, as shown in Fig. 16. The face surface of the cathode head unit 44 is in this instance covered with a thin layer 45 of molybdenum having a thickness, for example, of .010 to .020 inch. To obtain advantage of the mass of the iron forming the cathode head proper, the layer 45 is preferably copper brazed in position. Preferably, the layer 45 is further coated on its outer surface with some poor electron emitting, high work function material of which platinum and carbon are the presently best known examples so as to reduce to a minimum the emission of inverse electrons from the cathode surface. This coating need be only a mil or so in thickness. So that the inverse electron beam from the anode will not cause the generation of X-rays from the cathode face, preferably the layer of poor electron emitting, high work function material is composed of an element or alloy of elements of low atomic number, such as, for example, carbon and beryllium, such

It will be obvious to those skilled in the art from inspection of the curves of Fig. 5 and the tabulated chart above that the present invention enables usage of a much smaller focal spot for the same applied voltage-exposure time rating than is permissible with conventional tubes and which is highly desirable. Moreover, the cost of expensive voltage rectifying equipment is eliminated and tube life is, of course, greatly increased.

From the description given above, it will be observed that the anode arrangement as described may be accomplished merely by rotating the anode about its longitudinal axis through an angle of approximately 45° so that the major axis of the anode, when viewed along the axis of the tube, extends at an angle of 45° with respect to the longitudinal direction of the cathode filament. In other words, referring to the view of Fig. 6, when viewed along the longitudinal axis of the anode, the anode face is circular in shape and in the conventional X-ray tube arrangement as illustrated in Fig. 4, the major axis of the elliptical anode face and indicated by the line 46 lies in the same plane as the longitudinal axis of the elongated filament 39. In accordance with the present invention, the anode unit is angularly rotated about its longitudinal axis through such an angle that the major axis of the elliptical anode face lies in a plane parallel with the axis of the anode and inclined at an angle of substantially 45° with respect to the longitudinal direction of the filament. It is to be understood, however, that the target insert 43, and which is usually of rectangular configuration, is maintained in parallel alignment with the longitudinal direction of the cathode filament as indicated.

In the conventional tube the projected focal spot on the anode target, when viewed through the envelope window at right angles to the main axis of the tube, is usually of rectangular configuration as shown in Fig. 7. Due to the additional angle of slope of the anode face resulting from the present invention and extending in the direction laterally with respect to the longitudinal direction of the filament, the projected focal spot on the anode target from the conventional cathode structure assumes a rhombic configuration as shown in Fig. 8. Such rhombic configuration of the focal spot is undesirable and may be corrected by suitable design of the focusing cup of the cathode unit in a manner as indicated in Fig. 9. As shown therein, the opposite end walls 51 of the focusing cup 52 provided in the cathode face 53 are parallel with each other but inclined with respect to the parallel side walls 54 of the focusing cup at angles corresponding substantially to the angles of inclination between the corresponding inclined edges 50 of the focal spot pattern shown in Fig. 8 but in the opposite direction. These inclined end walls 51, closely adjacent the opposite ends of the filament 55 create a space charge capable of influencing the cathode electron beam so as to crowd in the electrons at one pair of diagonal corners of the beam and to cause them to spread out on the other pair of diagonal corners. A rhombic spot is thus formed on the anode target, which when viewed through the envelope window in a direction at right angles to the anode axis, will be of rectangular form substantially as shown in Fig. 7. The desired cathode cup structure may be produced in various ways such as shown, for example, in the perspective view of Fig. 10. The cathode head is provided with a transversely milled slot 56 having width and depth as desired for the cup and a pair of end wall inserts 57 are suitably welded in place adjacent the opposite ends of the filament 55 at the proper angle with respect to the side walls of the slot 56.

The invention as described up to this point has been with particular respect to the provision of a lateral angle of slope upon the anode face. It will be apparent to those skilled in the art that somewhat similar results may be accomplished by leaving the anode unchanged but by providing a lateral angle of slope upon the cathode face. As illustrated in the views of Figs. 11 and 12, the anode unit 60 as shown in this instance is as arranged in a conventional tube and with the major axis of the face 61 thereof extending in a plane parallel with the longitudinal direction of the cathode filament 62. The face 63 of the cathode head 64, in this instance, is inclined at an angle substantially equal to the angle of inclination of the anode face 61 but in a direction at right angles with respect to the direction of slope of the anode face. The primary electron beam 66 impinging upon the anode target will result in a rectangular focal spot appearing through the window of the envelope substantially as in the case of a conventional tube. However, due to the angular slope of the cathode face 63 the primary electron beam 66 is focused upon the anode target by the focusing cup 67 at an angle substantially as indicated. The focusing cup 67 and the filament 62 positioned therein are laterally offset with respect to the perpendicular of the focusing spot so that the inverse electron beam as might be emitted from the anode target and indicated at 69 and flowing back toward the cathode will impinge harmlessly

against the face 63 of the cathode head and thus miss the cathode filament itself.

From a perusal of the foregoing disclosure, it will be observed that the basic concept of the present invention may be executed in virtually any type of an X-ray tube. It is merely essential that the face of the cathode head and of the anode unit be so angularly disposed with respect to each other that the inverse electron beam from the focal spot on the anode target and in a direction perpendicular to the plane of the anode face strike the cathode head to one side of the cathode filament. Stated in another way, it is necessary that the cathode filament be laterally displaced from the perpendicular projection of the plane of the anode target at the focal spot.

For example, considering the rotating anode type of tube, in which the anode target rather than being plane, is of frusto-conical configuration, the present invention may be incorporated in a manner as indicated schematically in the views of Figs. 13 and 14. In Fig. 13, the cathode unit 71 is tilted with respect to the longitudinal axis of the tube indicated at 72 and which may be expeditiously accomplished simply by shifting the position of the entire cathode structure into a desired angular relation with respect to the axis of the envelope at the time that the re-entrant stem portion 73 supporting the cathode unit is sealed onto the end portion 74 of the envelope by the glass blower. Due to the angle of slope thus imparted to the face 75 of the cathode unit, the focal spot 76 upon the rotating anode target will be angularly offset with respect to the cathode and the inverse electron beam leaving the anode surface in a direction perpendicular thereto will impinge harmlessly upon the cathode head to one side of the filament, in much the same manner as previously described.

In the structure illustrated in Fig. 14, the rotating anode unit indicated generally at 81 is tilted at an angle with respect to the longitudinal axis 82 of the tube rather than the cathode unit, as previously described, with substantially the same results insofar as the displacement of the inverse flow from the anode toward the cathode is concerned. Referring to the enlarged end view of the rotating anode unit of either of the modifications shown in Figs. 13 and 14, the normal position of the focal spot upon the anode target area is indicated at 83 whereas in accordance with the present invention, the anode spot is laterally shifted to some such position as indicated at 84. Due to the frusto-conical configuration of the anode target surface 85, only a relatively slight shift of the focal spot upon the target is required to effect a considerable displacement of the path of travel for the inverse electron flow. It will be apparent that in the instance of a curved target surface the inverse electron flow from any given point thereon will be perpendicular to the plane tangent to that point so that there will be a slight divergence between the paths of travel of the inverse electrons emitted from the anode surface. This is of no particular moment to the present invention inasmuch as the focal spot will be substantially planar and such divergence as does occur is entirely beneficial since the inverse electrons will be distributed over a greater portion of the surface of the cathode head and in any event will not be directed upon the cathode filament. It will be understood, therefore, that the term "planar" or relevant term in reference to the anode target includes slightly curved surfaces arranged in the

manner shown and described in respect to the cathode filament.

Having described the invention in what is considered to be a preferred embodiment thereof, it is desired that the specific details shown are merely illustrative and that the invention may be carried out in other ways.

I claim:

1. An X-ray tube comprising cooperating anode and cathode units facing each other in a spaced apart relation, said anode unit having a target area in the surface thereof facing said cathode unit, said cathode unit including a head having an elongated focusing cup recess in the surface thereof facing said anode unit, an elongated filamentary cathode element mounted longitudinally within said recess whereby the beam of electrons emitted by said cathode element impinge upon said target area in an elongated focal area, said focusing cup in said cathode head being wholly disposed in a laterally displaced relation relative to any plane perpendicular to the focal area of said anode and parallel with the longitudinal direction thereof, said cup recess extending in a direction parallel with said perpendicular plane, whereby inverse electron emission from said target area and leaving the surface thereof perpendicularly with respect thereto will impinge upon said cathode head in a laterally displaced relation with respect to said cathode element and focusing cup.

2. An X-ray tube comprising coaxially mounted cooperating anode and cathode units facing each other in a spaced apart relation, said anode unit having a plane surfaced target element in the surface thereof facing said cathode unit, said cathode unit including a head having an elongated focusing cup recess in the surface thereof facing said anode unit, an elongated filamentary cathode element mounted longitudinally within said recess and extending in a plane normal to the axis of said units, whereby the beam of electrons emitted by said cathode element will impinge upon said target element over an elongated focal area, said focusing cup in said cathode head being disposed parallel with and in a laterally displaced relation relative to any plane perpendicular to said target element and parallel with the longitudinal axis of said elongated focal area on said anode target element throughout the entire width of said focal area whereby inverse electron emission from said target element and leaving the surface thereof perpendicularly with respect thereto will impinge upon said cathode head in a laterally displaced relation with respect to said cathode element and focusing cup.

3. An X-ray tube comprising coaxially mounted cooperating anode and cathode units facing each other in a spaced apart relation, said cathode unit including a head having an elongated focusing cup recess in the surface thereof facing said anode unit, an elongated filamentary cathode element mounted longitudinally within said recess and extending at right angles to the axis of said anode and cathode units, the face surface of said anode unit being of elliptical shape and inclined at an angle of approximately 20 degrees with respect to the perpendicular of said axis, the major axis of the elliptical face of said anode unit inclined at an angle of approximately 45 degrees with respect to the longitudinal direction of said filament when viewed in the axial direction.

4. An X-ray tube comprising an anode unit having a plane surfaced target element imbedded in the face thereof, a cathode unit including a

head having an elongated focusing cup recess in the surface thereof facing said anode unit, an elongated filamentary cathode element mounted longitudinally within said recess, the outer peripheral edge of said recess terminating substantially in a plane, the plane surface of said target element of said anode unit facing said cathode unit being disposed at such an angle relative to the plane defined by the peripheral edges of said recess whereby any perpendicular to the target surface at the electron focal spot intersects said cathode head to one side of said cathode element.

5. An X-ray tube comprising an anode unit having a target element imbedded in the face surface thereof, a cathode unit including a head having an elongated focusing cup recess in the surface thereof facing said anode, an elongated filamentary cathode element mounted longitudinally within said recess, the outer peripheral edge of said cathode head facing said anode unit terminating substantially in a plane, said cathode element extending substantially parallel with said last mentioned plane, said cup recess serving to focus electrons emitted by said cathode element at a focal spot upon said target element, the surface of said target element being inclined at a first angle with respect to said plane of said cathode head in the direction longitudinally of said cathode element, said surface of said target element being also inclined at a second angle relative to said plane of said cathode head in the direction at right angles with respect to the longitudinal direction of said cathode element whereby inverse electron emission from said focal spot leaving said target surface normal thereto will be directed in a laterally displaced relation with respect to the position of said cathode element.

6. An X-ray tube comprising an anode unit having a plane surfaced target element imbedded in the face thereof, a cathode unit including a head having an elongated focusing cup recess in the surface thereof facing said anode unit, an elongated filamentary cathode element mounted longitudinally within said recess and substantially parallel with the outer face surface of said head, the outer surface of said head facing said anode unit being substantially plane, said cup recess serving to focus electrons emitted by said cathode element at a focal spot upon said target element, the plane surface of said target being tilted at an angle of substantially 20 degrees with respect to the plane surface of said cathode head in the direction parallel with the longitudinal direction of said cathode element, the plane surface of said target element of said anode unit being also inclined at an angle of substantially 20 degrees relative to the plane surface of said cathode head in the direction at right angles to the longitudinal direction of said cathode element whereby any perpendicular of said target surface within the focal spot area thereupon will intersect the plane of said cathode head at a point laterally removed from said cathode element, said last mentioned angle of inclination being effective for causing inverse electron emission leaving said target element normal to the face thereof to fall upon said cathode head laterally displaced from said cathode element.

7. An X-ray tube comprising cooperating elongated anode and cathode units arranged in a spaced apart relation, said anode unit having a target area in the surface thereof facing said cathode unit, the face surface of said anode unit being inclined at an angle with respect to the longitudinal axis of said anode unit, said cathode

11

unit including a head having an elongated focusing cup recess in the surface thereof facing said anode unit, an elongated filamentary cathode element mounted longitudinally within said recess, the beam of electrons emitted by said cathode element impinging upon said target area in an elongated focal area, said focusing cup in said cathode head being disposed in a laterally displaced relation relative to a plane perpendicular to the focal area and parallel with the longitudinal direction thereof, the opposite end walls of said focusing cup being parallel with each other and with the axis of the cathode unit but inclined at an angle with respect to the side walls of said cup whereby said focal area will be of rectangular shape when viewed in a direction at right angles to the axis of said anode unit.

8. An X-ray tube comprising an elongated anode unit having a plane surfaced target element imbedded in the face thereof, an elongated cathode unit including a head having an elongated focusing cup recess in the surface thereof facing said anode unit, said units facing each other in a cooperative spaced apart relation, an elongated filamentary cathode element mounted longitudinally within said recess, the longitudinal axes of said units being tilted at such an angle with respect to each other whereby the perpendicular to the target at the electron focal spot intersects said cathode head in a laterally displaced relation with respect to said cathode element.

9. An X-ray tube having cooperating anode and cathode units, said cathode unit comprising a head having a face surface facing said

12

anode unit, a focusing cup recess in said cathode face surface, a filament in said recess, a layer of material having a higher melting point than the material of said head covering the said face surface surrounding said recess, said anode unit comprising target means positioned at such angular relation to said cathode face surface that the inverse electron emission from the focal spot on said target means impinges upon said layer in laterally displaced relation to said recess.

10. An X-ray tube as set forth in claim 9 wherein said layer consists of molybdenum.

11. An X-ray tube as set forth in claim 9 wherein the outer surface of the layer of high melting point material is coated with a material having high work function and poor electron emitting characteristics.

12. An X-ray tube as set forth in claim 9 wherein the layer of high melting point material comprises molybdenum and the outer surface of said layer is coated with platinum.

13. An X-ray tube as set forth in claim 9 wherein the layer of high melting point material is coated with beryllium.

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