

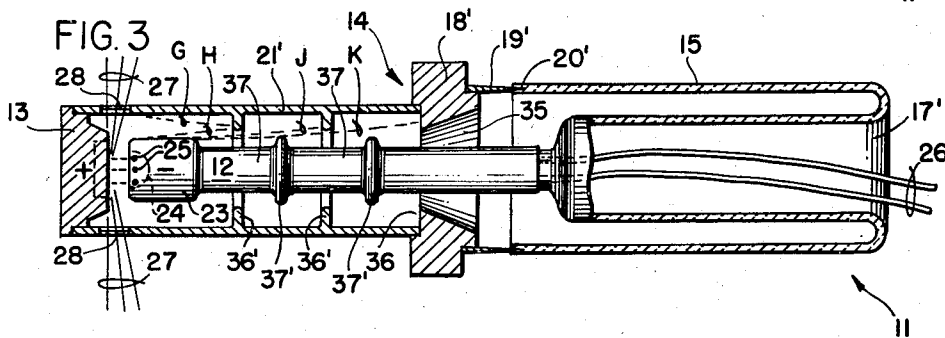
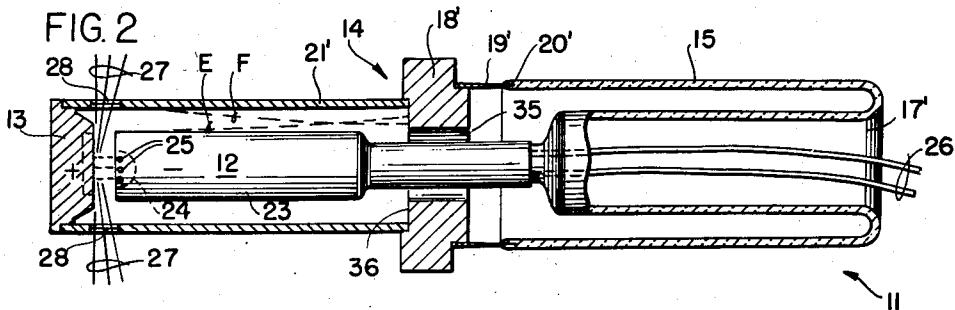
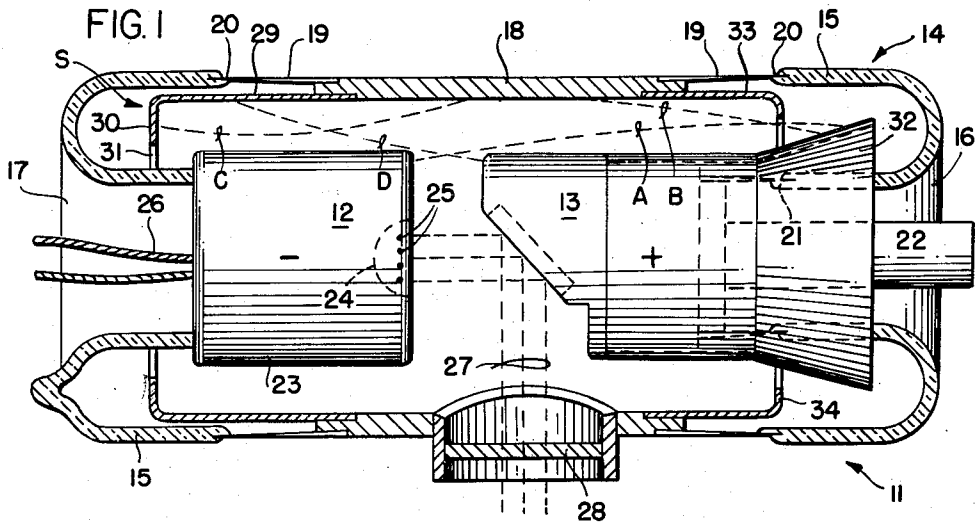
June 17, 1958

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2,839,698

ELECTRON SHIELDING IN X-RAY TUBES

Filed July 1, 1955



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2,839,698

## ELECTRON SHIELDING IN X-RAY TUBES

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Application July 1, 1955, Serial No. 519,480

11 Claims. (Cl. 313—55)

The present invention relates in general to electronics and has more particular reference to X-ray generating tubes.

X-ray generating tubes commonly comprise spaced apart anode and cathode electrodes sealed in facing relationship within an enclosing envelope. The envelope may be made entirely of glass or may embody glass zones, as at the opposite electrode carrying ends thereof, whereby to electrically insulate the anode from the cathode. X-ray generating tubes function to produce X-rays in response to the activation of the anode, as an X-ray source, by the high speed impingement thereon of electrons emitted by and at the cathode. A limiting factor in the design and rating of an X-ray generating tube is undesired electronic bombardment of the insulating portions of the envelope. Such bombardment may be effected by stray electrons, that is to say, those which escape from the stream of electrons delivered from the cathode for X-ray generating impingement on the anode, or by secondary electrons which may emanate from many sources within the generating tube, including the anode and cathode structures and portions of the envelope itself, as the result of bombardment of such secondary electron sources by electrons emitted from the cathode, or derived from such cathode emission by repeated generations and deflections. Secondary or stray electron bombardment of the envelope may result in the development of undesirable space charge effects, in excessive heating of insulating material, in harmful electrical discharge across insulation, or in direct disruption of the insulator, as by puncture.

Heretofore, various expedients, including the application of electron screening hoods around the anode and various forms of hooded or immersed anode and cathode electrodes, have been employed in order to minimize the deleterious effects of secondary or stray electron bombardment of the insulating portions of the envelope, by screening the source of such bombardment; but such expedients have, in turn, imposed limiting conditions and hence have been generally undesirable. In that connection, for example, when emission of exceedingly soft radiation from the generating tube is desired, any electron screening hood that may be disposed in the path of emitted rays operates as a filter which limits the quantity and quality of emitted X-rays.

An important object of the present invention is to provide a means for blocking or preventing undesirable electron bombardment of the insulating portion of an X-ray generating tube envelope without interfering in any fashion with the emission path of useful radiation generated by the operation of the tube.

Another important object of the invention is to take advantage of the lateral curvature imparted to the path of movement of an electron when passing adjacent to an electrified object, such as the anode or cathode of an X-ray tube, in applying electron blocking baffles in position to screen the insulating portions of an X-ray generating tube envelope from stray or secondary electron bombardment, the baffles being disposed outwardly of the

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path of useful X-rays generated at and emitted from the anode of the tube.

Another important object is to provide an electron shield or baffle in an X-ray generating tube in position to intercept undesired electrons and prevent these electrons from deleteriously bombarding the insulating portions of the envelope while providing sufficient radial clearance so that the tube components, including the electron screening baffle or shield, may be readily assembled.

Another important object resides in providing effective means for shielding all insulating portions of the envelope of an X-ray generating tube through the employment of metallic shields or baffles disposed in position to intercept stray electrons following curved paths of travel, under the influence of the electrified anode or cathode components of the tube, whereby the electron intercepting baffles or shields do not extend between the anode electron target and the X-ray emission window, thereby avoiding undesired filtration of X-rays emitted from the generating tube when in operation.

Another important object is to provide entirely metallic electron shielding means having definite voltage relationships with respect to the other components of the generating tube whenever the tube is energized for operation, whereby the shielding members, to be effective, do not depend upon a charge accumulation derived from the tube operation.

Briefly stated, in accordance with one aspect of the invention, metallic baffle means of generally cylindrical configuration may be applied at the anode and cathode carrying ends of an X-ray generating tube in position offset outwardly of the path along which generated X-rays are emitted from the anode electrode and thence delivered outwardly of the envelope, as through a window formed therein, such baffle means, at the cathode end of the tube, having an inwardly extending flange or shoulder in position to intercept outwardly curving secondary electrons moving longitudinally toward the cathode carrying end of the envelope, said baffle means, at the anode end of the envelope, comprising an outwardly inclined shoulder, flange or skirt disposed in position to intercept electrons traveling longitudinally of the envelope along inwardly curving paths alongside of the anode element.

The foregoing and numerous other important objects, advantages and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawings, discloses preferred embodiments of the invention.

Referring to the drawings:

Fig. 1 is a sectional view taken longitudinally through an electron generating tube fitted with electron intercepting baffle means embodying the present invention; and

Figs. 2 and 3 are sectional views taken through electron generating tubes embodying modified arrangements of electron intercepting baffles embodying the present invention.

To illustrate the invention, the drawings show X-ray generating tubes 11, each comprising an electron emitting cathode 12 and an anode 13 disposed in spaced facing relationship within a sealed and evacuated envelope 14 of generally elongated configuration, the anode and cathode being supported upon the envelope, as at the opposite ends thereof. As shown, the envelope 14 embodies envelope portions 15 of electrical insulating material, such as glass, forming circumferentially extending envelope zones which serve to electrically insulate the anode and cathode.

The envelope 14, as shown in Fig. 1, may comprise re-entrant end portions 16 and 17 of glass, constituting the insulating zones 15 at the opposite ends of the envelope, the envelope comprising a medial cylindrical portion 18,

as of metal, said cylindrical metal portion, at its opposite ends, carrying sealing members 19 forming glass-to-metal seals 20 with the outer walls of the re-entrant portions 16 and 17. The anode 13, as shown in Fig. 1, may be sealed upon the inner wall of the re-entrant portion 16, at one end of the envelope, as by an annular glass metal seal 21, through which a portion 22 of the anode extends outwardly of the envelope. The cathode 12 likewise may be supported on the other re-entrant portion 17, at the opposite end of the envelope, and may be sealed to the inner wall of said re-entrant portion 17, as by a glass-to-metal seal similar to the seal 21.

As shown in Figs. 2 and 3, the envelope 14 may comprise a central collar portion 18', as of metal, a re-entrant portion 17', as of glass, and a sealing member 19' secured to the collar 18' on one side thereof in position to form a glass-to-metal seal 20' with the outer wall of the re-entrant glass portion 17'. The envelope 14 of the embodiments shown in Figs. 2 and 3 also comprises an anode carrying tube 21' sealed at one end on the collar 18' on the side thereof remote from the re-entrant envelope portion 17', the tube 21' carrying the anode 13 sealed in the end thereof remote from the medial collar portion. The cathode 12 of the devices shown in Figs. 2 and 3 extends within the tube 21' and through a central opening in the medial envelope portion 18', the cathode being sealingly mounted and secured upon the inner wall of the re-entrant envelope portion 17', as by means of a glass-to-metal seal like the seal 21. The re-entrant envelope portion 17' thus supports the cathode in spaced facing relationship with respect to the anode 13.

It should be understood that X-ray generators function to produce X-rays in response to the activation of the anode as an X-ray source by impingement thereon of electrons emitted by and from the cathode. To this end, the cathode may comprise a head 23 formed with a cavity or cup 24, facing the anode, and an electron emitting filament 25 supported in the cup and electrically connected thereto. The filament 25 may be constituted as an electron emitting element when energized by the passage therethrough of electrical current supplied, as through conductors 26, from a source of filament energizing power outwardly of the envelope. By applying electrical potential between the cathode 12 and the anode, as by connecting one of the conductors 26 and the outwardly extending portions of the anode with a suitable source of electrical potential, electrons emitted by the filament may be caused to travel thence as an electron stream and to impinge upon the anode to constitute the same as an X-ray source adapted to emit X-rays, a portion of which may be transmitted as a beam 27, outwardly of the envelope through a suitable window or windows 28 formed in the envelope. In the embodiment illustrated in Fig. 1, the window 28 of an X-ray pervious material, such as beryllium, may be formed in the medial wall portion 18 of the envelope, which may be and preferably is maintained at ground potential. In the embodiments illustrated in Figs. 2 and 3, the windows 28 may be formed in the anode carrying tube 21'.

When X-ray tubes of the sort shown in Figs. 1, 2 and 3 are in operation, the anodes and cathodes thereof, respectively, are relatively positive and relatively negative with respect to the electrons emitted by and at the cathode for delivery upon the anode. As a consequence, electrons, either stray electrons or secondary electrons, which at any instant may be traveling in the anode region toward insulating portion 16, will tend to be attracted toward the relatively positive anode and hence will follow paths of the sort shown at A and B in Fig. 1, which curve continuously inwardly toward the body of the anode. When traveling in the vicinity of the cathode, however, electrons tend to be repelled by its relatively negative character. As a consequence, such electrons will follow paths which curve continuously away from the body of the

cathode, as shown in dotted lines at C and D in Fig. 1, at E and F in Fig. 2, and at G, H, J and K in Fig. 3.

As shown more particularly in Fig. 1, the path A is of the sort which might be followed by a secondary electron emitted from the cathode as the result of reverse bombardment thereof by an electron reflected from the anode. The paths B and C are of the sort which might be followed by secondary electrons emitted from the grounded sleeve portion 18 of the envelope as the result of impingement thereon of stray electrons. The path D is of the sort which might be followed by a secondary electron emitted from the anode as the result of electron impingement thereon outwardly of the X-ray generating target area. Obviously, electrons emitted by the anode, cathode and metallic envelope portions along paths of the sort shown at A, B, C, and D in Fig. 1 may impinge upon and deleteriously affect the insulating portions 15 of the envelope structure.

In order to prevent such undesirable envelope deterioration, the present invention contemplates the provision of a metallic shield S comprising a preferably thin gauge metal sleeve 29 secured at one end in the envelope structure, as on the metallic sleeve portion 18 thereof, in position encircling the cathode 12, the sleeve portion 29 at its end remote from the envelope portion 18 being provided with an intumed lip or flange 30 defining an opening 31 of size barely large enough to permit the cathode structure to be passed axially therethrough during the assembly of the generating tube. Such a shield will guard the insulating portion 17 of the tube envelope, at the cathode end thereof, against impingement by electrons traveling toward said insulating portion outwardly of the cathode, because of the outwardly curving configuration of the paths traversed by such electrons outwardly of the cathode structure. The electrical clearance of the shield with respect to the cathode structure is thus obtained principally in a direction parallel to the general path of electrons that otherwise might strike the insulating end portions of the envelope. The shield thus effectively closes the space between the envelope portion 18 and the cathode without interfering with the assembly of the cathode axially in the envelope and within the shield. Effective blocking of electrons from the insulating end portions of the envelope is thus achieved without complete dimensional closure of the shield by the cathode, thereby preserving sufficient dimensional clearance to permit the assembly of the cathode in operative position in the X-ray tube structure.

To guard the envelope portion 16, in the anode end of the envelope, against electron bombardment, the anode 13 may be provided with an outwardly flaring peripheral skirt 32 which may conveniently comprise a conically tapered sheet metal sleeve mounted in the anode structure, said sleeve being adapted to intercept electrons traveling toward the insulating portion 16 at the anode carrying end of the envelope because of the inwardly curving configuration of the paths traversed by such electrons outwardly of the anode. The outwardly flaring skirt 32 may perform its desired function in conjunction with a preferably thin gauge metal sleeve 33 encircling the anode structure and secured at one end, as on the metallic sleeve portion 18 of the tube envelope. The sleeve portion 33 at the end thereof remote from the envelope portion 18 may terminate inwardly of the end of the sleeve 32 and may be sized to register substantially with the terminal edge of said skirt. If desired, the skirt encircling end of the sleeve 33 may be provided with an intumed lip 34 of width sufficient, in conjunction with the skirt 32, to assure the exclusion from the insulating portion 16 of electrons traveling toward said portion outwardly of the anode. Indeed, the sleeve may extend in a direction outwardly of the anode beyond the intumed lip 34 and then flare abruptly outwardly to provide a configuration which will exclude stray or secondary

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electrons from reaching the insulating portion 16. Of course, any preferred configuration of the skirt may be employed for the accomplishment of the desired electron blocking function between the anode and the member 18.

The present invention is not necessarily limited or restricted to the particular shape of the electron blocking means at the anode and cathode ends of the tube, specific shape or configuration being immaterial other than for the purpose of meeting physical requirements in blocking electrons traversing outwardly and inwardly curved paths, respectively alongside of the cathode and anode of the X-ray generating device. Accordingly, the electron blocking means may take the form of a flange, flare, collar, shoulder, skirt, lip, rib or other projection extending in the path of electrons traveling alongside of the anode and cathode of the tube toward the insulating end portions of the envelope.

As shown more particularly in Figs. 2 and 3, the principles of the present invention may be applied in X-ray generating tubes of the sort wherein the cathode 12 is immersed or enclosed within the anode structure comprising the sleeve 21'. The desired protection may be accomplished in such devices by extending the central anode carrying collar portion 18' inwardly of the anode sleeve 21' to an extent such that the minimum dimension of the central opening 35 of said collar is of a size barely large enough to permit the cathode structure to be passed axially therethrough during the assembly of the generating tube. Such arrangement provides shoulders 36 in position, between the cathode structure 12 and the cathode carrying and insulating portions 15 of the envelope, to effectively shield such glass portions against impingement by electrons traveling within the anode tube 21', as along paths E and F in Fig. 2 or path K in Fig. 3, outwardly of the cathode 12. It will be seen that the circumferential shoulder portions 36 in the Fig. 2 and Fig. 3 embodiments are comparable to the inwardly turned lip 30 in the Fig. 1 embodiment, in guarding the insulating cathode carrying envelope portions against electron impingement by taking advantage of the outwardly curving configuration of the paths followed by electrons traveling toward such cathode carrying envelope portions outwardly of the cathode structure.

As shown in the Fig. 3 embodiment, the anode sleeve 21' may be formed with one or more inwardly extending, longitudinally spaced apart, circumferential ribs 36', providing electron blocking shoulders comparable to the shoulder portions 36 and disposed in position to block electron paths of the sort shown at G, H and J, thereby aiding in the exclusion of electrons from the cathode supporting envelope portions 15. In order to maintain adequate electrical spacement between the cathode structure 12 and the surrounding ribs 36', the cathode carrying stem may be provided with necked-in portions 37, opposite said ribs 36, and defining outstanding ribs 37' on the cathode in staggered or offset relation with respect to the ribs 36' and the shoulder 36 on the cathode enclosing sleeve 21'. The alternating or staggered relation of the ribs 36' and 37' tends to concentrate and shape the electrical force field extending therebetween in order to affect the curvature of electron paths alongside of the cathode, to thereby increase the likelihood of electron impingement upon the blocking ribs 36' or the shoulder 36 and consequently reduce the possibility of electron impingement upon the glass envelope portion 15.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction, and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the forms herein disclosed being preferred embodiments for the purpose of illustrating the invention.

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The invention is hereby claimed as follows:

1. In an X-ray generating tube, having an electron emitting cathode and a cooperating anode facing the cathode and therewith enclosed in a sealed envelope, the cathode being supported on an insulating cathode mounting portion of said envelope, the combination, with said cathode, of electron shielding means on said envelope and comprising a flange disposed at the anode remote end of the cathode, between the cathode and said insulating portion of the envelope, said flange defining an opening of area comparable with the transverse area of the cathode and sized to permit the cathode to be snugly yet freely passed through the opening, during assembly of the cathode in the envelope, whereby said flange may extend inwardly sufficiently to intercept substantially all electrons traveling toward said cathode mounting portion of the envelope, along outwardly curving paths alongside of the cathode.

2. In an X-ray generating tube, having an electron emitting cathode and a cooperating anode facing the cathode and therewith enclosed in a sealed envelope, the cathode being supported on an insulating cathode mounting portion of said envelope, the combination, with said cathode, of electron shielding means on said envelope and comprising a flange disposed at the anode remote end of the cathode, between the cathode and said insulating portion of the envelope, said flange defining an opening of size permitting the cathode to snugly yet freely pass therethrough during assembly of the cathode in the envelope, said flange having width sufficient to intercept substantially all electrons traveling past the cathode toward said cathode carrying portions of the envelope, along outwardly curving cathode repelled paths.

3. In an X-ray generating tube, having an electron emitting cathode and a cooperating anode facing the cathode and therewith enclosed in a sealed envelope, the cathode being supported on an insulating cathode mounting portion of said envelope, the combination, with said cathode, of electron shielding means on said envelope and comprising a sleeve of electrical conducting material in position encircling said cathode and having an intumed circumferential lip disposed at the anode remote end of the cathode, between the cathode and said insulating portion of the envelope, said lip defining an opening of size substantially equal to the transverse area of the cathode and extending inwardly sufficiently to intercept substantially all electrons traveling toward said cathode mounting portion of the envelope, along outwardly curving paths alongside of the cathode.

4. In an X-ray generating tube, having an electron emitting cathode and a cooperating anode facing the cathode and therewith enclosed in a sealed envelope, the anode being supported on an insulating anode mounting portion of said envelope, the combination, with said anode, of electron shielding means comprising an outwardly flared skirt, on the cathode remote end of said anode, in position to intercept substantially all electrons traveling toward said anode mounting portion of the envelope, along inwardly curving paths alongside of the anode.

5. In an X-ray generating tube, having an electron emitting cathode and a cooperating anode facing the cathode and therewith enclosed in a sealed envelope, the anode being supported on an insulating anode mounting portion of said envelope, the combination, with said anode, of electron shielding means comprising a sleeve of electrical conducting material on said envelope in position encircling said anode and terminal end disposed opposite the cathode remote end of the anode, and an outwardly flared skirt, on said cathode remote end of the anode and extending within and beyond the said terminal end of the sleeve, in position to intercept substantially all electrons traveling within said sleeve and

toward said anode mounting portion, along paths alongside of and curving inwardly toward said anode.

6. In an X-ray generating tube, having an electron emitting cathode and a cooperating anode facing the cathode and therewith enclosed in a sealed envelope, said anode and cathode being supported upon anode and cathode mounting envelope portions of insulating material, the combination, with said anode and cathode, of electron shielding means for guarding said envelope portions against electron impingement comprising a flange disposed at the anode remote end of the cathode, between the cathode and said insulating portion of the envelope, said flange defining an opening of area substantially equaling the transverse area of the cathode and sized to permit the cathode to be snugly yet freely passed through the opening, during assembly of the cathode in the envelope, whereby said flange may extend inwardly sufficiently to intercept substantially all electrons traveling toward said cathode mounting portion of the envelope, along outwardly curving paths alongside of the cathode, said anode having an outwardly flared skirt on the cathode remote end of said anode, in position to intercept substantially all electrons traveling toward said anode mounting portion of the envelope, along inwardly curving paths alongside of the anode.

7. In an X-ray generating tube, having an anode and cathode enclosed in a sealed envelope embodying a tubular anode portion carrying the anode sealed in an end thereof and a cathode mounting portion of insulating material, sealed to the anode remote end of said tubular portion and supporting the cathode in anode facing position immersed in said tubular anode portion, the combination, with said anode portion, of means forming an inwardly extending flange on the said tubular anode portion, opposite the anode remote end of the cathode and between it and the said cathode mounting portion, said flange defining an opening of size permitting the cathode to snugly yet freely pass therethrough during assembly of the cathode in the envelope, said flange being sufficiently wide to intercept substantially all electrons traveling past the cathode toward said cathode carrying portions of the envelope, along outwardly curving cathode repelled paths.

8. In an X-ray generating tube, having an anode and cathode enclosed in a sealed envelope embodying a tubular anode portion carrying the anode sealed in an end thereof and a cathode mounting portion of insulating material, sealed to the anode remote end of said tubular portion and supporting the cathode in anode facing position immersed in said tubular anode portion, the combination, with said anode portion, of a collar sealed, on one side, to the anode remote end of the tubular anode portion, said collar, on its other side, being sealed to said cathode mounting portion, said collar having portions extending inwardly of said tubular anode portion to form a circumferential electron intercepting shoulder on said anode portion at the anode remote end of the cathode, said shoulder defining an opening of size permitting the cathode to snugly yet freely pass therethrough during assembly of the cathode in the envelope, said shoulder being sufficiently wide to intercept substantially all electrons traveling past the cathode toward said cathode carrying portions of the envelope, along outwardly curving cathode repelled paths.

9. In an X-ray generating tube, having an anode and cathode enclosed in a sealed envelope embodying a tubular anode portion carrying the anode sealed in an end thereof and a cathode mounting portion of insulating material, sealed to the anode remote end of said tubular

portion and supporting the cathode in anode facing position immersed in said tubular anode portion, the combination, with said anode portion, of means forming an inwardly extending flange on the said tubular anode portion, opposite the anode remote end of the cathode and between it and the said cathode mounting portion, said flange defining an opening of size permitting the cathode to snugly yet freely pass therethrough during assembly of the cathode in the envelope, said flange being sufficiently wide to intercept substantially all electrons traveling past the cathode toward said cathode carrying portions of the envelope, along outwardly curving cathode repelled paths, said tubular anode portion having an inwardly extending circumferential rib defining an opening of size substantially equal to that of the flange defined opening, said cathode having a neck portion of reduced size extending in said opening.

10. In an X-ray generating tube, having an anode and cathode enclosed in a sealed envelope embodying a tubular anode portion carrying the anode sealed in an end thereof and a cathode mounting portion of insulating material, sealed to the anode remote end of said tubular portion and supporting the cathode in anode facing position immersed in said tubular anode portion, the combination, with said anode portion, of means forming an inwardly extending flange on the said tubular anode portion, opposite the anode remote end of the cathode and between it and the said cathode mounting portion, said flange defining an opening of size permitting the cathode to snugly yet freely pass therethrough during assembly of the cathode in the envelope, said flange being sufficiently wide to intercept substantially all electrons traveling past the cathode toward said cathode carrying portions of the envelope, along outwardly curving cathode repelled paths, said tubular anode portion having a plurality of spaced circumferential ribs defining openings of size substantially equal to that of the flange defined opening, said cathode having neck portions of reduced size extending in said openings.

11. In an X-ray generating tube, having an anode and cathode enclosed in a sealed envelope embodying a tubular anode portion carrying the anode sealed in an end thereof and a cathode mounting portion of insulating material, sealed to the anode remote end of said tubular portion and supporting the cathode in anode facing position immersed in said tubular anode portion, the combination, with said anode portion, of a collar sealed, on one side, to the anode remote end of the tubular anode portion, said collar, on its other side, being sealed to said cathode mounting portion, said collar having portions extending inwardly of said tubular anode portion to form a circumferential electron intercepting shoulder on said anode portion at the anode remote end of the cathode, said shoulder defining an opening of size permitting the cathode to snugly yet freely pass therethrough during assembly of the cathode in the envelope, said shoulder being sufficiently wide to intercept substantially all electrons traveling past the cathode toward said cathode carrying portions of the envelope, along outwardly curving cathode repelled paths, said opening being flared in said collar in a direction away from the anode and immersed cathode and toward the cathode mounting portions of insulating material.

#### References Cited in the file of this patent

#### UNITED STATES PATENTS

|           |           |                |
|-----------|-----------|----------------|
| 1,974,703 | Bouwers   | Sept. 25, 1934 |
| 2,168,780 | Olshevsky | Aug. 8, 1939   |