Aug. 24, 1937. A. BOUWERS 2,090,722

X-RAY TUBE

Filed Oct. 22, 1935

Fig. 1

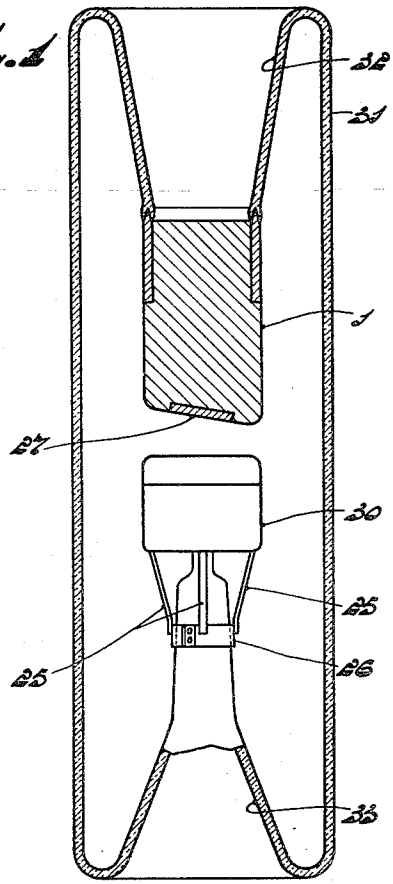


Fig. 5

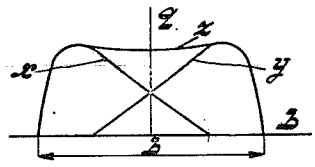


Fig. 4

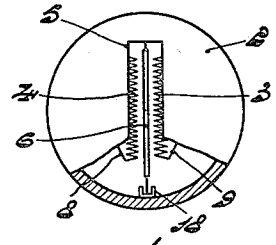


Fig. 3

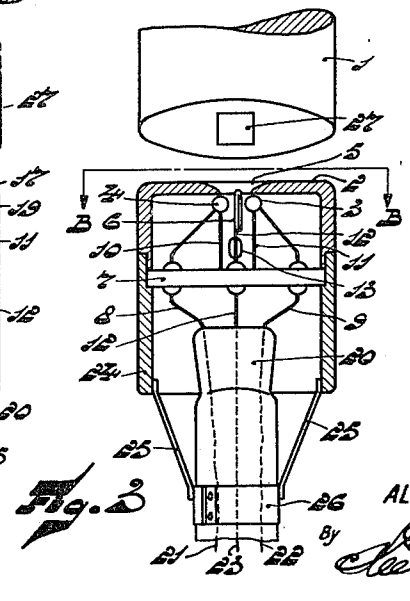
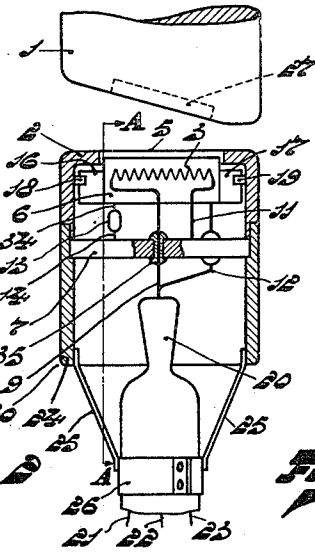


Fig. 2



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UNITED STATES PATENT OFFICE

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X-RAY TUBE

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Application October 22, 1935, Serial No. 46,204
In Germany November 9, 1934

4 Claims. (Cl. 250—35)

My invention relates to X-ray tubes having a variable focal spot and more particularly to X-ray tubes in which an auxiliary electrode is used for varying the size of the focal spot.

The size of the focal spot of X-ray tubes can be varied by changing the potential difference between a focusing device or an auxiliary electrode, and the incandescible member of the cathode, whereby the size of the focal spot can be increased or decreased in accordance with the individual load being applied to the tube.

In X-ray tubes using an auxiliary electrode, a spreading effect on the cathode rays given off by the incandescible cathode can be obtained by applying to the auxiliary electrode a potential which is negative with respect to the cathode; the size of the focal spot being increased by increasing the potential difference. In such cases the auxiliary electrode acts as a spreading device.

For this purpose several types of spreading devices have been used. For instance the incandescible member is arranged in a ring and an auxiliary electrode in the form of a metal pin extends centrally through the ring. In another construction a wire helically wound in the form of a tube extends to the front of the incandescible member. Such types of spreading devices, however, had the disadvantage—which was particularly noticeable in the case of elongated focal spots—that they caused the intensity of the electron bombardment over the focal spot to be uneven when the spreading device was in operation. Because of this, the focal spot was weakly loaded in the central portion and was strongly loaded over strips near its outer edges, with the result that the definition of the X-ray picture was much poorer than if the focal spot were evenly loaded throughout its entire surface.

In accordance with the present invention the above-mentioned disadvantages are overcome and an even loading of the focal spot is obtained by arranging the spreading device in the plane of symmetry between two parallel incandescible elements which are spaced apart and serve as the incandescible cathode. The incandescible cathode preferably consists of two helically-wound filaments, whereas the spreading device is preferably formed as a metal strip located in the plane of symmetry between these filaments.

In order that my invention may be clearly understood and readily carried into effect, I will more fully describe same with reference to the accompanying drawing, in which:

Figure 1 is a cross-sectional elevation of an X-ray tube according to the invention;

Figure 2 is an enlarged cross-sectional view of a portion of Figure 1;

Figure 3 is a cross-sectional view taken on lines A—A of Figure 2;

Figure 4 is a partly sectionized view taken on line B—B of Figure 3;

Figure 5 is a diagram for use in connection with the explanation of the spreading device according to the invention.

The X-ray tube shown in Figure 1 comprises a vitreous envelope 31 forming two re-entry portions 32 and 33. Hermetically sealed to and supported by the re-entry portion 32 is an anode 1 of good heat-conductive material, for instance copper, having a target 27 of highly refractory material, for instance tungsten. Supported from the reentry portion 33 by means of a ring 26 and four arms 25 is a cathode structure 30.

As shown in Figs. 2 to 4, the cathode structure 30 consists of a cup-shaped focusing device 2 having on its upper side an aperture 5. Secured to the focusing device 2 and extending downwards therefrom is a cylindrical shielding member 24 to which the arms 25 are secured. A metal plate 7 suitably supported between the focusing device 2 and the cylinder 24 serves as a shield.

Within the focusing device 2 and arranged parallel to each other behind the aperture 5 are two incandescible cathode elements 3 and 4 having the form of helically-wound filaments. The element 3 is supported from the plate 7 by means of lead supports 9 and 11. The lead 11 is electrically connected to the plate 7, whereas the lead 9 passes through the plate 7 and is insulated therefrom and secured thereto by means of a glass bead 35. In a similar manner the cathode element 4 is supported from plate 7 by lead supports 8 and 10. The leads 8—9 are hermetically sealed in a pinch 20 of the re-entry portion 34 and are connected to lead wires 21 and 22 respectively. Thus the cathode elements 3 and 4 are connected in series by leads 10 and 11 and plate 7 and the heating current is supplied thereto through the leads 21 and 22.

Arranged between the cathode elements 3 and 4 and parallel thereto is a spreading device 6. The spreading device 6 is in the form of a bent-over metal plate and is insulatingly supported from the plate 7 by rods 14 and 34 and lead support 12. The rods 14 and 34 are secured to the plate 7 and the device 6 respectively, and are secured to and insulated from each other by means of a glass bead 13. The lead 12, which passes through the plate 7 and is secured and insulated therefrom in a manner similar to that described

in connection with leads 8 and 9, is hermetically sealed in the pinch 20 and is connected to a lead wire 23.

To insure the correct positioning of the spreading device 6 with respect to the walls of the focusing device 2, two small plates 16 and 17 of insulating material, for instance mica, are pressed between the folds of the bent-over plate 6 and extend from each end thereof. The plates 16 and 17 fit into U-shaped prongs 18 and 19 respectively, secured to the inner side of the focusing device 2 (see Fig. 4), and thus prevent any lateral movement of the spreading device 6.

To cause spreading of the cathode rays emitted by the elements 3 and 4—and hence a change in the width of the focal spot—a negative potential relative to the cathodes 3 and 4 can be applied to the spreading device 6 by means of the supply wire 23. If desired this potential may be automatically controlled in known manner in accordance with the amount of anode current being passed through the tube.

Due to the use of the two cathode elements 3 and 4, there are actually produced upon the target 27 two individual focal spots which overlap each other to some extent. By applying a negative potential to the spreading device 6 these two individual focal spots are pushed away from each other and together form one focal spot over the surface of which the impinging electrons are substantially evenly distributed.

This is shown diagrammatically in Fig. 5 in which the ordinates represent the intensity of the electron bombardment or the specific loading on the focal spot, and the abcissae represent the width of the focal spot. One of the cathode elements 3 or 4 would individually produce upon the target a focal spot whose specific loading is represented by the curve x, whereas the other element would produce a second focal spot whose specific loading follows the curve y; the curves x and y being of the same shape, but reversed on the abscissa axis.

The curve z, which represents the actual specific loading over the width b of the focal spot, is the sum of curves x and y. The curve z is substantially flat over the greater portion of the width b and indicates a substantially even loading of the focal spot. Thus the operation of the spreading device according to the invention will not cause any decrease in the sharpness of the X-ray images due to uneven loading of the focal spot, and instead of merely a division of this surface into portions which are separated to a greater or lesser degree, an actual variation in the size of the loaded anode surface is achieved.

By applying a more negative potential to the spreading device 6, the curves x and y move slightly outward so that the focal spot will be larger. The curve z becomes slightly convex thereby but as the two curves x and y remain overlapping, there will be no unloaded portions in the focal area.

While I have described my invention in connection with specific examples and in specific applications, I do not wish to be limited thereto, but desire the appended claims to be construed as broadly as permissible in view of the prior art.

What I claim is:

1. An X-ray tube comprising an envelope, an anode, and a cathode structure comprising two elongated incandescible elements spaced apart and extending substantially parallel to each other, a spreading device disposed in the plane of symmetry between said elements and electrically insulated therefrom, and a separate lead for supplying a biasing voltage to said device.

2. An X-ray tube comprising an envelope, an anode having a target, and means to produce on said target substantially uniformly-loaded focal spots of varying size, said means comprising two elongated incandescible elements, spaced apart with their longitudinal axes substantially parallel, a spreading device disposed in the plane of symmetry between said elements and electrically-insulated therefrom, and a lead for applying a biasing voltage to said device.

3. An X-ray tube comprising an envelope, an anode having a target thereon, means to produce upon said target two partly overlapping focal spots comprising two elongated incandescible elements spaced apart with their longitudinal axes substantially parallel, and means comprising a spreading device disposed in the plane of symmetry between said elements to spread said focal spots apart, said spreading device being electrically-insulated from said elements and being adapted to be negatively biased with respect to said elements.

4. An X-ray tube comprising an envelope, an anode having a target thereon, two elongated incandescible elements spaced apart with their axes substantially parallel for producing upon said target two partly overlapping focal spots, a metal strip disposed in the plane of symmetry between said elements and electrically insulated therefrom, and means to apply to said strip a negative potential relative to said elements to move said focal spots away from each other.

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