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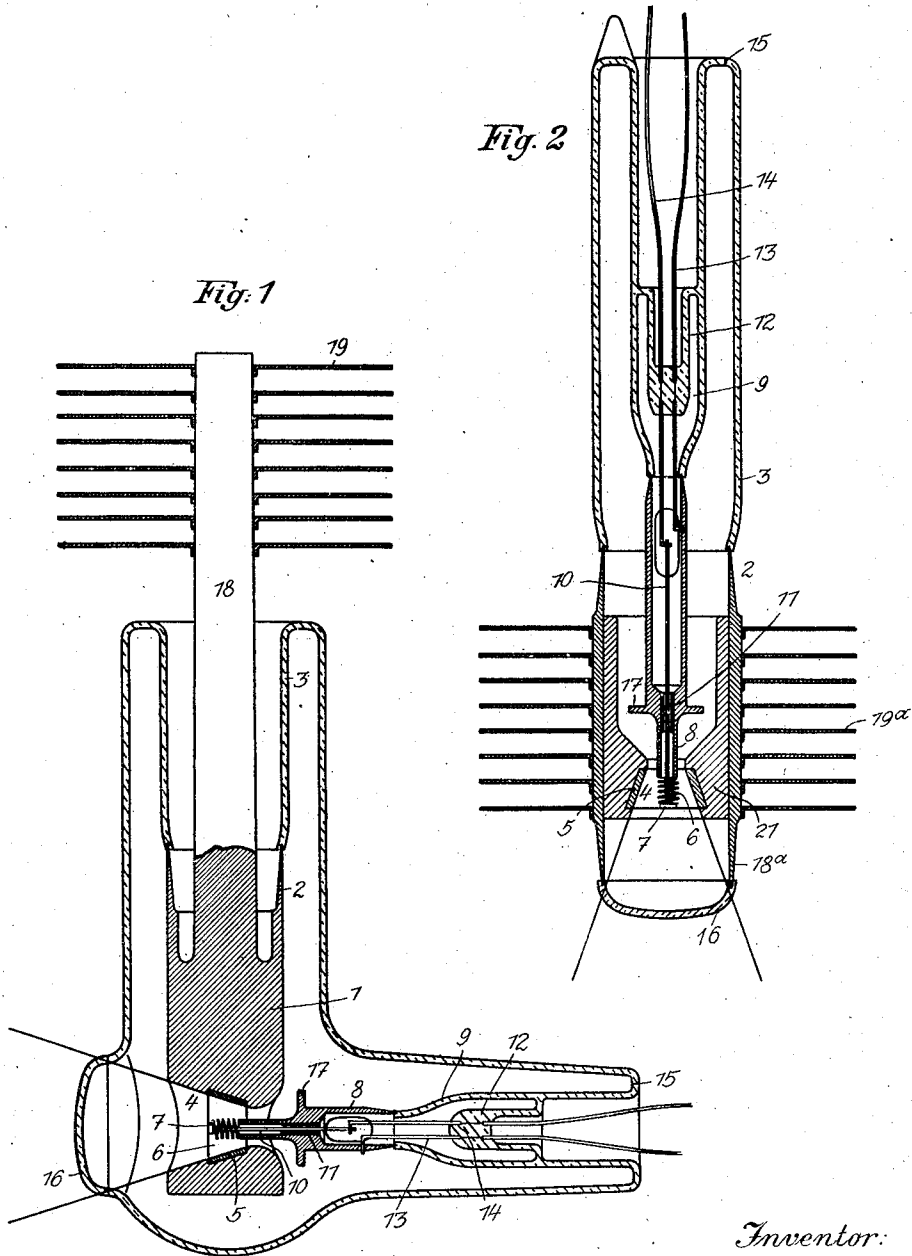
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VACUUM TUBE FOR THE PRODUCTION OF SOFT X-RAYS

Filed April 15, 1926

2 Sheets-Sheet 1



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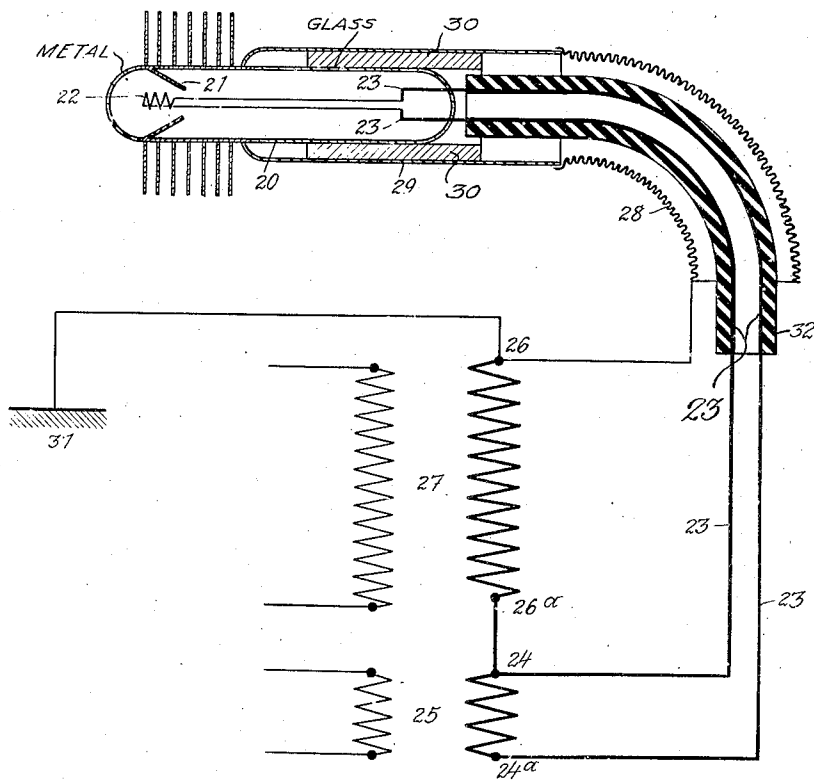
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Fig. 3



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UNITED STATES PATENT OFFICE.

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VACUUM TUBE FOR THE PRODUCTION OF SOFT X RAYS.

Application filed April 15, 1926, Serial No. 102,130, and in Germany April 25, 1925.

My present invention relates to X-ray tubes, and particularly to X-ray tubes employing incandescent cathodes. The object of my invention is to provide a simple, compact and readily cooled vacuum tube of the above indicated class which is adapted for the production of soft X-rays, such as are used, for instance, for the treatment of skin diseases. An important advantage of the new tube is the fact that it permits to reach a comparatively large field or area with the X-ray radiation, even when such field or area is located close to the source from which the X-rays radiate, or the so-called focal spot.

Satisfactory embodiments of my improved X-ray tube are illustrated by the accompanying drawings, in which Figs. 1, 2 and 3 are longitudinal sections illustrating vacuum tubes embodying my invention, Fig. 3 also indicating suitable electrical circuit arrangements.

In Fig. 1 the anti-cathode body 1 is shown as provided with an annular extension 2 the sharp edge portion of which is connected by fusing with the tubular portion 3 of the vacuum tube. This anti-cathode may be made of any suitable metal. The inner end of the anti-cathode is provided with a tapering or conical perforation 4, the axis of which is perpendicular to that of the anti-cathode 1. Along a portion of said perforation 4 is located a frusto-conical lining 5, made of tungsten, tantalum, platinum or other suitable material, and serving for the production of the X-rays. The inner surface of this lining is preferably flush with the adjacent surface of the anti-cathode perforation 4. Located axially within the lining 5 is the incandescent cathode 6, which may, for instance, be of the coiled type shown and serves to produce an annular focal spot on said lining 5. The free end of the incandescent cathode 6, which is located toward the wide end of the lining 5, is connected with a metal disk 7, the other end of said cathode being secured to a tubular metallic carrier 8. This carrier is connected with a glass carrier 9 by fusion and surrounds at a distance a wire 10, one end of which is fastened to the disk 7, said wire being arranged axially within the carrier 8, and being preferably separated therefrom by an insulating sleeve 11.

With the glass carrier 9 is connected a glass socket 12, through which extend the lead wires 13, 14, for the supply of the heating current to the cathode 7. The wire 13 is connected with the metallic carrier 8 and the wire 14 is connected with the wire 10. The glass carrier 9 is connected by fusing in the usual manner with the tubular portion 15 of the vacuum bulb. At a point in registry with the perforation 4 of the anti-cathode body 1, the vacuum tube is provided with a window 16, made of glass which has a high degree of permeability to X-rays. For instance, this window may be made of the lithium borate glass known as Lindemann glass. As this window is located in the immediate vicinity of the annular focal spot produced on the lining 5, the exit angle of the bundle of X-rays is relatively large, and the result is that even at a short distance from said focal spot, a large field or area can be covered by the X-rays. These rays are of a very soft character, and as their intensity is low, so that they are appreciably absorbed even by the air, it is a material advantage to have them spread over a wide field at a very short distance from the vacuum tube. Adjacent to that end of the perforation 4, through which the carrier 8 extends, the latter is provided with a disk 17, serving as a screen to prevent the escape of X-rays in that direction, that is, towards the tubular portion 15. In order to keep the anti-cathode body 1 cool, it is made or connected with a cooling rod 18, the outer end of which projects beyond the tube 3 and is preferably provided at its exposed portion with heat radiating disks or fins 19.

In operating the tube described above, I connect the anti-cathode with the positive pole of a source of high potential current, for instance, from 20,000 to 25,000 volts, while the cathode 6 is connected with the negative pole of said source. The heating current is supplied in the well known manner to the cathode 6, through the wires 13, 14, so that this cathode will project cathode rays on the lining 5 which surrounds it. The impact of these cathode rays produces X-rays and owing to the arrangement shown and described, these X-rays can escape from the vacuum tube, only through the window 16, the escape of the X-rays in the opposite direction being prevented by the disk or screen 17.

The heat produced at the lining 5 finds a short way to the outside through the cooling rod 18, provided with the fins or other heat radiating appliance 19, so that the heat is quickly dissipated, and premature destruction of the anti-cathode, and particularly of its lining 5, is prevented.

The X-ray tube shown in Fig. 2 is of the same general character as the one shown in Fig. 1. The perforation 4, however, is not arranged at right angles to the axis of the anti-cathode 21, but co-axially therewith. This anti-cathode, which is of tubular character, practically forms a portion of the outer wall of the tube. The metallic carrier 8 of the incandescent cathode 6 is, in this form of the invention, located within the anti-cathode and extends lengthwise thereof. A cooling sleeve 18*, made of metal and provided with heat radiating disks or fins 19*, is slipped directly on the outer surface of the anti-cathode 21. The window 16 through which the soft X-rays leave the X-ray tube is, in this form of my invention also, located in the longitudinal axis of the anti-cathode body 1, and in axial alignment with the frusto-conical sleeve or lining 5. The construction shown in Fig. 2 affords even a better dissipation of the heat from the X-ray tube, according to Fig. 1, for the reason that the distance from the lining 5 to the cooling body 18*, is shorter than the distance from the lining 5 to the cooler 18, 19, and furthermore, the cross-section of the bodies which are employed to carry the heat away from the lining 5, is greater in Fig. 2 than in Fig. 1. Therefore, the tube according to Fig. 2 will be able to stand a higher load than the one according to Fig. 1. Furthermore, the glass portions of the tube shown in Fig. 2 can be protected readily by surrounding jackets made of suitable material, for instance, the one known under the trade name of "Pertinax".

The exhaustion of a tube constructed according to Fig. 2 is preferably conducted by first heating the entire vacuum tube in a pump box to a temperature of from 400 to 450° centigrade, according to the temperature which the glass employed can withstand, and at the same time the Lindemann window which at such temperature would become soft, is cooled by blowing cold air against it. At the same time the cathode is brought to incandescence by passing a current through it. After this operation has been continued for a sufficient length of time, the anode or anti-cathode of the tube is heated to red heat by an external source of heat, for instance, by means of an annular gas burner or an electric heating body of corresponding shape, and the vacuum pump is operated to remove air from the tube. After the removal of air has been continued to the proper point, the vacuum tube is filled with a pure rare gas, for instance, helium or neon,

until the function of the tube remains uniform or constant at a pressure of about 10^{-2} millimeters of mercury. When this condition has been attained the vacuum tube is sealed off from the pump by fusion, in the well known manner.

With a tube constructed according to Fig. 2, the anti-cathode can be readily grounded in such a manner that the attendant can not touch any part carrying high voltage current, and therefore the attendant will not be exposed to any danger of shocks. For this purpose, as shown in Fig. 3, the tubular anti-cathode 21 of the vacuum tube 20 is connected with a metal hose 28, by a metal sleeve 29. This metal hose 28 is grounded by being connected with one terminal 26 of the high tension transformer 27, which terminal is grounded at 31. The other terminal 26* of the secondary of said transformer 27 is connected with the terminal 24 of the auxiliary transformer 25, which is employed to supply the heating current to the incandescent cathode 22, by means of wires 23, which may be conducted through a tube 32 made of rubber or other insulating material. The glass wall of the vacuum tube 20 may be insulated from the metal sleeve 29, by means of a sleeve 30 made of rubber or other insulating material. It will be noted that the anti-cathode 1, 2 (Fig. 1) or 21 (Figs. 2 and 3) virtually forms a portion of the wall of the X-ray tube and is therefore very firmly supported and not liable to be thrown out of its proper position by jars or other influences.

Various modifications may be made without departing from the nature of my invention as defined in the appended claims.

I claim as my invention:

1. A vacuum tube for the production of soft X-rays, comprising an incandescent cathode, a flaring anti-cathode surrounding said cathode at a distance, a window of a material of high permeability to X-rays, located in line with the longitudinal axis of the cathode at that portion of the vacuum tube toward which said anti-cathode flares, and a disk or screen likewise located in line with the longitudinal axis of the cathode, but at the opposite side of the X-ray producing anti-cathode, to prevent the X-rays from issuing in a direction away from said window.

2. A vacuum tube for the production of soft X-rays, comprising an incandescent cathode, an anti-cathode surrounding said cathode at a distance and flaring lengthwise thereof, a window of a material having a high permeability to X-rays, located at that portion of the vacuum tube toward which said anti-cathode flares, wires for supplying a heating current to said cathode, and a metal hose surrounding said wires and connected with the anti-cathode, said metal hose being grounded.

3. A vacuum tube for the production of

soft X-rays, comprising an evacuated bulb provided with a window of higher permeability to X-rays than the other portions of the bulb, an anti-cathode constituting virtually a portion of the wall of said bulb and forming a chamber which flares toward said window, and an incandescent cathode extend-

ing within said chamber and adapted to produce an annular focal zone upon the inner surface of the anti-cathode. 10

In testimony whereof I have hereunto set my hand.

KARL WILHELM DAUMANN.