May 28, 1929. C. T. ULREY ET AL 1,715,152

X-RAY TUBE

Filed April 30, 1926

FIG. 1

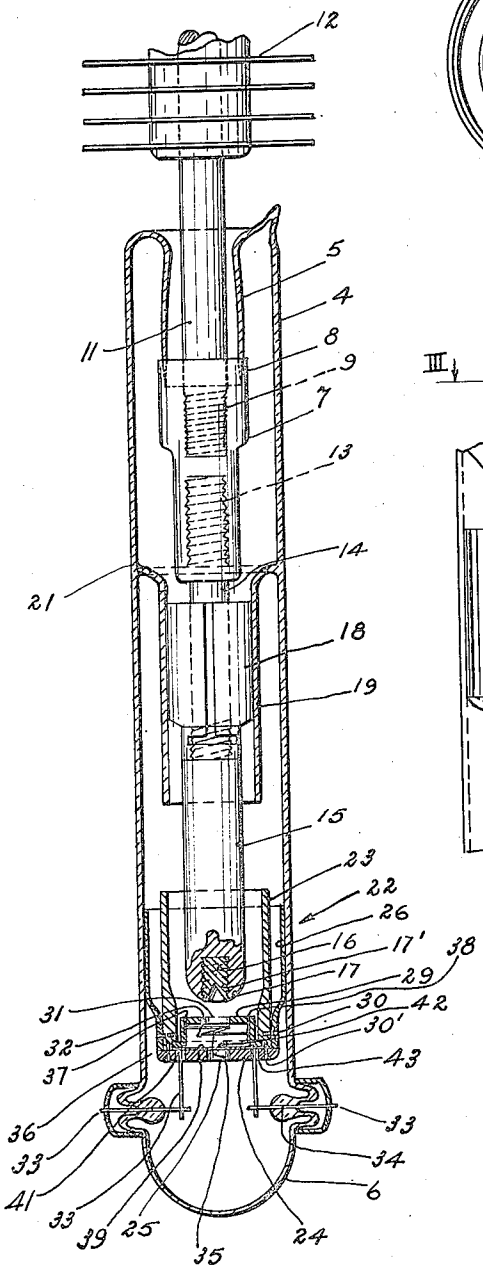


FIG. 3

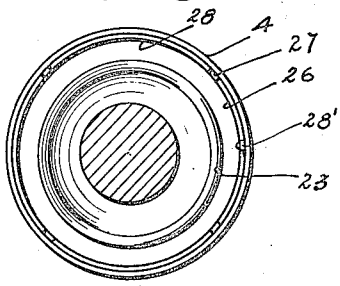
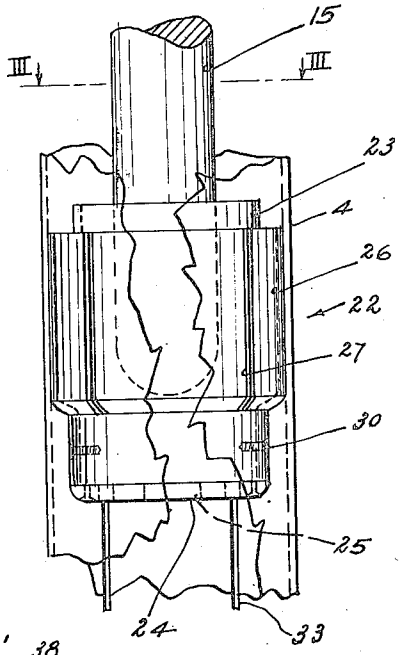


FIG. 2



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UNITED STATES PATENT OFFICE.

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X-RAY TUBE.

Application filed April 30, 1926. Serial No. 105,640.

This invention relates to X-ray tubes and more particularly to such tubes adapted for general radiographic purposes.

The invention comprises certain improvements in the form of X-ray tube illustrated and described in the application of Clayton T. Ulrey, Serial No. 38,395, filed June 20, 1925.

The construction of the X-ray tube as disclosed by the aforementioned application for patent, comprises a cylindrical envelope having a reentrant tube of high heat-resistant glass sealed at one end of the envelope and extending to near the other end thereof. This tube surrounds the anode stem and is also adapted to support the cathode. The inner end of the reentrant tube extends beyond the face of the anode and is enclosed by a metal cup which is adapted to screen out undesirable X-radiation. The metal cup is of such size that it extends to each side of the face of the anode. In addition to supporting the metal cup, the reentrant tube also supports an insulating focusing device within which the thermionic cathode is supported.

In a tube of such design, if the voltage is high, electrical stresses will be set up in that portion of the reentrant tube disposed within the metal cup and adjacent the face of the anode, due to the electrostatic pull between the positively charged anode and the negatively charged metal cup.

In order to adapt a tube of the foregoing design for general radiographic purposes, it has been found desirable to modify somewhat, the internal structure of the tube, particularly at that portion of the tube where electrical stresses are set up.

According to the present invention this has been accomplished by supporting the metallic cup together with the focusing device and hot cathode upon the inner sides of the glass envelope and shortening the reentrant tube housing to such an extent that it is not subjected to detrimental electrical stresses.

Referring to the drawings for a better understanding of the invention,

Fig. 1 is a longitudinal view partly in cross-section, of an X-ray tube embodying the invention.

Fig. 2 is an enlarged view of the metal cup, illustrating the manner in which it is supported within the glass envelope; and,

Fig. 3 is a view of the metal cup looking in the direction of the arrows in Fig. 2.

An embodiment of the invention may comprise a glass envelope 4 of cylindrical form having a reentrant tube 5 at one end, and a hemispherical glass enclosure 6 at its other end. To the reentrant tube 5 is sealed a support coupling 7, preferably of copper, having a thin annular flange 8 to which the reentrant tube 5 is hermetically sealed. The coupling has a threaded recess 9 in which is screwed a copper or other metallic rod 11 which supports a radiator 12. Another threaded opening 13 in the coupling, oppositely disposed with respect to the recess 9, engages the threaded end 14 of the anode 15.

A target 16 of thorium or other good ray-radiating material, is mounted in the rounded face 17 of the anode. The target may be formed as a cone 17′ so as to provide a larger surface upon which the electrons impinge and at the same time provide for a sharp focus or concentrated beam of X-rays. A spring sleeve 18 threadedly secured to the anode 14 frictionally engages the inner surface of a reentrant tube 19, to assist in supporting and maintaining the anode in proper position with respect to the cathode and other elements subsequently to be described.

The reentrant tube 19 is sealed or fused at 21 to the envelope 4 and is so spaced from the anode shank, that no detrimental ionization occurs within such space. The tube 19 extends within the envelope to a point beyond the juncture of the anode 15 and the spring sleeve 18.

Disposed around the end of the anode is an X-ray screen 22 consisting of nickel-iron. The X-ray screen comprises a cylinder 23, serving to screen out undesirable X-rays, a cap 24, having an opening 25 therein for the exit of the desirable X-rays, and a spring sleeve 26, slit at 27 (Fig. 3) so as to form four resilient tongues 28. The spring sleeve is of such character with respect to the inner diameter of the envelope 4, that when forced within the latter, it will frictionally engage the same with sufficient force to hold it in proper position with respect to the face of the target and end of the anode. If desired, the glass may be heated and pressed inwardly to engage an opening 28′ in the spring sleeve to

lock the screen securely in position. The spring sleeve may be secured to the cylinder 23 by screws 30 and the cap 24 may be fastened to the cylinder 23 by screws 30'.

Mounted within the X-ray screen is an insulating focusing member 29 having an aperture 31 in axial alignment with the opening 25 and the longitudinal axis of the anode 15. A helical wire 32, serving as a thermionic cathode, is mounted within the focusing cup. Connections to the cathode for supplying electrical current thereto are provided in the form of leading-in conductors 33, having portions 34 thereof capable of forming an hermetic seal with the glass envelope. The cathode is so designed that it has an opening 35 for permitting the X-rays produced by electronic bombardment of the target 16 to emerge from the tube via the passageways 31, 35 and 25 and the glass enclosure 6.

The X-ray screen, focusing device and cathode are assembled outside of the tube 4 in the following manner. The friction sleeve 26 may first be secured by the screws 30 to the cylinder 23, after which the insulating focusing device 29 may be inserted in the end of the cylinder, annular shoulders 36 being provided for this purpose. The helical cathode 32 with the lead-wires 33 secured thereto may then be positioned within the focusing device, with the ends 37 of the leads inserted in openings 38 within the focusing member 29. A mica disk 39 having openings 41 through which the leads 33 are threaded and a central opening 42 for the X-rays may then be placed within the focusing member. The focusing member, cathode and mica disk may then be secured in position by means of the metal cap 24 which has openings 43 through which the lead wires 33 are threaded and a central opening 25. The cap is secured to the cylinder 23 by means of screws 30'. The assembly thus completed is inserted within the glass tube 4 through the end which is subsequently closed by the spherical glass closure 6. Previously to closing this end of the tube the seal wires 34 are secured to the lead wires 33 and sealed in the glass tube 4. The end of the glass tube 4 is then closed.

The spacing of the cathode with respect to the anode should be such that it is less than the mean free path of the electrons for the pressure of the gas within the envelope. For example, with a gaseous pressure of neon of 9 microns at room temperature (25° C.) the mean free path of the electrons is approximately 10 cm. It is preferable to employ a factor of safety so that the ionization current is negligible as compared with the pure electron current, and therefore, the spacing of the electrodes should not be greater than 1/10 of the mean free path of the electrons.

A tube constructed in accordance with the present invention has been devised and found to operate satisfactorily at 100,000 volts across the electrodes and with a current of 5 milliamperes flowing between the electrodes. Even though there is present a considerable pressure of neon, no detrimental ionization occurs, however, ionization is present since it may readily be measured by means of an ionization gage. We prefer to employ neon because of the relatively small quantity of ionization therein and furthermore, because it is not so readily absorbed by the materials composing the tube. The neon should be free of all other active gaseous constituents, but may contain inert gases such as helium. In addition the glass parts as well as the metallic parts of the tube, should be thoroughly freed of gas.

Although we have illustrated the metallic screen as disposed within the envelope, the same results can be secured by providing upon or against the outer surface of the envelope, a layer of metal, such as lead, or any suitable material which will effectively absorb X-rays. Furthermore, the screen may be combined with the casing member which is usually employed with tubes of this type.

Modifications of our invention may occur to those skilled in the art, however, such modification as come within the spirit and scope of the invention as defined by the appended claims are contemplated by us.

What is claimed is:

1. An X-ray tube comprising an envelope containing an inert gas at a substantial gas pressure, a reentrant insulating tube extending within said envelope, an anode within said reentrant tube and extending beyond the end thereof, an X-ray screen disposed around the end of said anode and spaced from and free from the end of said reentrant tube and a focusing device and thermionic cathode supported by said X-ray screen.

2. In an X-ray tube having an envelope housing an anode and an incandescable cathode, an X-ray screen surrounding the end of said anode, and resilient means for supporting said screen from the interior wall of said envelope.

3. An X-ray tube comprising an envelope containing neon at about nine microns pressure, a reentrant tube of insulating material, an anode supported by said reentrant tube and closely spaced therefrom, a cathode closely spaced from the face of said anode, an insulating focusing device surrounding said cathode, and an X-ray screen surrounding the face of said anode and supported by the inner wall of said envelope, said screen being out of contact with said reentrant tube.

4. An X-ray tube comprising an enclosing envelope, an anode and a cathode therein, said envelope containing an inert gas at a pressure exceeding 0.6 of a micron, a reentrant tube of insulating material through which said anode is sealed, an insulating sleeve surrounding the anode and supporting the same, and

a metallic X-ray screen disposed about the end of the anode out of electrical connection with said insulating sleeve.

5. An X-ray tube comprising an enclosing envelope, an anode and a cathode therein, said envelope containing an inert gas at a substantial pressure, an insulating sleeve surrounding said anode, a metallic screen disposed about said cathode and the end of said anode, and spaced in electrically non-conductive relation to said insulating sleeve.

In testimony whereof, we have hereunto subscribed our names this 28th day of April 1926.

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