Feb. 14, 1928.

1,659,133

W. D. COOLIDGE

X-RAY DEVICE

Filed Dec. 18, 1924

Fig. 1.

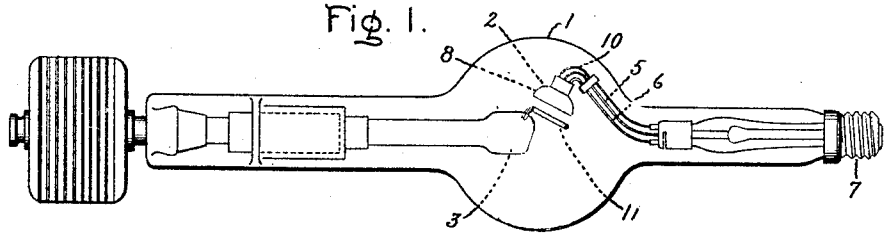


Fig. 2.

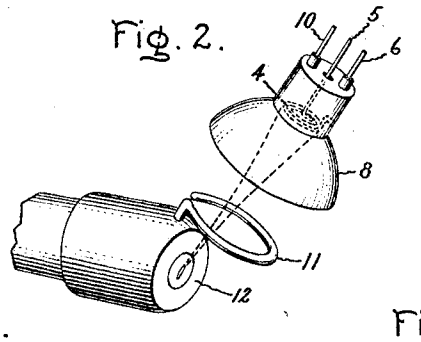


Fig. 5.

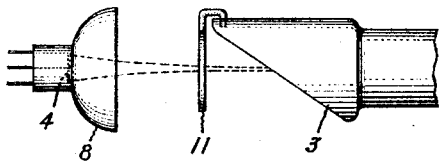


Fig. 4.

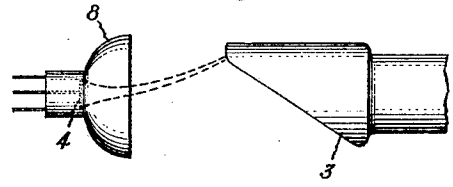
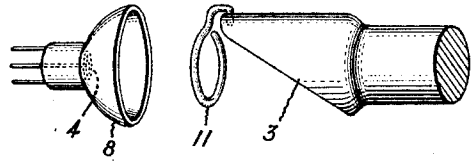


Fig. 3.



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His Attorney.

Patented Feb. 14, 1928. 1,659,133

UNITED STATES PATENT OFFICE.

WILLIAM D. COOLIDGE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

X-RAY DEVICE.

Application filed December 18, 1924. Serial No. 756,313.

The present invention comprises an improved X-ray tube and its object is to increase the energy capacity of such tubes, while still retaining sharpness of definition in the radiographs produced thereby.

X-ray tubes have been made with a straight line-shaped cathode so as to produce upon the target an elongated focal spot. If the X-rays emanating from such an elongated spot are utilized in a direction fore-shortening the elongated spot, as sharp outlines in the radiograph may be obtained as given by a circular focal spot having a diameter equal to the width of the elongated spot. The X-ray output of the elongated spot can be made greater than that of a circle by reason of its greater area.

Because of difficulties encountered in the construction and arrangement of the cathode and focussing devices, it has not been possible to secure a uniform distribution of energy over the focal spot in X-ray tubes containing linear shaped cathodes. Lack of uniformity of energy distribution entails a lowering in the allowable energy input per unit of focal area. The distribution may easily be so bad with a linear shaped cathode that nothing is gained by the elongation of the focal spot.

I have provided an X-ray tube constructed to cause a beam of electrons emitted from a non-linear cathode to impinge upon an elongated area on the anode or target surface. In accordance with my invention a round beam of cathode rays is produced which when intercepted by the target face at a grazing angle will produce a focal spot of elongated elliptical shape, which when foreshortened gives the effect of a small focus. My invention has been embodied in an X-ray device provided with a field modifying device whereby deflection of the circular electron beam from a desired direction with respect to the target face is prevented so as to produce the desired elongated focal spot.

Two embodiments of my invention are illustrated by the accompanying drawing; Fig. 1 showing in outline a complete X-ray device; Fig. 2 showing in perspective the electrodes of the device illustrated by Fig. 1. Fig. 3 illustrates in perspective the electrodes only of a modification and Figs. 4 and 5 illustrate the path of the electron beam under different conditions.

The X-ray tube shown in Fig. 1 is adapted to operate with a pure electron discharge and in general is constructed in accordance with the principles described in my prior patents and publications as now well understood. The tube essentially comprises a sealed, highly evacuated envelop 1 in which are contained a cathode 2 and an anode 3. As best shown in Fig. 2 the cathode comprises a filament 4 coiled into the shape of a generally flat spiral, a form which may be termed a broad surface cathode as distinguished from a line cathode. This filament is connected to the sealed-in conductors 5, 6, which are joined to an external screw base 7. The cathode is surrounded by a bell-shaped focussing device 8 which is supported by a wire 10 as well as the wire 6.

The anode 3 comprises a mass of copper connected to an external radiator and having imbedded therein on its face a plate of refractory metal. This type of X-ray tube is described particularly in my prior patent 1,326,029 issued on December 23, 1919. When the target surface is inclined with respect to the cathode in the absence of a field modifying device (such as about to be described) the circular beam of electrons emanating from the cathode follows a curved path being attracted to the toe of the anode as indicated in Fig. 4 by dotted lines, the electrons traveling at right angles to the equipotential surfaces of the electrostatic field. Hence the beam of electrons strikes the face of the anode nearly at right angles. The ellipticity of the focal spot under these conditions cannot be increased beyond a certain limit because of this deflection of the cathode beam.

In accordance with my invention I have provided a member 11 upon the anode whereby this deflection is prevented. This member may take the form of a nearly circular ring embedded at one end in the body of the copper anode as indicated at 12. The electrons emanating from the cathode 4 are caused to pass through the positively charged ring 11 in a somewhat converging nearly circular form, as the electric field between the focussing member 11 and the face of the anode 12 is substantially zero. As shown in Fig. 5 the electrons are not deflected from their path after passing through the ring 11 and strike the face of the anode at a glancing or grazing angle so as to produce an elliptical focal spot.

The size and shape of this elliptical focal spot may be varied as desired by arrangement and shapes of the described members in the tube, but ordinarily the length of the ellipse should be several times greater than the width. In the form of my invention shown in Figs. 1 and 2, a cathode is arranged out of line with the length axis of the anode and the charge-receiving face of the anode is nearly perpendicular to the longitudinal axis of the tube. The electrons emanating from the cathode spiral 4 are made to converge by the focussing member and pass as a narrow circular beam through the ring 11 and strike the anode face at a grazing angle producing a greatly elongated focal spot. The X-rays from the elongated focal spot may be readily utilized in a generally downward direction at such an angle that the focal spot is fore-shortened as much as desired, thus giving the same apparent effect as though the X-rays were emanating from a smaller spot.

In the arrangement shown in Figs. 3 and 5 the cathode 2 and the anode 3 are arranged on a common length axis, but the face of the target is inclined at an angle to the electron beam, which preferably is less than 45°. The target face preferably should be so much inclined that the cathode spot is an ellipse of which the major axis is several times larger than the minor axis. In this case the presence of the ring 11 also causes the electrons to be projected upon the face of the anode on an elongated area to enable the above described fore-shortening effect to be obtained.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. An X-ray tube comprising an evacuated bulb, a broad-surface cathode therein consisting of refractory wire, means for heating said cathode by passage of current, a focussing device whereby electrons emitted by said cathode are caused to converge, a target positioned to intercept said electrons at a grazing angle and means for equalizing the electrostatic field adjacent the face of said target.

2. An X-ray tube comprising an evacuated container, a broad surface cathode, means for focussing electrons emitted therefrom and a cooperating anode and a ring-shaped member mounted upon said anode in a position substantially parallel to said cathode, the charge-receiving face of said anode being inclined to said cathode at an angle so small that the focal spot is an ellipse having a major axis several times longer than the minor axis.

3. An X-ray tube comprising an evacuated bulb having arms substantially in line with each other and extending in opposite direc-directions, an anode sealed into one of said arms having a target surface which is arranged substantially at right angles to the main longitudinal axis of said tube, the cathode having conductors sealed into the opposite end of said tube, said conductors being bent into such shape that the cathode is out of line with the longitudinal axis and in a position to project an electron beam at an angle of less than 45° upon the target surface of said anode and a ring shaped member mounted upon said anode in such position that the electron beam will pass symmetrically therethrough to the anode without substantial deflection.

In witness whereof, I have hereunto set my hand this 17th day of December, 1924.

WILLIAM D. COOLIDGE.