W. D. COOLIDGE.

ROENTGEN RAY DEVICE.

APPLICATION FILED FEB. 5, 1916.

1,253,156. Patented Jan. 8, 1918.

Fig. 1.

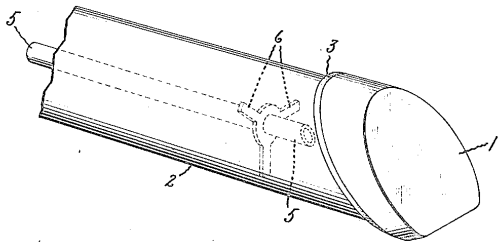


Fig. 2.

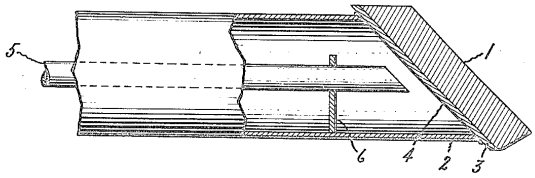


Fig. 3.

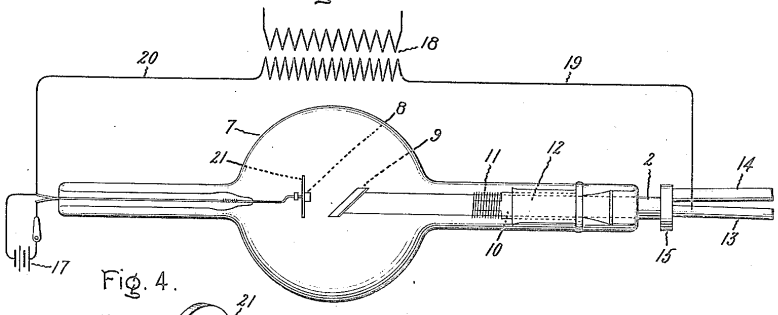
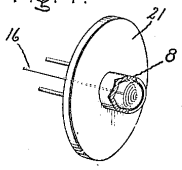


Fig. 4.



Inventor:
William D. Coolidge,
by Albert G. Davis
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UNITED STATES PATENT OFFICE.

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ROENTGEN-RAY DEVICE.

1,253,156. Specification of Letters Patent. Patented Jan. 8, 1918.

Application filed February 5, 1916. Serial No. 76,350.

To all whom it may concern:

Be it known that I, WILLIAM D. COOLIDGE, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Roentgen-Ray Devices, of which the following is a specification.

The present invention comprises an improvement in the construction of anodes for high powered electron discharge devices, particularly targets for X-ray tubes.

Roentgen ray devices are commonly operated with a variable current such, for example, as derived from the rectification of a high potential alternating current or when a rectifying tube is used, it may be connected directly to a transformer. In either case the heat generated at the target or anode varies in step with the energy input. In the X-ray devices operating by virtue of the ionization of residual gas, inputs of energy large enough to cause harmful effects because of the intermittent character of the heating can be impressed upon the tube for time intervals too short to cause damage, say for a second or two, due to the excessive heating of the bulb. However, X-ray tubes operating with a substantially pure electron discharge may be operated continuously without excessive heating of the bulb.

I have found that when an X-ray tube of this type is operated continuously with a relatively large energy input, for example, one or more kilowatts, that a mechanical disintegration of tearing of the anode results which is not observable with low powered apparatus. My experiments have shown that this disintegration is the result of the mechanical tearing caused by the rapid expansion and contraction taking place due to the intermittent conveyance of heat from the heat receiving face to the cooled section of the anode.

In accordance with my present invention the anode is preserved intact by making the energy receiving face of the anode of sufficient thickness to afford heat storage capacity great enough to transfer the variable heat input to the actively cooled parts of the metal at a rate nearly uniform. My invention is particularly applicable to an anode comprising a face plate of highly refractory metal, such as tungsten and a backing of other metal such, for example, as copper.

My invention will be more fully described in connection with the accompanying drawing in which Figure 1 illustrates an X-ray target in perspective; Fig. 2 is a cross-sectional view of the same, Fig. 3 illustrates an X-ray tube provided with a target made in accordance with my invention, and Fig. 4 is a detail view of a cathode.

Referring to Figs. 1 and 2 the target illustrated comprises a ray-receiving plate 1 consisting of tungsten or other highly refractory metal and a backing tube 2, the end wall 3 of which is in intimate heat-conveying relation to the plate 1. For example, when the end wall 3 of the cooling device consists of copper, a desired intimate weld may be secured by melting boronized copper in contact with the tungsten plate in a vacuum as described in my Patent 1,162,341 of November 30th, 1915. The copper plate 3 may then be soldered or welded to the tube 2 in any convenient way, for example, as indicated at 4. A tube 5 supported and centered by lugs 6 serves for the introduction of a cooling fluid, such, for example, as water. The target 1 should be relatively thick as compared with face plates heretofore employed in water-cooled X-ray targets. For example, in a tube capable of operating with a current of about 0.1 amperes at about 50,000 volts with currents of commercial frequency, for example, 60 cycles, a tungsten plate of about $\frac{1}{4}''$ in thickness should be used. With a plate of this thickness the heat delivery to the plate 3 is uniform enough to reduce the tearing or disintegrating effect of rapid expansion and contraction of the backing metal, sufficiently to give the X-ray tube a satisfactory life.

Fig. 3 shows one form of X-ray tube in which a target above described has been operated continuously for days at a time without interruption. The tube comprises the usual glass envelop 7, an electron-emitting cathode 8, such as described in the *Physical Review* for December 1913 and a water-cooled anode 9 of the type above described. The tube 2 is mounted on an iron tube 10 and bound by a wire 11. A glass tube 12 joined to the arm of the envelop serves to center and support the tube 2. The cooling fluid is supplied by tubes 13 and 14 through the junction box 15 to the anode. The cathode filament 16, Fig. 4 is heated by a battery 17 or other convenient low-poten-

tial source. The main current is supplied by a transformer 18, the secondary of which is connected to the terminals of the X-ray tube by the conductors 19, 20. As described in the above article in the *Physical Review*, the tube is evacuated to a pressure so low that positive ionization of residual gas is substantially absent or negligible.

When the tube is operated with alternating current any slight amount of gas evolved from the anode is electrically precipitated by a discharge emanating from the electrode 9 when acting as cathode for a current wave negative with respect thereto, thereby vaporizing or sputtering copper. When a unidirectional current supply is used, the focusing ring 21, Fig. 4, about the cathode is constituted of copper, or other readily sputtered metal. Positive ionization of residual gas causes positive ion bombardment of the cathode and sputtering of the focusing ring thereby improves the vacuum.

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

An anode for an electron discharge device comprising a member of soft metal of food heat conductivity, means for cooling said member and a plate of highly refractory metal in intimate heat conveying relation to said member, said plate having a mass which will provide a heat storage capacity sufficiently great to transfer heat to the soft metal member at a substantially constant rate when operated with variable currents of commercial frequency.

In witness whereof, I have hereunto set my hand this 2nd day of February, 1916.

WILLIAM D. COOLIDGE.

Corrections in Letters Patent No. 1,253,156.

It is hereby certified that in Letters Patent No. 1,253,156, granted January 8, 1918, upon the application of William D. Coolidge, of Schenectady, New York, for an improvement in "Roentgen-Ray Devices," errors appear in the printed specification requiring correction as follows: Page 1, line 36, for the word "of", first occurrence, read *or;* page 2, line 27, for the word "food" read *good;* and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of February, A. D., 1918.

[SEAL.]

J. T. NEWTON,

Commissioner of Patents.

Cl. 250—35.