W. D. COOLIDGE.

X-RAY APPARATUS.

APPLICATION FILED APR. 13, 1917.

1,310,061.

Patented July 15, 1919.

Fig. 1.

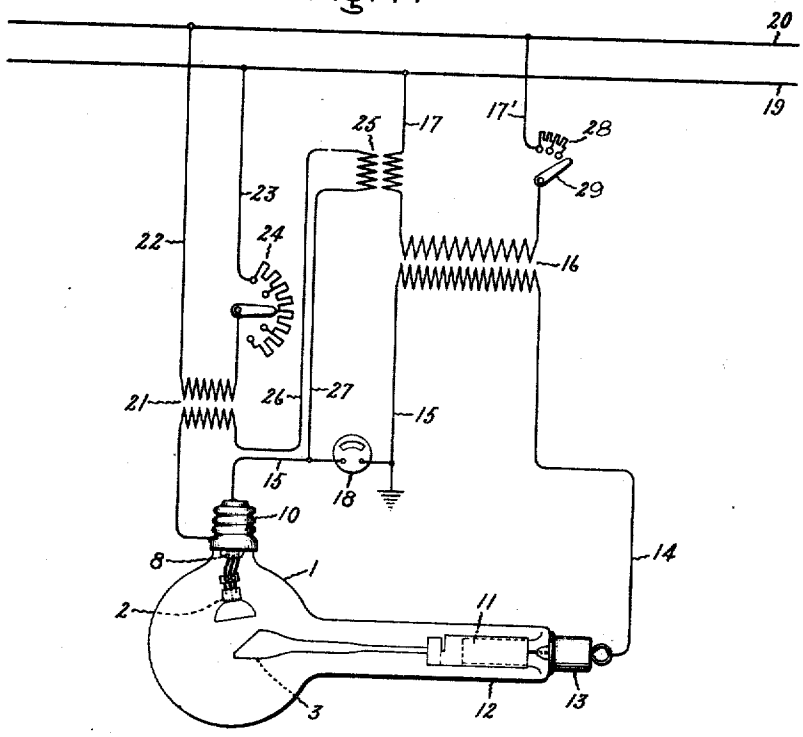
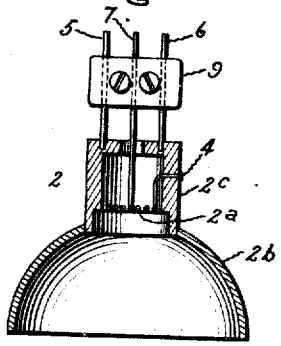


Fig. 2.



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UNITED STATES PATENT OFFICE.

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X-RAY APPARATUS.

1,310,061. Specification of Letters Patent. Patented July 15, 1919.

Application filed April 13, 1917. Serial No. 161,892.

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, State of New York, have invented certain new and useful Improvements in X-Ray Apparatus, of which the following is a specification.

The present invention comprises an X-ray device having a number of novel features rendering it particularly suitable for operation by people who have little special training in the operation of X-ray apparatus.

Among the novel features of my invention, I desire to call attention to the following:

The X-ray tube itself is constructed with anode and cathode located at substantially right angles so that the terminal which is at high potential may extend away from a patient being examined to avoid danger of electric shock.

The X-ray tube is connected directly to the secondary winding of a transformer which is designed to furnish current at voltages high enough for X-ray purposes, when the primary winding is supplied with alternating current of ordinary commercial voltage and frequency. The focusing device surrounding the cathode of my new tube is proportioned and located to intercept the electron discharge emitted by a heated focal spot when the tube is connected to an alternating current source.

The X-ray tube is so proportioned that the operating current is determined largely by the electric field in the tube instead of being dependent mainly on the cathode temperature as in thermionic X-ray tubes now in use.

The novel features of my invention will be pointed out with greater particularity in the appended claims and more fully described in the following description taken in connection with the accompanying drawing in which Figure 1 is a diagram illustrating the novel structural features of the X-ray tube and showing a system of connections embodying my invention; and Fig. 2 is an enlarged detail view of a cathode adapted for use with the X-ray tube.

Referring to Fig. 1, the X-ray tube comprises an envelop 1 consisting, for example, of glass, into which are sealed a cathode 2 and anode 3. As shown in Fig. 2 the cathode comprises a coiled filament 2^a, consisting of highly refractory metals, such, for example, as tungsten, and a surrounding focusing device having a hemispherical member 2^b and a cylindrical member 2^c, preferably also consists of refractory metal, for example, molybdeum, or tungsten. The cathode and the focusing member are electrically connected by attaching the end of the cathode to the focusing member, as shown at 4. Two wires 5 and 6 which are connected to the focusing member 2^c, together with a wire 7, which is connected to one end of the cathode spiral 2^a, are sealed into a stem 8 of the X-ray tube. An insulating bridge piece 9 maintains the wires 5, 6 and 7, spaced apart and serves to preserve rigidity. A heating current is conducted to the cathode spiral through the wires 6 and 7, which are connected to an external threaded terminal 10 constructed similar to an incandescent lamp base. The cathode is positioned, as by bending the wires 5, 6 and 7, or in any other way, to intercept on the focusing member 2^b, any inverse discharge taking place from a heated focal spot on the electrode 3 when negative with respect to the electrode 2. In this manner an inverse thermionic discharge is prevented from impinging on the opposite glass wall and injuring the tube.

The anode 3 of the X-ray tube consists preferably of wrought tungsten and is connected to an iron tube 11 carried by a glass stem of the tubular extension 12 of the X-ray tube. Connection is made to an external metal cap 13 provided with a ring to which electrical connection may be easily made.

As more fully described in my Patent No. 1,203,495, issued October 31, 1916, the X-ray tube is thoroughly freed from the gases and exhausted to a pressure so low that conduction of energy may take place therethrough by thermionic current substantially independent of gaseous ionization. The tube is permanently connected by the conductors 14, 15, to the secondary terminals of a transformer 16. The primary of the transformer is connected by conductors 17 and 17′ to a source of alternating current as represented by conductors 19 and 20. The current through the tube may be indicated by a suitable milli-ammeter 18.

A current for maintaining the cathode filament 2^a at incandescence is furnished by a small low voltage transformer 21, the primary of which may be connected conveniently by conductors 22, 23, to the same source of alternating current which supplies the main high potential transformer 16. In series with the conductor 23 is an adjustable resistance 24 for regulating the cathode heating current. The conductor 15 preferably is grounded as indicated in the drawing.

The current through the X-ray tube depends mainly on three factors, namely, the electron emissivity of the cathode; the tube design; and the impressed voltage.

In accordance with my invention the tube is designed so that the current limiting effect of the negatively charged focusing member 2^b upon the electrons emitted by the cathode is relatively high. The cathode spiral 2^a is operated at such a high temperature that more than sufficient electrons are provided to carry the current, as determined by the geometric construction of the tube and the secondary voltage of the transformer 16. Therefore, with a fixed operating potential, slight changes of cathode temperature have little effect upon the amount of operating current through the tube, as the current is largely governed by the electrostatic conditions within the tube, or what is known as "space charge" conditions.

However, as a very substantial drop in voltage occurs in the mains 19, 20, when the tube is taking current from the main transformer 16, means is provided for maintaining the voltage of the filament heating current substantially constant under these conditions to prevent any material change in the temperature of the cathode. One way for compensating for this drop in voltage is shown in Fig. 1 and comprises a boosting transformer 25, the primary of which is in series with the primary of the main transformer 16 and the secondary of which is connected by conductors 26, 27, in series with the secondary of the transformer 21. In some cases this boosting transformer may be omitted.

Should the apparatus described be connected to be switched directly to a source of alternating current and connection were made at the peak of a current wave, there would occur a substantially higher voltage impulse due to the rapid change of magnetization in the transformer. As the transformer and the tube are preferably designed to operate only at more nearly normal voltage, a resistance 28 is provided which is first included in circuit by the closure of the switch 29. This resistance may be removed from circuit immediately and the tube operated directly from the alternating current source. For this reason a hand or foot switch may be arranged to close the circuit through the resistance and to automatically eliminate the same by moving the switch to its final closed position. In a divisional application, Serial No. 245,055, filed July 15, 1918, I have claimed certain circuit arrangements herein described whereby an X-ray tube is connected initially with the resistance which is thereafter removed from circuit.

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

1. An electron discharge device comprising a bulb, evacuated to a pressure so low that conduction of energy may occur in the evacuated space independently of gas ionization, a cathode and an anode mounted in said bulb, means for heating said cathode, and a conductor surrounding said cathode for focusing the cathode discharge upon said anode, said conductor being located and proportioned to receive an electron discharge from a heated focal spot on said anode.

2. An X-ray device operating by substantially pure electron conduction comprising an evacuated bulb, a cathode and an anode mounted therein, means for heating said cathode and a substantially hemispherical conductor surrounding said cathode located to intercept cathode rays from the heated focal spot.

3. An incandescent cathode device comprising a container, coöperating electrodes in said container, one of which is operable at incandescence, and a conductive member, connected to said cathode, located to receive an electron discharge emanating from said anode, thereby shielding the wall of the container from said discharge.

In witness whereof, I have hereunto set my hand this 12th day of April, 1917.

WILLIAM D. COOLIDGE.