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X-RAY SYSTEM

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Fig. 1.

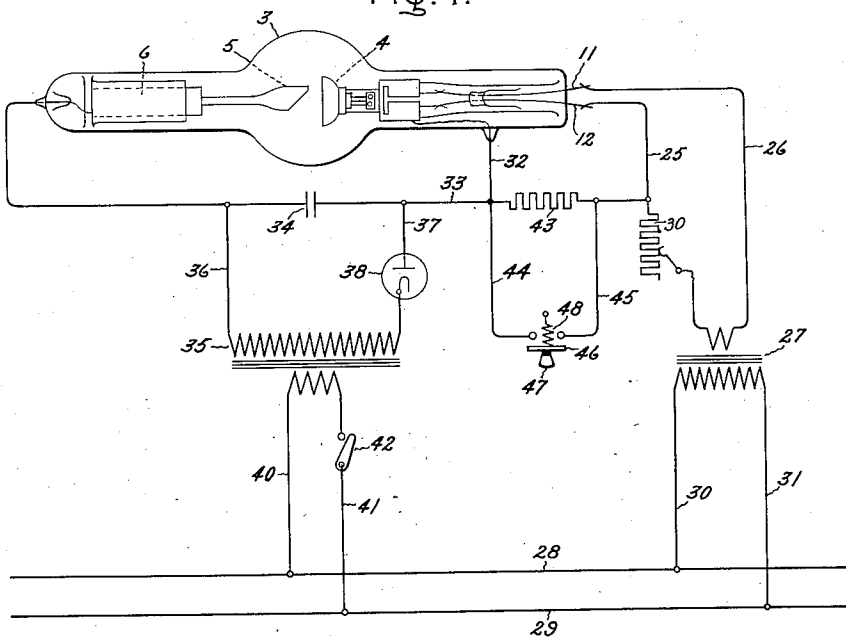
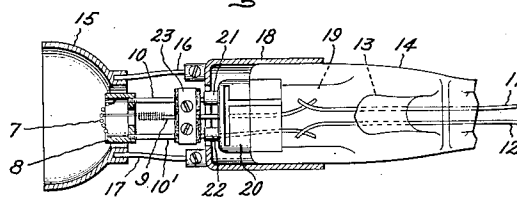


Fig. 2.



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X-RAY SYSTEM

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7 Claims. (Cl. 250—34)

The present invention relates to the generation of X-rays and its object is to provide an apparatus whereby high tension current through an X-ray tube may be easily and instantaneously switched on and off.

My invention is particularly applicable to X-ray apparatus in which currents of relatively high amperage are used for very short intervals as in so-called instantaneous radiography for taking radiographs of moving objects. In order to reduce the size of transformers required to furnish the current, such an apparatus may be provided with one or more capacitors which are arranged to be discharged when a radiograph is desired. The switching or control of a high voltage capacitor in an X-ray system presents difficulties of its own. My improved apparatus provides for the control or switching on or off of large currents equally as well when the energy is delivered by a capacitor as when it is delivered by a transformer, battery, or other form of supply device.

As will be hereinafter described in greater detail my improved apparatus comprises an X-ray tube containing a control electrode, together with circuit connections for charging said control electrode to a negative potential whereby flow of current through the X-ray tube is inhibited until desired. An arrangement is provided whereby the negative potential may be instantaneously released at the will of the operator, as by a push-button switch thereby bringing the control electrode to cathode potential and permitting a desired high current to energize the X-ray tube for producing X-rays. The novel features of my invention will be pointed out with greater particularity in the appended claims.

The accompanying drawing shows in Fig. 1 a side elevation of an X-ray tube and a diagram of circuit connections and Fig. 2 is an enlarged longitudinal section of the cathode and control electrode assembly.

Referring to the drawing, the X-ray tube 3 is of the thermionic type operating with a substantially pure electron discharge as described in U. S. Patent 1,203,495 of W. D. Coolidge. The cathode and control electrode structure is shown generally at 4 in Fig. 1. The anode which is shown at 5 as being of the form commonly used in X-ray tubes and may consist of tungsten, or other refractory metal. Its form and structure are not material to this invention. The anode is supported by the well-known tubular holder assembly 6 which requires no separate description.

As shown in Fig. 2 the current emanates from

a thermionic filament 7, which is surrounded by a tubular focusing electrode 8. One end of the filament 7 is connected to a conductor 9, the opposite end being connected to the electrode 8 which in turn is connected to the conductor 10'. The conductors 9, 10' in turn are connected to the conductors 11, 12 which are sealed into the glass stem 13. Surrounding this stem is a tube 14, also consisting of glass. A cup-shaped control and focusing electrode 15 surrounds the cathode 7 and the ring-shaped electrode 8. This electrode 15 is mounted by support wires 16, 17 on a metal sleeve 18 which encircles the tube 14.

The cathode electrodes 7, 8 are supported from an inner tube 19 by a split metal tube 20, the wires 10, 10' are firmly held in bosses 21, 22. The wire 9 is insulated therefrom by an insulating clamp 23.

The cathode conductors 11, 12 are connected by the conductors 25, 26 to the low potential secondary of a step-down transformer 27, the primary of which is connected to the supply mains 28, 29 by the conductors 30, 31. A resistance 30 is provided to regulate the heating current in the circuit 25, 26.

The capacitor 34 is charged by the high potential secondary of a transformer 35 to which it is connected by the conductors 36, 37 in series with a rectifier 38. This rectifier preferably is of the high vacuum thermionic type, such, for example, as described in U. S. Patent 1,287,265, of Saul Dushman. The primary of the transformer 35 is connected by the conductors 40, 41 in circuit with a switch 42, to the mains 28, 29.

In the high potential circuit 33 is an impedance 43, which may assume the form of an ohmic resistance. The end of the resistance which is connected to the capacitor 34 also is connected by the conductor 32 to the control electrode 15, which surrounds the filament 7. The resistance 43 is shunted by the conductors 44, 45, the circuit through which is arranged to be completed by the switch 46. This switch 46 may be of any suitable form for operation in a high voltage circuit, the circuit diagram merely showing a simple switch closed by pressure upon the insulated knob 47 against the spring 48.

When the apparatus is operated the resistance 30 is adjusted to a value at which a desired heating current is obtained in the cathode 7, and the switch 42 is closed, thereby causing the capacitor 34 to be charged through the rectifier 38. If the cathode 7 is heated to its operating temperature by energy supplied by the circuit 25, 26 only a small current will pass through the X-ray tube

as the potential drop in the resistance 43 results in a high enough negative potential upon the control electrode 15 to reduce the space current to a very small value. For example, with an impressed voltage of 85,000 volts and a resistor of about 2 megohms used as resistance 43, a current of one tenth of a milliampere will be passed through a given X-ray tube,—(the particular value of this current depending on the geometry of the X-ray tube). A current of this magnitude will not produce any substantial X-ray effect, nor will it discharge the capacitor 34. However, when switch 46 is closed, short-circuiting the resistance 43, the negative potential of control electrode 15 is reduced to zero (with respect to the filament 7) and the capacitor 34 discharges at a high rate. If this capacitor is chosen at a sufficiently high value a rush of current of the order of one thousand milliamperes may be produced at a given voltage through the X-ray tube 3 resulting in a high instantaneous output of X-rays. When the switch 46 is again opened high impedance conditions immediately reestablish themselves.

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

1. An electrical apparatus comprising a thermionic tube which is provided with a main anode, a main cathode, and an auxiliary electrode surrounding said cathode whereby current between said main electrodes may be controlled, a capacitor, electric supply conductors connected therefrom to said main electrodes, means for charging said capacitor, an electric impedance which is included in one of said supply conductors and having one terminal connected to said cathode, a circuit connection from the opposite terminal of said impedance to said auxiliary electrode, and means whereby said impedance may be short-circuited.
2. An electron discharge apparatus adapted for intermittent service for periods of short duration comprising a thermionic X-ray tube containing a cathode, an anode, and a control electrode which when charged to cathode potential will permit free passage of current through said tube while restraining current flow when charged to a higher negative potential, an electric supply source, conductors leading from said source to said tube, means in circuit with one of said conductors for charging said control electrode to a negative potential with respect to the cathode, discharge conductors connected to said charging means and means for connecting said discharge conductors to short-circuit said charging means and permit free flow of current through said X-ray tube.
3. An X-ray system comprising a thermionic cathode X-ray tube which is provided with main electrodes and a focusing and control electrode which is spatially so related to the cathode that flow of current from the cathode occurs with said control electrode at substantially cathode potential, electric current conductors connected to the main electrodes of said tube, an electric capacitor connected to said conductors, means for charging said capacitor, an electric resistance included in

circuit with one of said conductors which is connected between said capacitor and the cathode of said tube, a second conductor connected between said control electrode and a point in said first conductor common to said capacitor and said resistance, conductors connected to terminals of said resistance and means for connecting and disconnecting said last-named conductors.

4. An X-ray installation comprising an X-ray tube having a main cathode, a main anode and a control electrode surrounding said cathode, a source of energy, conductors connected to supply energy therefrom to said main electrodes, an impedance in circuit with one of said conductors, an electrical conductor connected to impress a fall of potential in said impedance on said control electrode and instantaneously operating means for short-circuiting said impedance at will.

5. An X-ray installation comprising an X-ray tube of the pure electron discharge type containing an anode, a thermionic cathode, and a control electrode surrounding said cathode, an energy supply source, conductors respectively connected therefrom to said anode and said cathode, a resistor in circuit with the one of said conductors which is connected to said cathode, an electric conductor connected between said control electrode and said resistor at a point remote from said cathode, conductors connected to the terminals of said resistor, and a manually-controlled switch connected to said last-named conductors.

6. An electrical apparatus comprising a thermionic X-ray tube containing a main cathode, a main anode and a control electrode which is spatially related to the cathode to permit flow of current in said tube when at cathode potential, electric supply conductors connected to said main cathode and said main anode, an electric energy source in circuit with said supply conductors which is capable of a high rate of discharge, an impedance device in circuit with said energy source and said supply conductors, another conductor connecting said control electrode to said main cathode in series with said impedance device, circuit conductors connecting with the respective terminals of said impedance device, and a push-button switch for connecting said circuit conductors in series.

7. An electrical apparatus comprising a thermionic X-ray tube containing a cathode, an anode and a control electrode spatially related to said cathode to permit free flow of current in said tube when at cathode potential, an electric energy supply for said anode and cathode which is capable of a high rate of discharge, conductors leading from said energy supply to said anode, cathode and control electrode respectively, means in circuit with said control electrode conductor for biasing said control electrode to a negative potential with respect to said cathode to restrain free flow of current, and instantaneously-operating means for rendering said biasing means ineffective.

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