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METHOD OF AND APPARATUS FOR CONTROLLING X-RAY TUBES.

APPLICATION FILED OCT. 29, 1913. RENEWED APR. 19, 1917.

1,251,388. Patented Dec. 25, 1917.

Fig. 1.

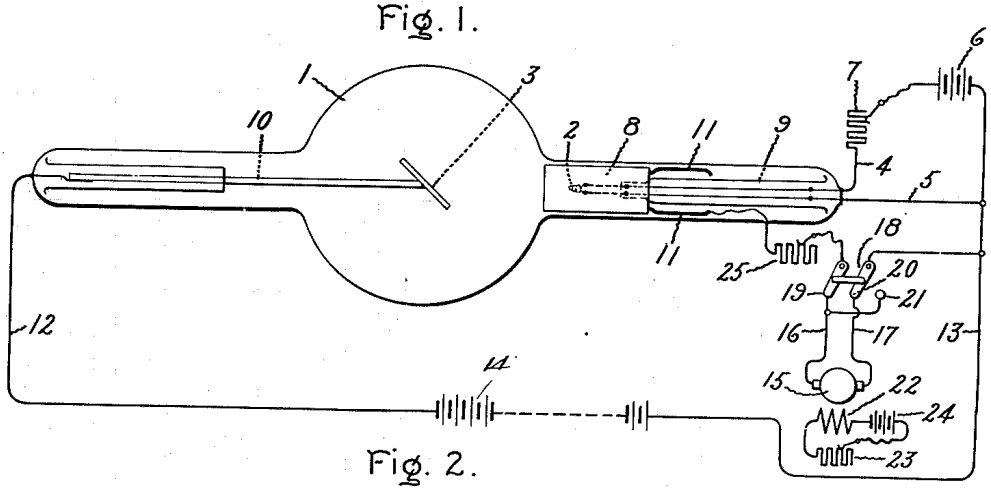


Fig. 2.

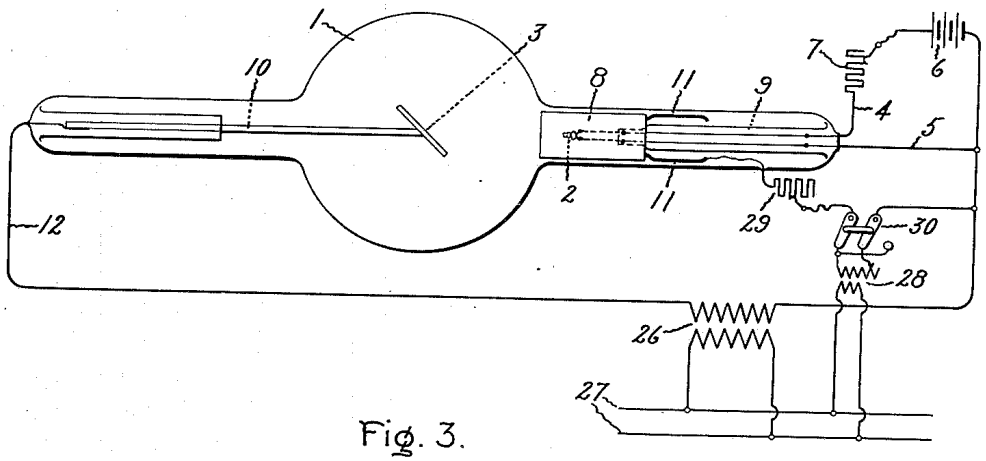
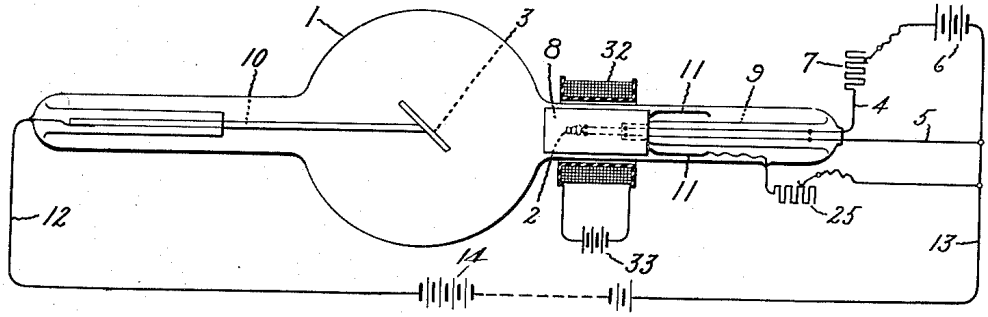


Fig. 3.



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METHOD OF AND APPARATUS FOR CONTROLLING X-RAY TUBES.

1,251,388. Specification of Letters Patent. Patented Dec. 25, 1917.

Application filed October 29, 1913, Serial No. 797,984. Renewed April 19, 1917. Serial No. 163,315.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Controlling X-Ray Tubes, of which the following is a specification.

The present invention relates to a system of connections for vacuum tubes of the incandescent cathode type, such, for example, as the X-ray tube described in Coolidge Patent 1,203,495, issued October 31, 1916. This type of X-ray tube operates at extremely high vacua with a pure electron discharge as contrasted with Röntgen tubes formerly constructed depending in their action upon the ionization of a residual gas. In one of the modifications of this tube the cathode rays are focused by means of a static focusing device, such as a ring, tube, or other conductive member surrounding the cathode and establishing a static field radially about the cathode. The focusing member appears to become statically charged by the electron emission of the cathode, and thus modifies the static field in the tube, which is controlling the motion of the cathode rays.

In accordance with my invention the length of the focus of the cathode rays is varied at will, thus controlling the area of the focal spot or surface by adjusting the distribution of potential in the static field directing the cathode rays inwardly to a common point, or outwardly from a virtual focus. For example, by means of a source of potential between the cathode and the focusing device the intensity and polarity of the static field may be varied as hereinafter described.

In the drawings, Figure 1 illustrates diagrammatically a Röntgen ray tube provided with a unidirectional source of potential between the cathode and static focusing means; Fig. 2 shows a Röntgen tube operated from an alternating current source and controlled by a potential which fluctuates in synchronism with the current supply for the tube; and Fig. 3 shows another means for varying the focus.

Referring to Fig. 1 it will be noted that the essential parts of the tube comprise an envelop 1 of glass, or quartz, a cathode 2 and an anode 3, located opposite the cathode, and serving also as a focal plate, or focal surface. The cathode, which is a primary source of electrons, consists of a refractory conductor, preferably tungsten. Energy is supplied to incandesce the cathode through leading-in wires 4 and 5 from a battery 6 in series with a variable resistance 7. The anode consists of refractory metal, preferably tungsten. Around the cathode is located a short tube 8 also consisting of metal, for example, nickel, iron or tungsten representing one form of focusing device. The supports for the various parts such as the stem 9 for the cathode, a rod 10 for the anode, and spring anchors 11 for the focusing means have been only diagrammatically indicated, as they form no part of the present invention. Electrical current is supplied to the tube through conductors 12 and 13 from a source of energy which may be a mechanical rectifier, a high potential battery, or even an alternating current source, such as an induction coil or transformer. The source 14 is symbolic of any of the sources mentioned or their equivalents.

A source of potential 15 which has been diagrammatically indicated as a direct current dynamo, but may also be a battery, or even a static source of potential such as a glass plate static machine, is connected by means of conductors 16 and 17 and a reversing switch 18 to the cathode and the focusing member. By changing the switch blades from contacts 19 and 20 to contacts 20 and 21, the polarity of the source may be reversed. The degree of potential may be varied in any desired manner, as by varying the excitation of the field coil 22 of the generator, for example, by cutting in or out resistance 23 in the circuit of an energizing battery 24, or in any other well understood manner. A resistance 25 is provided in circuit with the source of potential, which may be varied and also entirely short-circuited as indicated.

When the focusing member 8 is connected to the cathode without interposing any source of potential, one of the surfaces which may be plotted in space to include points of the same potential, will include the tip of the filament and the outer edge of the focusing tube 8. As such equipotential surfaces approach the anode they become less concave. The electrons emitted by the filament when traveling from the cathode to the

anode, tend to move perpendicularly to these equipotential surfaces, and are thus directed toward a spot of restricted area upon the anode, called the focal spot.

When the source of potential 15, is introduced into circuit between the cathode and focusing member 8, the positive terminal being connected to the focusing member, the shape of the equipotential surfaces will be changed, as the tip of the filament and the rim of the focusing member no longer are at the same potential. By making the positive potential high enough the focusing of the rays may be entirely prevented, that is, the rays will diverge instead of converge. By making the potential negative with respect to the focusing tube the focal area may be made smaller, or in other words, sharpness of the focusing may be improved. The charge on the focusing member also has an effect on the resistance of the tube and hence on the hardness of the X-rays. A positive charge decreases the hardness and a negative charge increases the hardness in proportion to the potential of the charge.

The structure of the Röntgen ray tube shown in Fig. 2 is the same as that shown in Fig. 1, but instead of a direct current source of potential for the focus control, an alternate-source, for example, a transformer 28 is used. As has been indicated this transformer may receive current from the lines 27 which supply current to the transformer 26 connected to the main terminals of the X-ray tube. The potential in the transformer 26, therefore, will vary in synchronism and be the same in polarity as the transformer 28. As in Fig. 1 a resistance 29 and a reversing switch 30 is provided in the control circuit connected to the secondary of the transformer 28.

The operation of the system described in Fig. 2 is similar to that already described in Fig. 1. Only the half waves of the supply current which are negative with respect to the cathode 2 can pass through the tube. Because of this rectifying property of the tube, the alternating potential between the focusing device 8 and the cathode 2 operates similarly to a direct current source, as it only functionates for waves of like polarity, the set of waves of opposite polarity being suppressed. The focal area may be broadened or focusing entirely prevented by connecting the positive terminal of the source of potential 26 to the focusing device 8, the opposite terminal being connected to the cathode, and in like manner the sharpness of focusing may be improved by connecting the negative terminal of the source of potential to the focusing member. In both the systems described in Figs. 1 and 2, the focusing may be varied by changing the degree of potential as well as the polarity.

For certain purposes focus control may be secured by changing the distribution of the static field in the tube by moving the focusing member 8 relative to the cathode. Means for carrying out this method has been shown in Fig. 3, in which the solenoid 32 energized by a suitable source of current such as the battery 33, is located outside of the tube in the neighborhood of the focusing member 8 which in this case consists of magnetic material such as iron. By moving the member 8 away from the anode 3 the length of the focus may be increased and the focal area broadened and conversely by moving the focusing tube toward the anode the length of the focus may be shortened and the focal spot decreased. Obviously the shape of the equipotential surfaces is changed in this manner.

Certain broad aspects of my invention described herein are claimed in a copending renewal application Serial No. 84,242, filed March 14, 1916, which is involved in interference.

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

1. In an electron discharge apparatus, a container, a cathode emitting electrons independently of positive ionization, an anode, a conductive member surrounding an axis passing through the cathode and anode, and a source of potential connected between the cathode and said conductive member, said apparatus being evacuated to a pressure so low that the focusing of electrons in the space between the cathode and the anode is controllable by an electric field.

2. The combination of a Röntgen ray tube comprising an evacuated container, an electron-emitting cathode, and a coöperating anode, means for focusing the cathode rays, and means for establishing a static field radially about the cathode, and means for varying said field to vary the area on a focal surface on which the cathode rays impinge to produce Röntgen rays.

3. An X-ray apparatus comprising an evacuated container, an incandescent cathode, a coöperating anode, a device for modifying the static field near the cathode, a source of potential between said cathode and said device and means for varying said potential at will.

4. The combination with a Röntgen ray tube having an electron-emitting cathode, and a focusing ring surrounding the cathode, of a source of potential between said cathode and focusing ring, means for varying said potential and means for reversing the polarity of said source at will.

5. The method of controlling the discharge emitted by the cathode of an electrical vacuum discharge device which consists in establishing a static field radially about the cathode causing the cathode rays to be diverted inwardly or outwardly, and

varying the intensity of the static field to vary the length of the focusing.

6. The method of controlling the focusing of rays emitted by a cathode of a Röntgen ray device, which consists in establishing a static field radially about the cathode to direct the rays inwardly or outwardly and varying the intensity and polarity of said field to vary the deflection of said rays.

7. An electron-discharge apparatus, comprising the combination of a container, a cathode constituting a primary source of electrons, an anode, a conductive member within said envelop adjacent said cathode for modifying the static field about said cathode, a source of potential connected respectively to said cathode and to said conductive member and means for varying said potential at will.

In witness whereof, I have hereunto set my hand this 27th day of October, 1913.

IRVING LANGMUIR.

Witnesses:
SAUL DUSHMAN,
HELEN ORFORD.