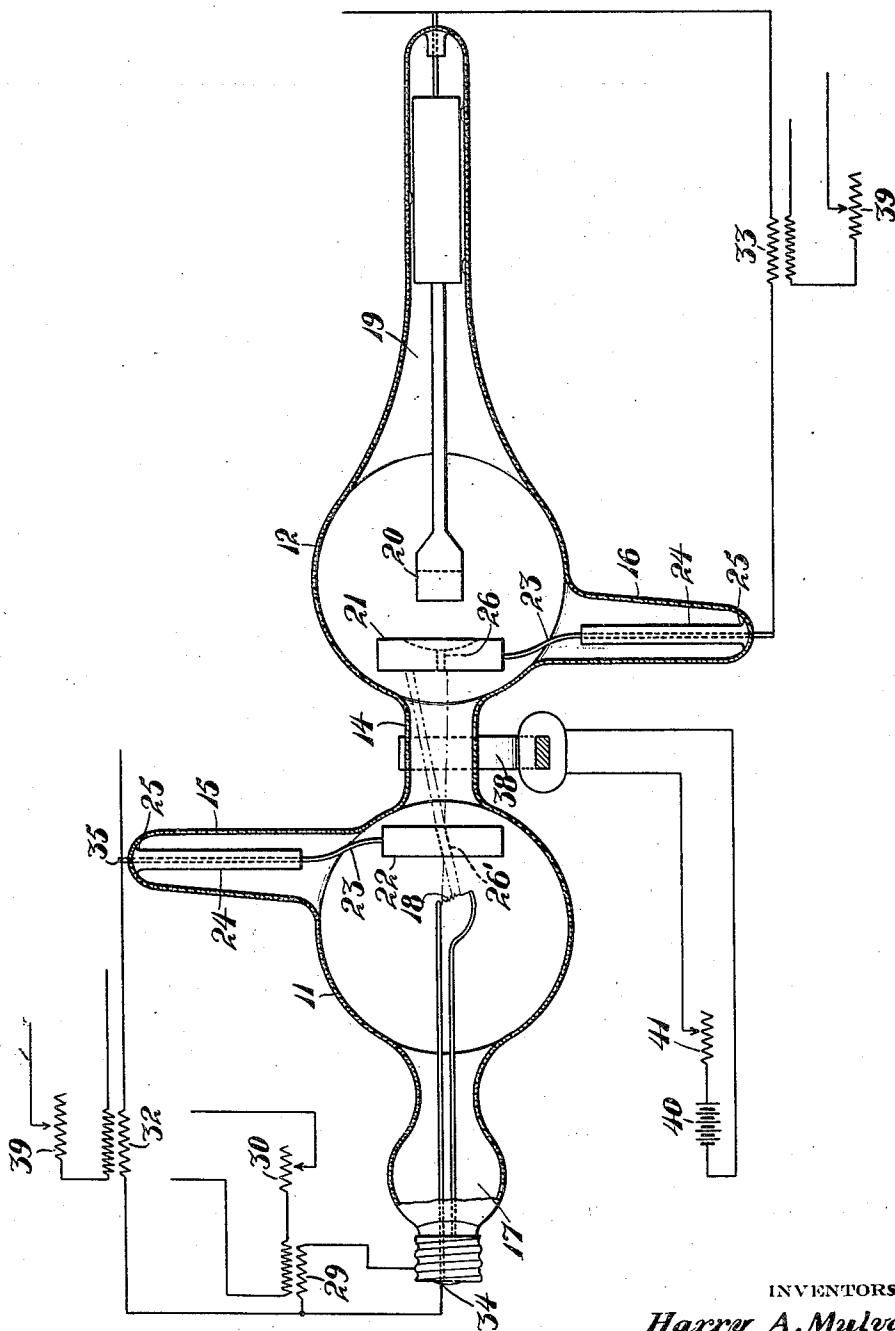


Aug. 31, 1926.

1,598,150

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X-RAY TUBE CONTROLLING MECHANISM

Filed Nov. 12, 1919



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X-RAY-TUBE-CONTROLLING MECHANISM.

Application filed November 12, 1919. Serial No. 337,563.

This invention relates to electron X-ray or Röntgen tubes, and more particularly to the type of X-ray tube in which the tube is exhausted to a vacuum as near as practical and the passage of current through the tube is had through the medium of electrons.

It is well known that a vacuum or highly rarefied air remaining in a tube which has been highly exhausted is a non-conductor of electricity. This is true irrespective of the potential applied to the cathode and anti-cathode of a highly exhausted X-ray tube. It is found, however, that if a filament is used as a cathode in one end of the tube and heated to incandescence by the passage of a current through it, even slight potentials will pass current through the vacuum space between the heated filament or cathode and the anti-cathode, or, as it is commonly called, the target.

This phenomenon is explained in stating that the incandescent body throws off into the vacuated space, in the form of a stream, what are termed electrons or corpuscles, which are themselves electro-negatively charged masses or particles, the smallest particles into which matter is divisible; and it is further explained that this stream of electrons ionizes the vacuous space through its path of travel and provides a path for an electric current to flow from the filament or cathode to the target or anti-cathode. The electrons striking the target produce X-rays and the penetrating power thereof increases with the square of the potential applied.

The volume of X-rays produced is dependent upon the amount of current flowing between the cathode and anti-cathode, and, as is apparent from that previously stated, the flow of current is controlled by the volume and density of the stream of electrons.

It is an object of this invention to provide means whereby the flow of current between the cathode and anti-cathode can be accurately controlled. It is also an object of the invention to provide a means whereby the potential can be varied between the cathode and anti-cathode without changing the flow of current through the tube or vice versa. Still another object of the invention is to provide means whereby the current flowing between the cathode and anti-cathode can be varied without varying the heating current of the cathode or filament.

With the above and other objects in view, the invention consists in the novel features of construction, combination and arrangement of parts to be hereinafter more fully described, claimed, and illustrated in the accompanying drawings, in which—

The figure shown is a longitudinal section through a tube of the preferred construction and the connections thereof shown diagrammatically.

Referring to the drawing, a tube is provided, having a primary chamber 11 and a secondary chamber 12, said chambers being connected by a neck 14. On the opposing sides of the chambers are blown the arms or projections 15 and 16, respectively. In the primary end 17 of the tube there is properly positioned and sealed, as in any ordinary electric light bulb, the cathode or filament 18, and in the secondary end 19 of the tube there is provided the usual anti-cathode or target 20. Primary and secondary electrodes 22 and 21, respectively, are provided, which are circular in shape and each having a central aperture or orifice 26 and 26', respectively; the aperture 26' being inclined upwardly to the longitudinal axis of the tube and the aperture 26 in axial alignment with the longitudinal axis of the target 20 or the tube 10. These electrodes are of a suitable diameter to prevent any electrons passing through the neck 14, other than those which may pass through the aperture of each electrode. The electrodes are further provided with a lead or extension 23, which passes through a tube 24, blown centrally of each arm 15 and 16; the outer end of the tubes 24 being sealed about the leads 23, as at 25.

For energizing the tube, a transformer 29 is provided, the primary leads of which are connected to a suitable source of power and the secondary leads suitably connected to supply the cathode or filament 18 with a heating current. A variable resistance 30 is provided in the primary circuit of the transformer whereby the amount of heating current for the filament 18 may be regulated.

As shown in the drawing, 32 and 33 may represent two transformers although the same purpose may be accomplished by one transformer. When one transformer is used, a tap is made on the secondary winding which will supply a predetermined potential between the electrodes 22 and the

filament 18 and the full potential is applied between the electrode 21 and the target 20.

In the accompanying drawing, the terminals of the secondary of transformer 32 are connected to the filament or cathode 18 and electrode 22, as at 34 and 35, respectively. The electrode 21 is also connected to the secondary of the transformers 33, the purpose of which will later be made apparent. The secondary terminals of the transformer 33 are connected to the electrode 21 and the anti-cathode or target 20. The primary circuits of each transformer 32 and 33 are provided with a variable resistance 39, whereby the potential of the secondaries may be brought to any desired point.

About the neck 14 of the tube there is provided an electromagnet 38. The magnet may be of any suitable design, providing its lines of force coincide with a plane at right angles or perpendicular to the stream of electrons flowing from the filament 18. The magnet is energized by a battery 40 and its strength varied by a suitable resistance 41.

In the operation of the above-described X-ray tube, a predetermined current is supplied to the filament 18. Also, a predetermined potential is supplied by the secondaries of the transformers 32 and 33. The filament is heated to such a degree that the volume or density of the stream of electrons thrown off reaches the point of saturation. The velocity or impetus given the electrons at the time when the applied potential is at its maximum is sufficient to carry a substantial portion of the electrons through the aperture 26' in the electrode or what may be called anti-cathode 22; the remaining electrons being intercepted or screened away by the electrode 22. The magnet 38 is now energized and the stream of electrons which have passed through the aperture 26' is caused to diverge downwardly and pass through the aperture of the electrode 21 and strike the target 20. The electron stream now provides a path for the flow of current between the target and electrode in the secondary tube or chamber, the secondary electrode serving as a cathode.

It also can be readily seen that by varying the strength of the magnet 38 the volume of electron stream passing through the aperture of the electrode 21 can be accurately controlled; and, as has been previously stated, the amount of current is dependent upon the volume or density of the electron stream. It is then obvious that the flow of current between the electrode 21 and the target 20 can be accurately controlled.

Further, our invention permits the density of electron streams to be at the point of saturation without causing diffusion of the X-rays produced, from the fact that only a certain volume is permitted to pass through the aperture in the screening electrode 22.

It may be further pointed out that our invention permits a means of selection of any desired part of the alternating current wave produced. This may be clearly seen if we consider the character of the potential wave obtained at the secondary of the common closed core transformer now used almost universally in X-ray work. This wave very closely resembles a sine wave and if we examine it we find it starting at zero and raising to a maximum value which is approximately the square-root of two times the average value, then again dropping to zero. Now in X-ray work we are not alone interested in the average values of current and of the potential but also in the instantaneous values. With our invention it is possible to adjust the value of the magnetic field so that only the maximum values of currents will pass, eliminating the lower current values which will, with the present types of tubes, overheat the same and produce detrimental secondary X-rays.

Having thus described our invention, what we claim and desire to secure by Letters Patent—

1. In an exhausted X-ray tube a filament and a target, a pair of interspaced electrodes interposed between the filament and the target, said electrodes being perforated to limit and direct the flow of the electron stream to a predetermined path, and means between the electrodes adapted to partially or wholly deflect said stream from the predetermined path to control the current carrying capacity of the electron stream.

2. In an exhausted X-ray tube, a filament and a target, a pair of interspaced electrodes interposed between the filament and the target, said electrodes being perforated to limit and direct the flow of the electron stream to a predetermined path, and electro-magnetic means between the perforated electrodes adapted to partially or wholly deflect said stream from the predetermined path to control the current carrying capacity of the stream.

3. In an exhausted X-ray tube, a pair of spaced electrodes interposed between the cathode and anti-cathode thereof, each electrode having an aperture and adapted to restrict the electron stream between the cathode and anti-cathode through said apertures, and means between said electrodes adapted to partially or wholly deflect said stream of electrons and thereby vary the current carrying capacity thereof.

4. In an exhausted X-ray tube, a pair of spaced electrodes interposed between the cathode and anti-cathode thereof, each electrode having an aperture and adapted to restrict the electron stream between the cathode and anti-cathode through said apertures, means for creating an electro-magnetic field between said electrodes, said field being

adapted to deflect the electron stream from a straight course, and means for varying said magnetic field whereby the current carrying capacity of the electron stream may be controlled.

5. In an exhausted X-ray tube, comprising a cathode chamber and an anti-cathode chamber with a restricted passage therebetween, a cathode filament, an anti-cathode member or target positioned in their respective chambers, an electrode adjacent each end of the passage, said electrodes each having an aperture through which the electron stream is restricted to pass, and means for creating an electro-magnetic field between said electrodes adapted to deflect the stream of electrons, and means for varying said field whereby the current carrying capacity of the stream passing through said apertures may be controlled.

6. In an exhausted X-ray tube, comprising a cathode chamber and an anti-cathode chamber with a restricted passage therebetween, a cathode filament, an anti-cathode member or target positioned in their respective chambers, an electrode adjacent each end of the passage, said electrodes each having an aperture through which the electron stream is restricted to pass, a ring electro-magnet about the restricted passage between the cathode and anti-cathode chambers, adapted to deflect the course of the electron stream, and means for varying the potential for energizing said electro-magnet, whereby the cross section of the electron stream passing through the aperture in the electrode adjacent the anti-cathode may be controlled.

7. In an exhausted X-ray tube, a pair of spaced electrodes interposed between the cathode and anti-cathode, each electrode having an aperture and adapted to restrict the electron stream between the cathode and anti-cathode to such which passes through said apertures, means for creating a magnetic field between said electrodes, adapted for deflecting the stream of electrons passing therebetween, means for varying the strength of said field and thereby control the cross section of the stream which passes through the aperture of the electrode adjacent the anti-cathode, and a high potential source connection of the same polarity with the cathode and electrode adjacent the anti-cathode, and a connection of opposite polarity with the anti-cathode and remaining electrode.

8. In an exhausted X-ray tube, a pair of spaced screens interposed between the cathode and anti-cathode, each having a central aperture and adapted to restrict the electron stream between the cathode and anti-cathode to such as may pass through said apertures, means for creating a magnetic field between said electrodes adapted to deflect the straight course of said electron stream, and means for varying said field whereby the cross sec-

tion of said stream which passes through the electrode adjacent the anti-cathode may be controlled.

9. In an exhausted X-ray tube, a pair of spaced screen members interposed between the cathode and anti-cathode, the screen adjacent the cathode having an aperture adapted to direct the stream of electrons passing therethrough at an angle to the longitudinal axis of the tube, and the other screen having an aperture extending parallel with said axis of the tube, means for creating a magnetic field between said screens, adapted to bend the electron stream passing through the screen with its aperture at an angle to register and pass through the aperture of the other screen, and means for varying said field whereby the cross section of the electron stream passing through the last named screen may be controlled.

10. In an exhausted X-ray tube, a pair of spaced electrodes interposed between the cathode and anti-cathode, the electrode adjacent the anti-cathode having a horizontally disposed aperture formed therein, and the other electrode having an aperture extending at an angle to the horizontal and so positioned with relation to the cathode that only electrons having the greatest impetus and thrown from the cathode at the proper angle are permitted to pass therethrough, the remainder being screened away by said electrode, means for creating a magnetic field between the electrodes adapted to bend the electron stream passing through the electrode with the angularly disposed aperture so that said stream will pass through the aperture of the other electrode, and means for varying said field thereby permitting the cross section of the electron stream passing through the last named electrode to be controlled.

11. In an exhausted X-ray tube, a pair of spaced electrodes interposed between the cathode and anti-cathode, the electrode adjacent the anti-cathode having an aperture horizontally disposed, and the other electrode having an aperture disposed at an angle to the horizontal and the last named electrode adapted to limit the electron stream passing between the cathode and anti-cathode to such as will pass through its aperture, means for creating a magnetic field about the portion of the tube extending between the electrodes adapted to bend the electron stream passing through the electrode adjacent the cathode so that it will pass through the aperture of the other electrode, and means for varying the magnetic field whereby the portion of stream passing through the last named electrode may be selected.

12. In an exhausted X-ray tube, a pair of spaced electrodes interposed between the cathode and anti-cathode, the electrode adja-

cent the anti-cathode having an aperture horizontally disposed and the other electrode having an aperture disposed at an angle to the horizontal and the last named electrode adapted to limit the electron stream passing between the cathode and anti-cathode to such as will pass through its aperture, means for creating a magnetic field about the portion of the tube extending between the 10 electrodes adapted to bend the electron stream passing through the electrode adjacent the cathode so that it will pass through the aperture of the other electrode, means for varying the magnetic field whereby the portion of stream passing through the last 15 named electrode may be selected, a source of high potential current, connecting means therewith of the same polarity between the cathode and the electrode adjacent the anti-cathode, and connecting means between said 20 source and the anti-cathode and other electrode of the opposite polarity.

In testimony whereof we have hereunto set our hands.

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