

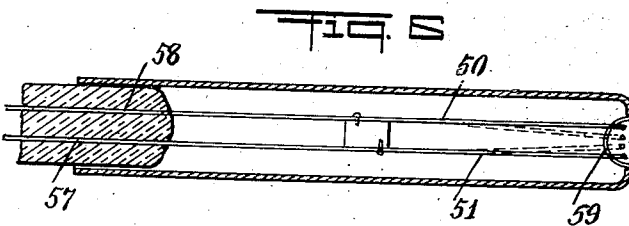
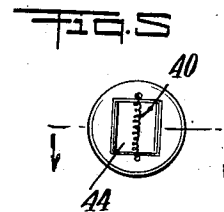
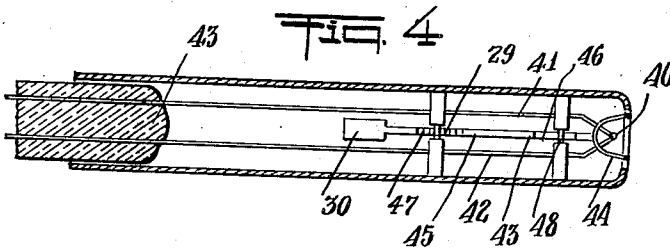
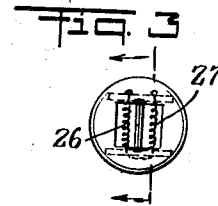
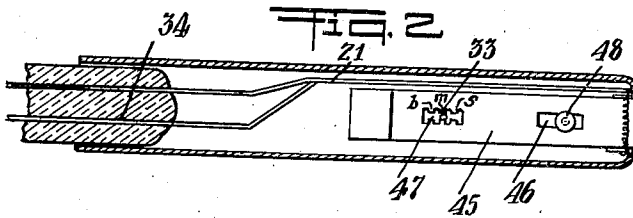
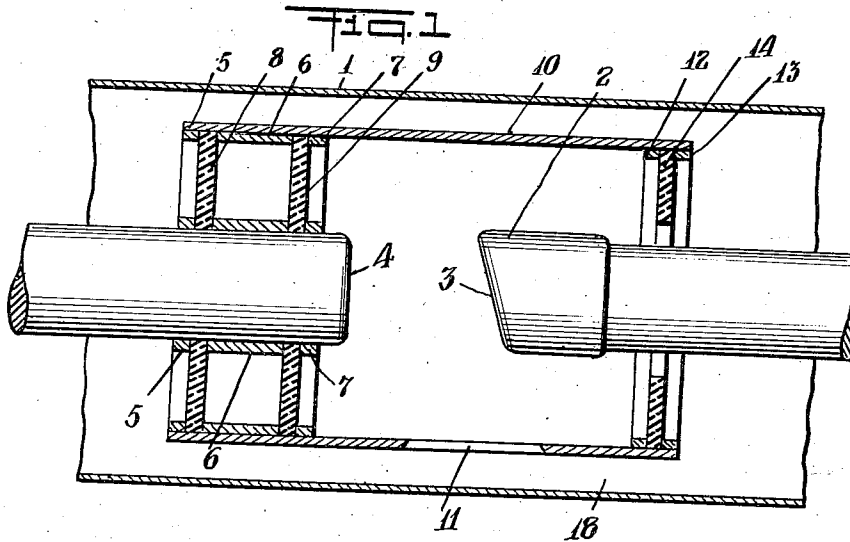
Jan. 9, 1940.

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2,186,380

X-RAY TUBE

Filed Oct. 22, 1931



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UNITED STATES PATENT OFFICE

2,186,380

X-RAY TUBE

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Application October 22, 1931, Serial No. 570,355

6 Claims. (Cl. 250—145)

My invention relates to X-ray tubes of the hot cathode type in which the electron discharge from the hot cathode is focused upon a predetermined area on the target of the anode. But more specifically stated, I have invented new methods of adjusting and regulating the size of the area on the anode upon which the discharge from the cathode is directed in accordance with the magnitude of the load, i. e., the current that passes through the X-ray tube.

Hitherto in the prior art, the devices and the means with which the size and form of the exposed area or focal spot on the anode was controlled were permanently installed and once the size and form of the focal spot was adjusted and the X-ray tube was closed, it was not possible by easy means to change it from the outside of the closed envelope to an either smaller or larger area. Therefore, since the volume of current that can be passed through an X-ray tube without injuring the focal spot depends primarily on the size or area of the focal spot, a tube of the prior art could not be changed if once completed either in the maximum amount of current that can be passed through it or in the quality of the definition that can be obtained with it, which, as is well understood, also depends on the size and form of the focal spot.

I have discovered means with which the size or area of the focal spot of an X-ray tube made according to my invention can be changed easily and quickly in order to adapt the tube for the particular exposure that is to be made with it. For instance, if it is desired to obtain the finest possible details or the greatest sharpness, then a very small focal area is required. My invention enables the X-ray operator to make a simple change in the adjustment of the cathode and then the X-ray tube will operate as a fine focus tube with properties of a fine focus tube which are well understood in this art. But if it should be desired to make an exposure with the maximum of current, as for instance of a rapidly moving organ such as the stomach, then for the larger volume of current it is necessary to let the discharge from the cathode fall upon a larger area on the anode in order to avoid injuring it by overheating resulting from too great an electron density per unit area on the anode target. In that case, with a simple and rapid manipulation, the operator can change the adjustment of the cathode in such a manner that the tube will operate as a broad focus tube. And of course for intermediate purposes, the focal area can be adjusted to any desired intermediate size.

In the accompanying drawing Fig. 1 is a fragmentary view of an X-ray tube; Fig. 2 is a fragmentary side view of the cathode and Fig. 3 is a front view of it. Fig. 4 and Fig. 5 are a top and front view of another form of a cathode and Fig. 6 is still another method, shown as a top view, of carrying out my invention. Fig. 7 is a front view of the cathode showing the two filaments in relation to the trough behind them.

In Fig. 1, which shows the middle portion of an X-ray tube embodying my invention, 1 is a cylindrical glass envelope which in the customary manner is sealed at the ends in order to be evacuated; therein is centrally located an anode 2 of the conventional design and provided with a target 3. Opposite it and in cooperating relation with it, there is a cathode 4 of which details of construction are shown in Figs. 2 to 6. On this cathode are support rings 8 and 9 of insulating material such as mica, quartz, porcelain, etc., which are held in place by the guard rings 5, 6 and 7. These support rings carry a cylindrical metal tube 10 which is opaque to the X-rays but provided with an opening 11 opposite the anode face 3. At its other end, this metal tube carries another such ring of insulating material 14 which is similarly carried by the guard rings 12 and 13.

This metal cylinder is floating electrically, i. e., it is supported by rings of insulating material and it is not otherwise connected to any of the two electrodes or to the ground and it is not in contact with the glass wall of the tube. In this fashion, if any electrons are deflected from their normal path, they may fall upon this cylinder and when a sufficient number of electrons have been gathered there, this cylinder assumes a negative potential due to which the electrons will then be prevented from further falling upon the cylinder. From that point on, the cylinder becomes part of the focusing device as it then aids materially in constricting the electron beam into a small stream. In order to prevent a discharge from taking place to the glass wall, there is left a separating space 16 between the cylinder and the glass wall. The ring of insulating material 14 is for the purpose of preventing visible light from the cathode from passing to the exterior of the tube.

The anode and the cathode lead in wires are sealed into the ends of the tube in the conventional manner and the tube is evacuated in a manner and by the methods well known in the art.

The construction of the cathode is shown in Figs. 4 and 5. A filament in the form of a small coil is shown at 40. It is supported by two con-

ductors 41 and 42 which are sealed into the glass pinch joint 43 and from there they lead out to suitable binding posts for connection with a suitable source of heating current. Surrounding this filament is a trough shaped focusing device 44 which is fastened to or carried by the metal strip 45. At the place 46 this metal strip is provided with a lengthwise slot. A pin 48 is provided with a groove in which the slot in the metal strip can slide back and forth. At 47 there is another slot provided with teeth of the form shown in Fig. 2. There is also a pin similar to the pin 48 and provided with a groove; 30 is a small weight so that by turning the X-ray tube upside down to the position shown in Fig. 2 and by sloping it either forward or backward the metal strip carrying the focusing trough can be caused to slide either forward or backward. Then by turning the tube again into position shown in Fig. 2, the metal strip drops down and the grooved pin slides into one or the other of the spaces between the teeth and it is there held in position. The regulation of the size of the focal area upon the anode is therefore variable from the outside of the tube.

An X-ray tube may be placed in any position without danger of the focusing shield sliding out of the position for which it is adjusted. The weight 30 proves helpful in displacing the focusing shield either forward or backward.

When the focusing trough 44 carried by the metal strip 45 is placed nearest to the filament, then the action of the focusing device is such that the smallest focal area is produced on the anode target. If however the shield is placed further back and away from the filament, then the focal spot will be larger or intermediate in size for the in-between positions. The size of the focal spot therefore is adjusted by shaking and tilting the tube into such positions that the metal strip 45 slides into that position which gives the correct distance between the filament and the focusing trough 44. Usually the teeth 29 are marked according to the size focus which they correspond to such as fine, medium and broad focus. Or the marking may be in terms of maximum milliamperes that can be carried by the tube with that particular focal spot.

Instead of a straight spiral filament, one that is wound in flat spiral or other form can be employed. The focal spot will then be round if the focusing member carried by the strip 45 is also circular in shape. With my device it is therefore possible to vary in size the form or shape of the focal spot.

In Figs. 2 and 3 a double filament is shown as 26 and 27. Between these two filaments which are connected in series and which are supported by the conductors 21 and 34, there is the metal strip 45 slidably arranged on the pin 48 by means of a slot 46 and also by means of the pin 33 and the toothed slot 47 as afore described. Therefore, by causing the metal strip to slide by tilting of the tube either forward or backward, the metal strip is caused to project more or less far out between the two filaments and it causes more or less widening of the focal band according to the distance it projects out between the two filaments. In case that the filaments should be round, then instead of a flat foil, a round pin is provided on the metal strip 45.

A slightly different method of carrying out my invention is shown in Fig. 6. In this illustration, 50 and 51 are two strips of thermostatic metal, each of these strips carrying a filament which by

means of a flexible conductor is connected in series through the two strips of thermostatic metal. These are further connected to the two conductors 57 and 58 which are sealed into the glass envelope and which lead to a source of heating current.

The aforementioned thermostatic metal consists of a combination of two metals with dissimilar thermal expansion coefficients due to which arrangement these strips bend when they are subjected to higher temperatures. These two strips are so placed and so dimensioned that the current required to heat the filaments to the proper emission temperature, will cause these strips to bend to such an extent that the two filaments, when they are heated to a maximum emission, are closest together or furthest away from the walls of the fixed focusing shield 59. When in that position, then the focal spot is largest or when furthest apart or closest to the walls of the focusing device, the focal spot is smallest. The regulation or adjustment of the area of the focal spot is in this case automatic and the size of focal spot changes as the magnitude of the heating current for the filaments is varied.

I claim:

1. An X-ray tube of the character described, comprising an evacuated glass envelope essentially cylindrical in shape, an X-ray anode and a cooperating cathode therein, and a metallic cylinder insulated both from the said anode and the said cathode and provided with a transparent space for the transmission of X-rays, said cylinder being supported on one of said electrodes and bridging about equally far over both electrodes and being of a diameter slightly larger than one half of the sum of the inside diameter of the glass tube and the outside diameter of the largest electrode.

2. An X-ray tube comprising an envelope and mounted therein an anode and a cooperating cathode, a main focusing means cooperating with and being movable with respect to said cathode and an auxiliary focusing device supported and cooperating with said cathode surrounding and bridging the gap between said anode and cathode and insulated therefrom, said auxiliary focusing device being opaque to X-rays and provided with a transparent window on side opposite the anode face for the exit of X-rays.

3. An electron discharge device comprising an evacuated envelope having mounted therein a cathode and an anode, an auxiliary focusing means mounted upon one of said electrodes and surrounding and bridging the gap between said anode and cathode and insulated therefrom, a main focusing means cooperating with said cathode said latter means being adjustable in respect to said cathode to vary the focal area in proportion to the load applied to the discharge device.

4. An X-ray tube comprising an evacuated enclosing envelope, an anode and an electron emitting cathode mounted therein, a main focusing means cooperating with said cathode to vary the focal area in proportion to the current load and an additional focusing device supported upon one of said electrodes consisting of an insulated metal cylinder surrounding and bridging the gap between said anode and cathode and provided with an X-ray transparent portion for the emission of X-rays.

5. In a discharge device of the character described comprising an envelope and mounted therein an anode and a cooperating electron

emitting cathode in combination with a metal shield electrically insulated from the anode and the cathode and also separated from the glass envelope, said shield being supported on one of said electrodes and cylindrical in form with its axis in the direction of the discharge and long enough to bridge fully over the space between the anode and the cathode and said shield having a portion through which X-rays are transmitted.

an envelope evacuated to a pure electron emission having mounted therein an anode and a cathode, a focusing device not affecting the magnitude of the discharge for controlling the direction of the discharge from the said cathode, and additional electrostatic means not in electrical contact with said envelope, said means being supported on one of said electrodes by means of insulating substance causing it to collect stray electrons.

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6. An electron discharge device consisting of