Feb. 14, 1939. A. KLINCKMANN 2,146,900

X-RAY TUBE

Filed Nov. 14, 1936

Fig. 1.

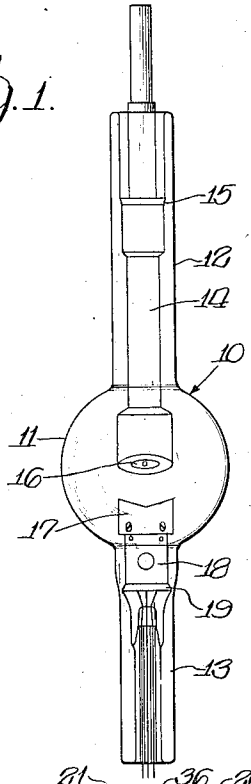


Fig. 2.

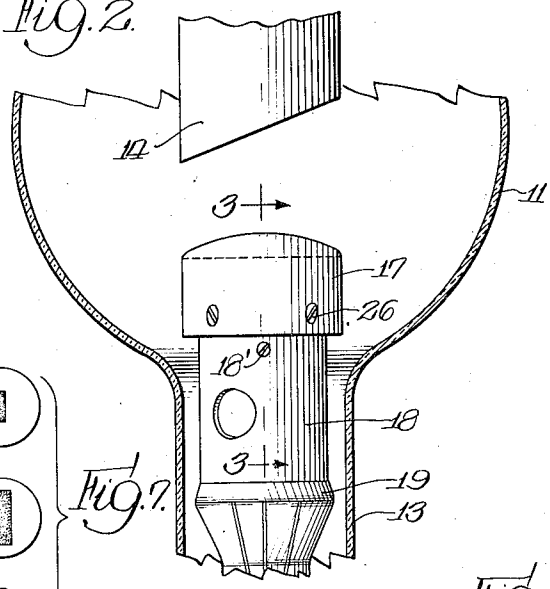


Fig. 7.

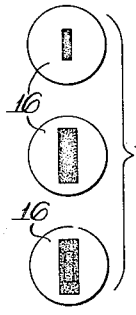


Fig. 3.

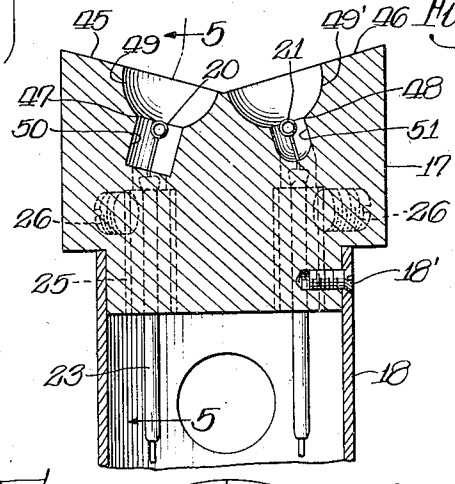


Fig. 6.

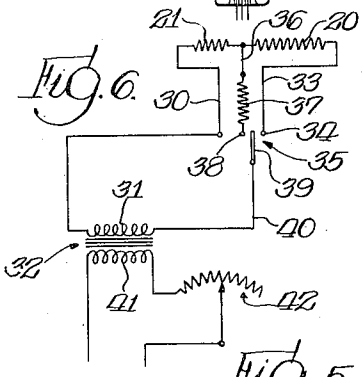


Fig. 4.

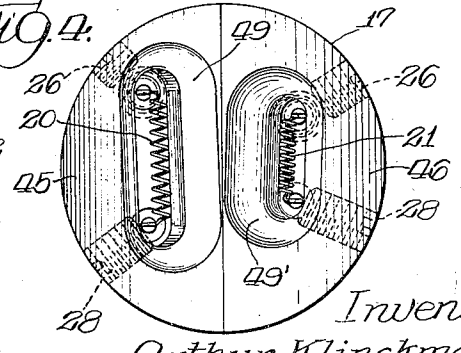
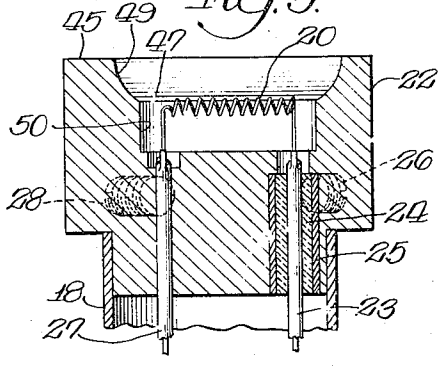


Fig. 5.



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UNITED STATES PATENT OFFICE

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X-RAY TUBE

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Application November 14, 1936, Serial No. 110,916

13 Claims. (Cl. 250—145)

The invention relates to an X-ray tube and has as a general object to provide such a tube of new and improved construction.

A more particular object of the invention is to perfect a new and improved X-ray tube adapted both for radiography and for fluoroscopy.

Another object of the invention is to provide an X-ray tube having a divided incandescent cathode, one portion only of which is employed for fluoroscopy, while the entire cathode is employed for radiography.

Yet another object is to provide an X-ray tube having an incandescent cathode divided into filaments of unequal size but simultaneously operable, each filament having an individual focusing device, so arranged that the focal spot of the discharge from the smaller filament falls on and reinforces the center of the focal spot of the discharge from the larger filament.

Other objects and advantages will become apparent from the following detailed description taken in connection with the accompanying drawing, in which:

Fig. 1 is an elevational view of an X-ray tube embodying the features of the invention.

Fig. 2 is an enlarged fragmentary view of the tube of Fig. 1 rotated through 90°.

Fig. 3 is an enlarged diametrical sectional view taken along the line 3—3 of Fig. 2.

Fig. 4 is an end elevational view of the cathode supporting head.

Fig. 5 is a sectional view taken along the broken line 5—5 of Fig. 3.

Fig. 6 is a diagrammatic view of the heating current circuit for the cathode.

Fig. 7 is a view of the target of the anode diagrammatically illustrating the distribution of the energy of the individual and the resultant focal spots.

As illustrated in the drawing, for purposes of disclosure, the invention is here embodied in an X-ray tube having a glass envelope generally designated 10 with a spherical intermediate portion 11 and oppositely disposed tubular extensions 12 and 13. Projecting into the spherical portion 11, through the extension 12, is a heavy rod 14 forming the anticathode and in this instance also serving as the anode of the X-ray tube. The rod 14 is sealed to the envelope at 15 in well-known manner and the inner face of the rod is disposed at an angle to the longitudinal axis of the tube. In order to increase heat conductivity, the rod preferably is made entirely of copper except for a small disk 16 embedded in the face of the rod which constitutes the target proper of the anode. This disk preferably is made of a material such as tungsten which is not readily melted by the heat generated by the bombardment thereof by the cathode rays. Disposed opposite the anode is the cathode and its support, comprising a metallic head 17 and a cylindrical shield 18 sealed to the envelope at 19, with the leads for the cathode projecting through the tubular extension 13. The shield is secured to the head by screws 18'. The envelope, of course, is highly evacuated.

New and improved means is provided herein for adapting this single tube for use in visual examination, that is fluoroscopy, as well is in radiography. To that end, the cathode is divided into portions with one portion arranged to be independently energized for purposes of visual examination and with the entire cathode energized for radiography. In addition, individual focusing devices for the discharge from the cathode are provided for each portion thereof with those devices designed to focus the discharge on the target in a manner to produce the desired quantities of X-rays for both fluoroscopy and radiography without overheating the target. More particularly, the cathode is composed of an elongated, cylindrically-wound wire filament 20 and a smaller filament 21 of the same construction. The filaments preferably are of tungsten and are mounted in the metallic head 17 in identical manner so that the description of the mounting of one will apply to the other as well. Accordingly the mounting of filament 20 only will be described.

One end of filament 20 (see Fig. 5) is connected to and extends through a metallic sleeve 23 which is spaced and insulated from the head 17 by means of a sleeve 24 of insulation, usually porcelain. The sleeve 24 in turn is surrounded by an outer metallic sleeve 25 which is firmly held in adjusted position by means of a set screw 26. The other end of the filament is likewise secured in and extends through a metallic sleeve 27 which, however, is in direct electrical contact with the metallic head 17. The sleeve 27 is secured in position by a set screw 28.

As best seen in Fig. 6, the insulated end of the smaller filament 21 is connected by a lead 30 to one end of the secondary winding 31 of a transformer 32. The insulated end of the larger filament 20 is connected by a lead 33 to one fixed terminal 34 of a switch generally designated 35. The head 17, with which the remaining ends of the filaments are in electrical contact, is connected by a lead 36 to one end of a small re-

sistance 37, the other end of which constitutes a second fixed terminal 38 of the switch 35. Completing the switch 35 is a movable contact 39 connected by a lead 40 to the remaining end of the secondary winding 31 of the transformer. The primary 41 of the transformer is connected to a suitable source of electrical energy through a rheostat 42 so as to vary the quantity of current flowing in the filaments. The transformer should be well insulated to withstand the high voltage applied in well-known manner, by means not here shown, across the cathode and anode. It will be apparent from the foregoing that by moving the contact 39 into engagement with the terminal 38 the smaller filament 21 only is energized, while movement of the contact 39 into engagement with the terminal 34 causes the entire cathode to be energized. The larger filament 20 cannot be energized independently of the smaller filament 21.

Herein the focusing devices for the filaments are formed directly in the head 17 and are so designed that the discharge from the larger filament 20 produces a focal spot of substantial area on the disk 16. This spot herein is substantially rectangular, see the intermediate representation of Fig. 7, with a greater concentration of energy at the periphery than at the center of the area. The focusing device for the smaller filament 21 produces a focal spot which also is rectangular but which is smaller than the spot produced by the focusing device for the filament 20. The smaller spot has a more even distribution of energy, see the top representation in Fig. 7, and moreover is located at the center of the focal spot of the larger filament so that when the entire cathode is energized a focal spot of large area and unusually uniform distribution results, as shown in the lower representation in Fig. 7. Thus when the smaller filament 21 is employed alone the required intensity and point origin of X-rays desirable for visual examination are obtained, while with the entire cathode energized a uniform yet large focal spot is obtained so as to produce the large amount of X-rays required for radiography without danger of melting the target.

To obtain those results, the end of the head 17 is herein formed with two faces 45 and 46 disposed at a large angle with one another and intersecting on a diameter of the head. The faces are disposed with their line of intersection in the plane of the longer diameter of the inclined end of the anode 14 (see Figs. 1 and 2) and each preferably forms an angle of approximately 18° with a transverse plane perpendicular with the longitudinal axis of the head. Formed respectively in the faces 45 and 46 are elongated recesses 47 and 48 having their major axis extending at but a very small angle, approximately 2°, with the line of intersection of the faces. Each of the recesses 47 and 48 has an outer portion 49 and 49' respectively, the walls of which are arcuate and in transverse cross section form parts of a semi-circle. The recess 47 has an inner portion 50 which, in transverse section, is rectangular, while the recess 48 has an inner portion 51 which, in transverse section, is U-shaped; the ends of both inner portions being rounded. The portion 50 is both wider and deeper than the portion 51 and the entire recess is longer in order that it may accommodate the larger filament 20. Both the filament 20 and the filament 21 are disposed longitudinally of the respective recesses just within the inner portion.

From the foregoing, it will be apparent that I have perfected a new and improved X-ray tube which may be employed advantageously for use both in radiography and fluoroscopy.

I claim as my invention:

1. An X-ray device comprising a highly evacuated envelope, an anode within the envelope, a cathode within the envelope adapted to be heated to incandescence, said cathode being divided into two portions of unequal size focused to have the focal spot of the smaller portion lie within the focal spot of the larger portion, and alternative circuits for energizing the smaller one only or both of said portions simultaneously, one of said circuits including the smaller portion and a resistance and the other of said circuits including both of the portions in series.

2. An X-ray device comprising a highly evacuated envelope, an anode within the envelope, a cathode within the envelope adapted to be heated to incandescence, said cathode being divided into two portions of unequal size and focused to have the focal spot of the smaller portion lie within the focal spot of the larger portion, and means for energizing only the smaller one of said portions or all of said portions simultaneously.

3. An X-ray device comprising a highly evacuated envelope, an anode within the envelope, a cathode within the envelope adapted to be heated to incandescence, said cathode being divided into portions focused so that the focal spot of one portion overlies the focal spot of the other portion, and alternative circuits for energizing one only or both of said portions simultaneously, one of said circuits including one only of the portions and a resistance, and the other circuit including both of the portions in series.

4. An X-ray device comprising a highly evacuated envelope, an anode within the envelope, a cathode within the envelope adapted to be heated to incandescence, said cathode being divided into two portions of unequal size, each of the portions having an individual focusing device with the focusing device for the larger portion producing a focal spot on the anode having an energy distribution heavier at the periphery than at the center, and with the focusing device for the smaller portion producing a smaller focal spot located at the center of the focal spot produced by the larger portion, and means for energizing only the smaller one of the portions of the said cathode or all of the portions simultaneously.

5. An X-ray device comprising a highly evacuated envelope, an anode within the envelope, a cathode within the envelope adapted to be heated to incandescence, said cathode being divided into two portions, an individual focusing device for each portion producing a focal spot on the anode of different size with the smaller spot located in the center of the larger area, and means for energizing the smaller one only of the portions of said cathode or all of the portions simultaneously.

6. An X-ray device comprising a highly evacuated envelope, an anode within the envelope, a cathode within the envelope adapted to be heated to incandescence, said cathode being divided into portions, a separate focusing device for each of said portions producing a focal spot on the anode of different size when different portions are energized, and means for energizing the smaller one only of the portions of said cathode or all of said portions simultaneously.

7. In an X-ray device, a highly evacuated envelope, an anode in said envelope, a divided cathode adapted to be heated to incandescence comprising two portions each composed of an elongated cylindrically-wound filament, means for supporting said cathode comprising a head having two faces disposed at a large angle to one another and generally directed toward said anode, an elongated recess in each of said faces having its major axis extending generally parallel with the line of intersection of said faces, each recess having an outer portion with arcuate side walls and an inner portion having parallel side walls, and means for supporting a portion of the cathode in each of said recesses.

8. In an X-ray device, a highly evacuated envelope, an anode in said envelope, a cathode adapted to be heated to incandescence and divided into two portions, and means for supporting said cathode comprising a head having two faces disposed at a large angle to one another and generally directed toward said anode, an elongated recess in each of said faces constituting a focusing device having its major axis extending generally parallel with the line of intersection of said faces, each recess having an outer portion with arcuate side walls and an inner portion, the inner portion of one of said recesses in transverse cross section being generally rectangular, the inner portion of the other of said recesses in transverse cross section being generally U-shaped, and means for securing a portion of the cathode in each of said recesses.

9. In an X-ray device, a highly evacuated envelope, an anode in said envelope, a divided cathode adapted to be heated to incandescence comprising two portions of unequal size, and means for supporting the portions and for focusing the discharge therefrom comprising a metallic head having on the end opposite the anode two faces disposed at a large angle with one another, an elongated recess in each of said faces having its larger axis extending generally parallel with the line of intersection of said faces, one of said recesses being larger than the other to accommodate the larger portion of the cathode, each recess having an outer portion with arcuate side walls, the larger recess having an inner portion which in transverse cross section is substantially rectangular, the smaller recess having an inner portion which in transverse cross section is substantially U-shaped, and means for securing the large and the small portion of the cathode respectively in the large and the small recess.

10. An X-ray device comprising an elongated, evacuated envelope, an anode in said envelope having its inner end face disposed at an angle to the longitudinal axis of the envelope, a divided cathode adapted to be heated to incandescence comprising two portions of unequal size, and means for supporting the portions and for focusing the discharge therefrom comprising a metallic head having on the end opposite the anode two faces disposed at a large angle to one another with the line of intersection of the faces lying in a plane through the major axis of the inclined face of the anode, an elongated recess in each of said faces with its major axis extending generally in the direction of the line of intersection of said faces, and means for securing a portion of the cathode in each of said recesses.

11. An X-ray device comprising an elongated, evacuated envelope, an anode in said envelope having its inner end face disposed at an angle to the longitudinal axis of the envelope, a divided cathode adapted to be heated to incandescence comprising two portions of unequal size, and means for supporting and for focusing the discharge from the portions of said cathode comprising a metallic head having on the end opposite the anode two faces disposed at a large angle to one another with the line of intersection of the faces lying in a plane through the major axis of the inclined face of the anode, an elongated recess in each of said faces with its major axis extending at a small angle with the line of intersection of said faces, and means for securing a portion of the cathode in each of said recesses.

12. In an X-ray device having an envelope, an anode and a cathode divided into individual filaments disposed within the envelope, means for supporting the filaments and for providing focusing devices for the filaments comprising a metallic head having its end opposite the anode divided into two opposed faces disposed at an angle with respect to a transverse plane perpendicular to the axis of the head, a recess opening through each face and extending inwardly at right angles thereto, each recess having an outer portion with arcuate side walls and an inner portion, one of the filaments of the cathode being mounted in each of the recesses just within the inner portion thereof.

13. In an X-ray device a cathode comprising an elongated, cylindrically-wound filament, and means for supporting the filament and for focusing the discharge therefrom comprising a metallic head having an elongated recess opening through the end thereof in which the filament is positioned, a metallic sleeve extending longitudinally through the head and secured to one end of the filament, a set screw threaded into the head and engaging said sleeve to retain the same rigidly in fixed position, a metallic sleeve secured to the other end of said filament and extending through said head, a sleeve of insulating material surrounding said metallic sleeve, a second metallic sleeve surrounding said insulation, and a set screw threaded into the head and engaging said last mentioned sleeve to retain the end of the filament in fixed position.

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