Oct. 31, 1933. A. BOUWERS 1,933,005

X-RAY TUBE

Filed March 13, 1930

Fig. 1.

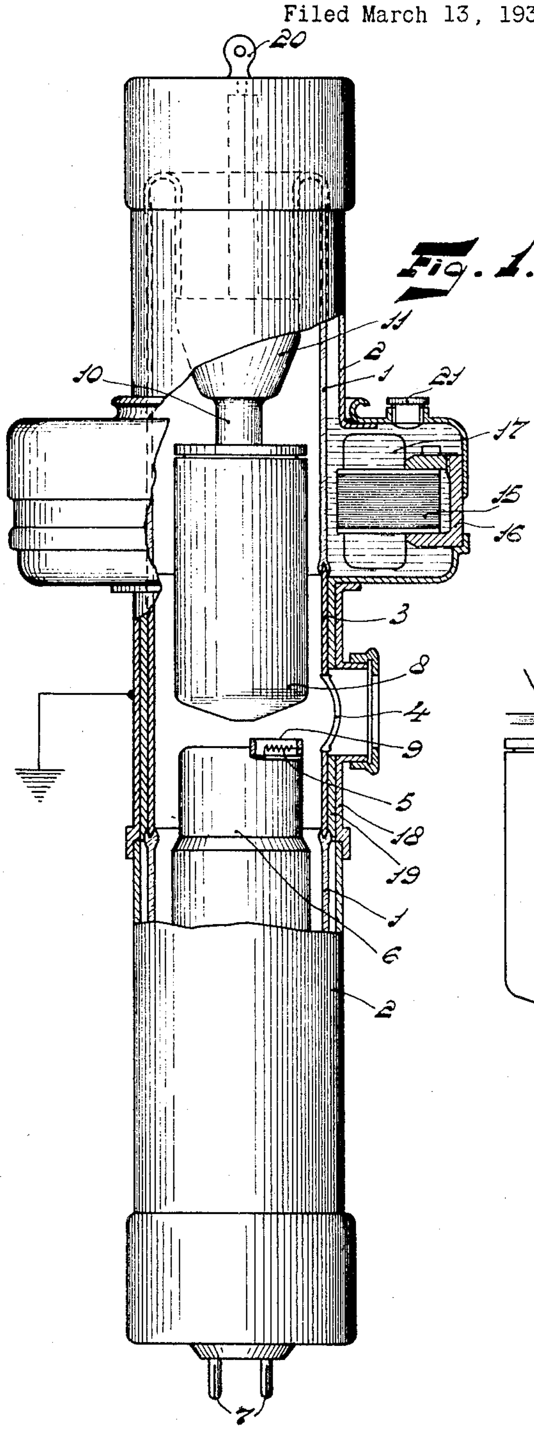


Fig. 3.

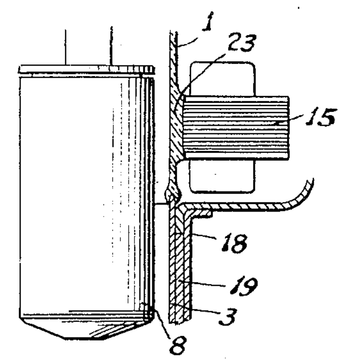
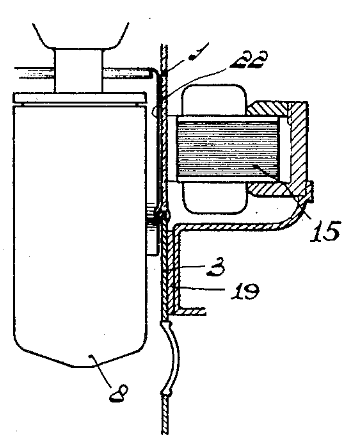


Fig. 2.



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X-RAY TUBE

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8 Claims. (Cl. 250—35)

This invention relates to X-ray tubes of the type having an anticathode which is made to rotate by means of a rotating magnetic field excited outside the tube. This may be done by arranging the tube in such manner that either the anticathode itself or a member which is mechanically connected thereto constitutes the rotor of an electric motor. The field may be excited either by a polyphase alternating current or by a rotatory magnet system. Since the bombarded surface of the anticathode is materially larger than in tubes of the type having a concentrated focal spot which is formed on a stationary anticathode, such tubes present the advantage that a much higher load may be applied.

The invention has for its purpose to still further increase the load capacity. We have found that in tubes having a rotatory anticathode, in which there prevails a great potential difference between the magnet system which is located outside the tube and the rotatable member, the admissible tension is limited by the intensity of the electric field in the air-gap between the vitreous wall of the tube and the magnet system.

The insulation path between this magnet system and the anticathode or the body connected thereto which acts as a rotor consists of three parts of which the first part is constituted by the space between the tube wall and the rotor within which prevails the high vacuum of the tube, the second part by the section of the tube wall and the third part by the air-path between the wall of the tube and the magnet system. The latter is least capable of withstanding electrostatic loads. At a definite potential difference ionization occurs in this air-gap, so that the air is rendered conductive and the vitreous tube wall is endangered.

The present invention relates to an X-ray tube of the type referred to above and comprises means for preventing the existence or for limiting the intensity of an electric field in air between the magnet system and the tube wall. For this purpose various means may be resorted to, some of which will be referred to hereinafter.

The above purpose may be attained either by suppressing the air-path of the magnetic lines of force itself or by neutralizing the electric field in the part of the magnetic circuit prevailing between the wall of the tube and the magnet system. This air path may be suppressed by filling the preferably narrow gap between the magnet system and the tube wall with an insulating material, for example, oil, compound, or other suitable materials. If the magnet system is constituted by one or more rotatory magnets then the latter may move in oil.

The electric field in the air-gap may be neutralized or limited by providing electrostatic screening means constituted by one or more electrically conducting members which are preferably electrically connected to the magnet system and mounted between the air-gap and the rotor. To this effect an electrically conducting ring or one or more electrically conducting plates may be arranged on or adjacent the wall of the tube, these members being surrounded by the magnet system.

One side, preferably the inner side of the tube wall may be provided with one or more metal coatings. If such a coating is provided on the inner wall of the tube and maintained at the same potential as the magnet system then the electrostatic load of the air-gap as well as that of the vitreous wall is neutralized so that the insulation is constituted only by the high vacuum which is particularly adapted for this purpose.

The invention will be more clearly understood by reference to the accompanying drawing, representing, by way of example, one embodiment of the invention. In this drawing:

Fig. 1 shows an X-ray tube having a rotatory anti-cathode and in which the anticathode itself constitutes the rotor of an induction motor.

Fig. 2 is a partial view of a tube of this type.

Fig. 3 is a similar view of another modification.

In the tubes shown in Fig. 1 and Fig. 3 the presence of air is prevented between the vitreous wall of the tube and the stator and in Fig. 2 the electric field outside the tube wall is neutralized.

The outer wall of the tube shown in Fig. 1 consists of two vitreous parts 1 surrounded by tubes 2 of insulating material which is substantially impervious to X-rays.

Between these vitreous parts a metal portion 3 is sealed. An alloy of iron and chromium which is not porous and may be readily sealed to glass is particularly suitable for use as material constituting this metal portion. This portion comprises a window 4 through which the X-rays may emerge from the tube.

Furthermore the tube comprises an incandescent cathode 5 which is mounted in a metal vessel 6 and connected to the contact pins 7 to which the leading-in wires for the heating current may be connected. The beam of electrons emitted by this cathode is concentrated on a small area of the anticathode 8, this area being determined by the shape of the aperture 9 in the focussing device 6.

The anticathode 8 is rotatably mounted on a spindle 10 ending in the metal member 11 which is sealed to the vitreous wall of the tube and connected to the contact member 20. The rotation of the anticathode is effected by arranging the tube in such manner that the anticathode constitutes the rotor of an induction motor. This anticathode preferably consists of a cylinder made of a good electrically conducting material, for example, copper, which surrounds a second cylinder consisting of a material with a high permeability.

The stator 15 of the motor lies entirely outside the tube. The field is excited by the magnet windings 17 which may be connected to a polyphase alternating current network. They may also be arranged in such manner as to be connected to an ordinary source of alternating current through the intermediary of arrangements by which a mutual phase displacement is brought about thus producing a rotating field by which the anticathode body is made to rotate like the rotor of an asynchronous motor. The stator is surrounded by a casing 16 secured to a metal tube 18 and connected to earth during the operation. This casing constitutes a closed space around the tube wall, which includes also the intermediate space between the stator iron and the vitreous wall of the tube.

According to the invention this closed space is filled with an insulating material for example, transformer oil, compound or a similar substance, so that the part of the magnetic circuit between the stator and the tube wall is entirely occupied by this substance. The apertures for pouring in the fluid are closed by means of screwed plugs 21.

When operating the X-ray tube the metal part 3 of the tube wall, the surrounding lead-ring 19, the metal tube 18 and the motor casing 16 are connected to earth as well as the middle of the secondary winding of the transformer supplying the high tension required for the operation of the tube. Consequently there exists a high tension between the stator 15 and the anticathode 8, this tension corresponding to half the potential difference between the electrodes. Without the filling with insulating material above referred to the danger might arise that the air enclosed between the stator and the tube wall is ionized at a definite potential difference, so that especially in case the potential difference is of an alternating nature, the tube wall might be heated to a dangerous extent thus giving rise to a breakdown.

Fig. 2 shows again the anticathode 8 and moreover part of the stator 15. In this figure the metal coating on the inner side of the tube wall 1 is denoted by 22. The lower side of this coating is secured to the metal wall portion 3 which is directly electrically connected to the stator 15.

In this manner an electric field outside the tube wall is entirely prevented and even the electric stress in transverse direction in the tube wall itself is neutralized. Besides the advantage that there is no longer a risk of ionization the additional advantage is obtained that the stator may be disposed close to the tube wall.

The second advantage might be also obtained without the means shown in Figs. 1 and 2, viz. by sealing the stator to the vitreous wall, as shown at 23 in Fig. 3. In this case it is necessary, however, to make the iron portion of the stator of a material whose coefficient of expansion corresponds to that of the glass. Of course, this condition does not hold good for a coating as shown in Fig. 2, which is preferably made of a non-magnetic material so as to prevent leakage.

If the neutralization of the electric field outside the wall is obtained by taking care that the wall portion 3 penetrates into the magnetic field of the stator 15, then it is advisable to make also this wall portion of a suitable material with a low permeability.

In case a metal coating is provided outside the wall, which may be advisable in some cases in view of the difficulties encountered in degasifying then it is important to take care that the coating bears closely on the wall.

The coatings may also consist of metal foil, for example, tin foil or of a layer which is precipitated on the wall by disintegration.

What I claim is:

1. An X-ray tube having a cathode and an anode rotatably mounted opposite thereto, a wall connecting said anode and said cathode, comprising a glass end portion and being cylindrical where it surrounds said anode, a metallic stator carrying magnetic coils for imparting rotative motion to said anode and arranged without the tube and surrounding a portion of the anode and of the cylindrical wall, said glass wall portion extending between said anode and the area surrounded by said stator and capable of withstanding the half potential difference between the electrodes, and a protective metal shield between said stator and anode and extending throughout said area, said shield being electrically connected to said stator.

2. An X-ray tube having an anode, a cathode and a wall connecting these electrodes, said wall consisting of a metallic cylindrical portion, two glass portions connected to said metallic portion each capable of withstanding the half potential difference between said electrodes, the anode being rotatably mounted and partly surrounded by said metallic wall portion and partly by one of said glass portions, a magnetic stator provided with a winding, said stator surrounding said one glass portion and electrically connected to the outer side of said metallic wall portion, a metallic shield arranged between said anode and the glass wall portion surrounding said anode, said shield being electrically connected with the inner side of said metallic wall portion.

3. An X-ray tube having a cathode, an anode and a wall connecting same, said wall comprising a conductive middle portion surrounding the discharge gap between said electrodes, and glass portions each connecting said middle portion to one of said electrodes, the anode being rotatably mounted, a magnetic stator provided with a winding, said stator surrounding the anode and serving to produce a rotating magnetic field to rotate said anode, a metallic enclosure surrounding said middle portion supporting said stator and constituting an electrical connection between the middle portion and the stator and a metallic coating covering the inner side of said glass wall and extending from said metallic portion throughout the area surrounded by said stator.

4. An X-ray tube having an evacuated envelope comprising at least one glass wall portion, an electron-emitting electrode disposed in said envelope, an X-ray emitting electrode rotatably mounted in said envelope so as to be at least partly surrounded by said glass wall portion thereof, a magnetic stator carrying magnet wind-

ings to impart rotative motion to said rotatable electrode and surrounding in closely spaced relation said glass wall portion, a conductive shield surrounding said rotatable electrode and disposed between the latter and said glass wall portion and a conductive connection between said shield and said magnetic stator.

5. An X-ray tube having an evacuated envelope comprising at least one glass wall portion, an electron-emitting electrode disposed in said envelope, an X-ray emitting electrode rotatably mounted in said envelope adjacent said glass wall portion, a magnetic stator carrying magnet windings to impart rotative motion to said rotatable electrode and surrounding the envelope of the tube, a conductive shield between the rotatable electrode and said stator at the point where the stator surrounds the envelope of the tube and a conductive connection between said shield and said stator.

6. An X-ray tube having an evacuated envelope comprising at least one glass wall portion, an electron-emitting electrode disposed in said envelope, an X-ray emitting electrode rotatably mounted in said envelope adjacent said glass wall portion, a magnetic stator carrying magnet windings to impart rotative motion to said rotatable electrode and surrounding the envelope of the tube, a metallic shield adjacent a part of the glass wall portion between the ends of the tube and located between the rotatable electrode and said stator at the point where the stator surrounds the envelope of the tube and a conductive connection between said shield and said stator.

7. An X-ray tube having an evacuated container comprising a wall consisting at least partly of glass, a cathode structure and a rotatable anode body disposed within said container and at least partly surrounded by said glas wall, a magnetic stator and a winding therefor serving to impart rotative motion to said anode body, said stator surrounding a glass portion of the tube wall around said anode body, and insulated from the latter by a wall portion capable of withstanding a high potential difference and a conductive surface between said stator and said anode for preventing gas-ionization under the influence of an electrostatic field in the space between said stator and said glass wall portion.

8. An X-ray tube having an evacuated envelope, a cathode and an X-ray emitting electrode mounted therein, said envelope comprising a cylindrical glass wall portion and said X-ray emitting electrode being rotatably mounted and at least partly surrounded by said cylindrical glass wall portion and a current conductor fused to said glass portion supporting said electrode, a magnetic stator provided with a winding, said stator surrounding said glass wall portion in spaced relation and serving to impart rotative motion to said electrode, the portion of the glass wall which extends from the region of the stator to said current conductor being capable of withstanding a high potential difference, and a metallic shield applied to the inner side of said wall portion which extends throughout the area surrounded by said stator and electrically connected to the latter.

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