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ELECTRIC DEVICE FOR THE OPERATION OF X-RAY TUBES

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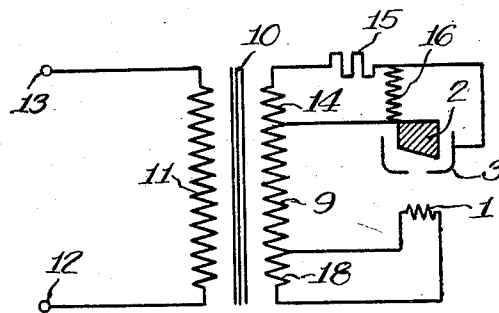


Fig. 1.

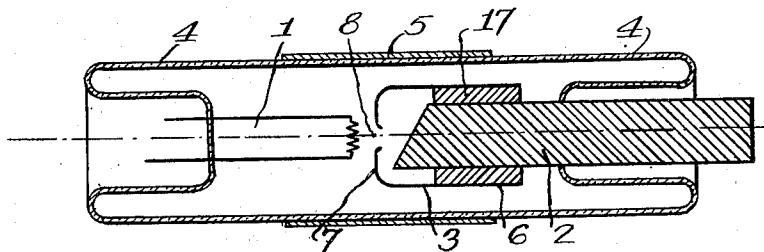


Fig. 2.

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ELECTRIC DEVICE FOR THE OPERATION
OF X-RAY TUBES

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6 Claims. (Cl. 250-146)

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It is known that the loading capacity of exhausted X-ray tubes is limited by the condition that the temperature of the anode must not exceed a given value which is dependent on the material of the anode and on the way the tube is made use of. If direct voltage is used this maximum temperature is fixed by the requirement that the anode must not melt and must not volatilize to any appreciable extent. If on the contrary alternating voltage is used, the more stringent requirement has to be fulfilled that the thermal electron emission of the anode should be extremely small. If such is not the case, back-firing occurs during the negative phase of the voltage when the cathode is positive with respect to the anode and this frequently leads to deterioration of the tube.

It has been suggested before to operate by alternating voltage X-ray tubes comprising an auxiliary electrode which is arranged adjacent the anode in the discharge path so as to constitute a screen between the anode and the cathode, a constant controllable voltage of low value compared with the tube voltage being applied between the cathode and the screen, or the screen being connected with the cathode. This measure does not prevent the setting up of back-firing in the antiphase of the voltage if the temperature of the anode is sufficiently high for thermal emission of electrons.

The use of the invention efficiently avoids the occurrence of backfiring in the negative phase of the terminal voltage, when operating the tube by means of alternating voltage. The invention relates to an electric device provided with an X-ray tube comprising an auxiliary electrode which is arranged between the anode and the cathode on the discharge path and comprises an aperture for the passage of the beam of electrons. The auxiliary electrode is insulated from the electrodes used for the generation of the X-rays. According to the invention, care is taken that the auxiliary electrode is negative with respect to the anode so long as the anode is negative with respect to the cathode. Even if the anode has an intense emission of electrons, a voltage of several thousands of volts will suffice to completely screen the field of the cathode at the area of the anode.

The auxiliary electrode may be connected in an electrically conductive manner with a connection to the set for the supply of the high voltage, this connection and the connecting terminal of the anode voltage having arranged between them a winding connected in series with the high volt-

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age winding. For this purpose use made be made of a separate transformer and due regard should be had to the winding being connected to the high voltage winding in such manner that the voltage difference between the auxiliary electrode and the cathode is higher than between the anode and the cathode. However, this construction has only advantages if the anode of the tube is connected to earth, as otherwise a transformer must be used whose secondary and primary are separated one from another by a high voltage insulation. Generally speaking, it will therefore be more advantageous that the auxiliary winding forms part of the high voltage winding of the supply transformer.

During the phase of the operating voltage in which the anode is positive with respect to the cathode, the auxiliary electrode may be positive with respect to the anode. The comparatively low potential difference of the auxiliary electrode with respect to the anode will not appreciably affect the course of the electrons because the speed of the electrons in the proximity of the screen is already very high, so that this is no source of trouble as far as the focussing of the beam is concerned.

It is desirable that the voltage on the auxiliary electrode should not lag behind the tube voltage. It is thus avoided that the electrode remains inactive during the first part of the negative phase of the operating voltage. Though the voltage between the electrodes is low, even then this might suffice to initiate the back discharge. This may be avoided by using means accelerating the phase of the voltage placed on the auxiliary electrode with respect to the tube voltage. This may be achieved by including a resistance in the voltage supply conductor for the auxiliary electrode, the series combination of the auxiliary winding and the resistance being shunted by an inductance. The phase difference between the terminal voltage and the voltage on the auxiliary electrode is dependent on the voltage drop in the resistance. The phase difference between the tube voltage and the voltage on the auxiliary electrode can be controlled by various other circuit-arrangements with the aid of resistances and condensers and/or inductances.

In a device according to the invention, use may be made of an X-ray tube in which the auxiliary electrode surrounds the front surface of the anode in the manner of a hood, the hood acting as a collector of secondary electrons, so that the electrons are prevented finding their way to the wall of the tube and causing undesirable charges

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which may lead to a breakdown of the wall. The anode of the tube may act as a carrier of the hood and the latter may be secured to the anode by the insertion of an intermediate piece of insulating material. The use of insulating material capable of conducting heat, such as porcelain or calite, ensures that the temperature of the screen invariably remains below the value at which thermal emission of electrons occurs.

X-ray tubes are known in which that portion of the anode surface which is struck by the electrons is surrounded by a hood made of metal which is carried by the anode and has the same potential as the latter. In this case, the area on which the electrons impinge and which is heated up to a high temperature, is located in a space free from field, so that electrons dislodged from the anode by thermal agency are free to enter through the aperture for the passage of the beam of electrons into the discharge path, where they bring about backfiring in the tube if alternating voltage is used for the operation of the tube.

The invention may also be applied to X-ray tubes having a rotary anode and is particularly important if use is made of a rotary anode made up of a thin metal disc, since this is not fully loaded until it has reached a high temperature.

It has been suggested on one or more occasions to cover the front surface of a rotatably arranged anode by a screen (vide French specification No. 713,190). It related to a tube for scientific investigation having characteristic rays. In order to prevent the formation of a deposit on the front surface of the anode as far as possible this was covered, but for the focal spot, by a stationary screen. To achieve the purpose to which the screen was put, it has to be arranged as close as possible to the surface of the anode. In this case, the screen may be heated during the load of the tube to such an extent that it starts acting itself as a source of thermal emission of electrons. The screen in the tube according to the invention must therefore be arranged at a slight distance from the front surface of the anode. If the screen is constructed so as to surround at least the space between the screen and the anode as hood, it can serve at the same time for arresting secondary electrons.

If arranged so as to be insulated the screen should be able to reject by radiation the heat radiated by the anode and absorbed by the screen. It is therefore advisable that the surface of the screen should have a high heat-radiating power and for this purpose it may, for example, be externally coated with a black film.

In order that the invention may be clearly understood and readily carried into effect, it will now be described more fully with reference to the accompanying drawing, in which

Fig. 1 shows, by way of example, a schematic circuit diagram of a device according to the invention;

Fig. 2 shows one form of construction of an X-ray tube for use in a device as shown in Fig. 1 having a stationary anode.

Referring to Fig. 1, the X-ray tube is shown very diagrammatically, 1 designating the cathode, 2 the anode and 3 the auxiliary electrode. As shown in Fig. 2, these electrodes are contained in a closed glass vessel 4 which may comprise a metal part 5 which surrounds the discharge path. The auxiliary electrode 3 is made up of a cylinder 6 which surrounds the anode 2 and, in the direction of the cathode 1, is closed by a dia-

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phragm 7 which extends between the anode and the cathode in the discharge path and which comprises an aperture 8 for the passage of the electrons emitted by the cathode. The smaller this aperture, the more efficient will be the screening effect of the diaphragm as regards the field of the cathode, so that it is advisable that the aperture is not larger than is required with a view to ensuring the passage of the beam of electrons. The cylinder and metal part 5 are each provided with an aperture for the passage of X-rays emitted from the anode surface. Likewise, the thickness of the wall of the glass envelope includes a portion of reduced thickness.

The voltage between the anode 2 and the cathode 1 of the tube is supplied by the secondary 9 of a high voltage transformer 10 whose primary 11 is connected to terminals 12 and 13 which are connected to the voltage controlling and adjusting members (not shown in the figure). The energy for the heating of the cathode 1 is supplied by a part 18 of the secondary of the high-voltage transformer. At the other end of the high voltage winding a number of turns 14 are connected in series with the high voltage winding 9. The anode hood 3 is connected to the end of these turns via a resistance 15, and the potential difference between the hood 3 and the anode 2 is shunted by an inductance 16. The use of this inductance has for its object to avoid any lag of the voltage that is due to the inductance of the transformer coils. It is thus ensured that the voltage on the hood does not lag behind the voltage on the anode. If it leads slightly a flow of electrons will be able to start flowing during the end of the negative phase from the anode to the cathode and, since it is not set up until the potential difference between the anode and the cathode has but a small value, will no longer lead to backfiring and breakdown of the tube.

The hood 3 is fixed to the anode 2 with the aid of an intermediate part 17 of electrically insulating material which is preferably made up of material capable of acting as a thermal conductor, so that any temperature differences between the hood and the anode are compensated and there is no risk of the hood being heated up to a temperature which is sufficiently high for the setting up of thermal emission of electrons.

What I claim is:

1. An electric device to be operated from an alternating voltage and comprising an X-ray tube provided with a cathode, an anode and an auxiliary electrode having a cylindrical portion surrounding the anode and a diaphragm portion extending parallel to the cathode and enclosing one end of the cylindrical portion between the cathode and the anode, the diaphragm having an aperture therein for the passage of an electron beam from the cathode to the anode; a main high-voltage transformer winding connected to serve as a source of alternating voltage for the tube and connected between the cathode and the anode; and a winding connected between the auxiliary electrode and the terminal of the main winding that is connected to the anode.

2. An electric device as claimed in claim 1, wherein the winding for the supply of the voltage to the auxiliary electrode is integral with the high-voltage winding.

3. An electric device as claimed in claim 1, including means connected between the auxiliary electrode and its source of voltage constituting a device for advancing the phase of the voltage

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placed on the auxiliary electrode with respect to the anode voltage.

4. An electric device as claimed in claim 1, including means connected between the auxiliary electrode and its source of voltage constituting a device for advancing the phase of the voltage placed on the auxiliary electrode with respect to the anode voltage, said phase-advancing device including a resistor and an inductance, with the resistor in the voltage supply conductor for the auxiliary electrode and the inductance connected to be subjected to the potential difference between the auxiliary electrode and the anode.

5. An X-ray tube system for alternating voltage operation of the tube, comprising an X-ray tube having a cathode, an anode and an auxiliary electrode between the cathode and the anode, the auxiliary electrode comprising a cylindrical portion surrounding the anode and a diaphragm portion extending parallel to the cathode and enclosing one end of the cylindrical portion between the cathode and the anode, the diaphragm having an aperture therein for the passage of an electron beam from the cathode to the anode; a source of alternating voltage connected between the cathode and the anode; and a source of alternating voltage for the auxiliary electrode and connected to be effective between the cathode and the auxiliary electrode to cause the potential difference from cathode to auxiliary electrode to be in phase with and greater than the potential difference from cathode to anode.

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6. X-ray apparatus comprising an X-ray tube coupled to a source of alternating current and including an anode and a cathode, a hood-like auxiliary electrode interposed between the cathode and anode in the discharge path and having an aperture therein for the passage of an electron beam, and means coupled to and adapted to be energized by the alternating current source for maintaining the auxiliary electrode negative with respect to the anode when the anode is negative with respect to the cathode.

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