Oct. 4, 1938. R. R. MACHLETT 2,132,175

X-RAY APPARATUS

Filed Sept. 8, 1937

Fig. 1.

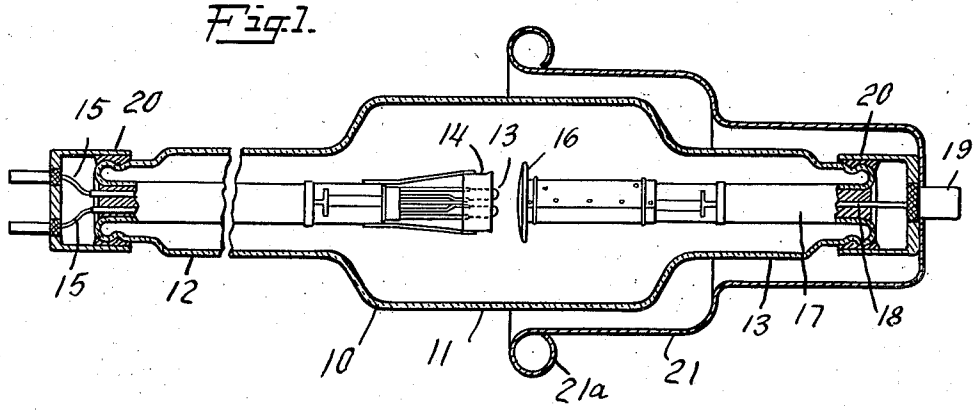
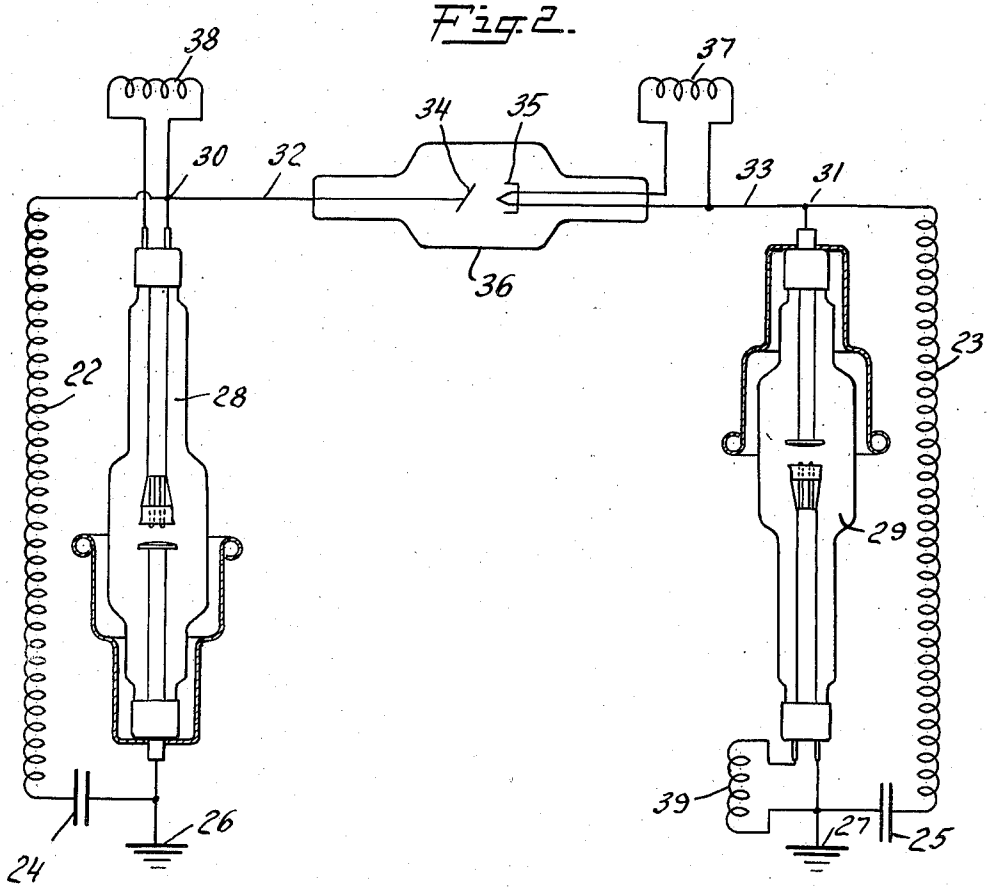


Fig. 2.



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X-RAY APPARATUS

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2 Claims. (Cl. 250—27.5)

This invention relates to high voltage thermionic discharge devices of the type in which one of the electrodes, during the operation of the device, acquires a high negative potential with respect to objects in its vicinity. More particularly, the invention is concerned with devices of the kind referred to having novel features of construction which increase the life of the devices and improve their operation. The principles of the invention may be embodied in thermionic discharge devices of various kinds and for various purposes, but, since the invention may be utilized to special advantage in high vacuum hot cathode rectifier tubes, a tube of that type containing the new features will be described in detail for purposes of explanation. It is to be understood, however, and will be readily apparent that the utility of the invention is not limited to devices of that particular kind.

A high vacuum hot cathode rectifier tube depends for its operation on the well known rectifying action of an electron-emitting filament opposing a cold plate in a vacuum tube. Such a valve tube is always operated below the saturation value and it is so constructed that the amount of current required to pass through it in the performance of its function flows through with a negligible voltage drop when the cathode is negative. On the succeeding half wave, during which the plate or anode is negative, no current flows and when the tube is blocking, that is, when the anode is negative, the potential of the anode with respect to the cathode, the tube walls, and other surrounding objects may become very high. Because of that, special precautions are taken in designing a valve tube to avoid the occurrence of cold emission or "field" currents which might cause electronic bombardment of unshielded portions of the tube and eventually cause a breakdown.

With a well designed tube installed in equipment as heretofore built, the expedients employed for preventing the undesirable effects above referred to, have ordinarily been adequate, even when high negative potentials of the order of two hundred PKV or more are applied to the anode. More recently, however, there has been an increased tendency to build such equipment in a more compact form and this is particularly true of the extremely high voltage equipment employed for deep therapy. In the most modern form, such equipment capable of producing voltages of 400,000 volts or more is entirely oil-immersed so that it will occupy a minimum of space and at the same time be shockproof. In such equipment, the various parts are in much closer proximity to each other than was previously the case, and, in addition, they are surrounded by a different dielectric medium, that is, oil instead of air.

Although apparently subjected to the same current and voltage conditions under which they operated satisfactorily in old style equipment, it has recently been found that valve tubes as heretofore constructed will, under the new conditions, become gassy and inoperative after a short period of use. This degeneration of the tube I have found to be caused by field currents within the tube which bring about bombardment of some of its unshielded parts and thus cause a liberation of undesirable gas. Apparently, the electric fields around the tube when installed in the new equipment are much stronger than those occurring in equipment of the older style and the expedients previously used to avoid the undesirable effects referred to are now insufficient for the purpose.

The present invention is, accordingly, directed to the provision of a valve tube which will operate satisfactorily for long periods of time when installed in modern generating apparatus of the compact type and immersed in oil. The new tube includes the usual envelope, filament, and anode, and, in addition, it is provided with an external metallic shield which is connected to the anode of the tube and encloses the anode neck, the shield preferably terminating some distance beyond the anode head in the direction of the cathode end of the tube.

Since the shield is directly connected to the anode, its potential is the same as that of the anode and when the latter attains a high negative potential in operation, a similar field is produced around the outside of the tube. With the development of the external field, undesirable bombardment of the glass walls and other delicate parts of the tube is avoided and rapid degeneration of the tube is prevented.

For a better understanding of the invention, reference may be made to the accompanying drawing, in which

Figure 1 is a longitudinal sectional view of a valve tube constructed in accordance with the principles of the invention, and

Figure 2 is a diagram illustrating the use of the new tube in high voltage generating equipment.

Referring to the drawing, the tube illustrated includes an envelope 10 having an enlarged central portion 11 and the usual necks 12 and 13 extending therefrom. The end portion of the tube is brought back into the neck 12 in the usual

way to provide a support for the filament 13, which is mounted within a shield 14 and is connected to lead-in wires 15 sealed through the envelope wall. Opposing the filament is the anode 16, which is in conventional form and is mounted on a reentrant end portion 17 of the envelope extending into the neck 13. The anode has a stem 18 which is sealed through the envelope wall and at its outer end, the stem is provided with a terminal 19. The tube is also provided with the usual end caps 20 and other features of standard construction.

Mounted on the anode stem in electrical connection with the terminal 19 is a metallic shield 21, this shield enclosing and being spaced from the neck 13 of the envelope and a portion of the central enlargement 11. The shield is made of any desired metal and the rim at its open end is preferably rolled upon itself, as indicated at 21a. The shield preferably extends somewhat beyond the face of the anode in the direction of the cathode, as illustrated.

A typical example of an X-ray apparatus in which the new valve tube is employed is illustrated in Figure 2. This apparatus is for the production of 400,000 volt X-rays and all parts thereof are completely oil-immersed, the grounded metal container or housing which encloses the apparatus and the oil in which it is immersed being omitted from the drawing. The entire apparatus occupies a small space and its various component parts are in close proximity to one another and to the walls of the container.

The apparatus illustrated employs the so-called Villard or voltage doubling circuit, each half of which builds up a potential of 200,000 volts from ground, positive on one side and negative on the other. The apparatus includes a pair of transformers, of which the secondaries 22, 23 only are shown, and one end of each secondary is connected through a condenser 24, 25, to ground at 26, 27. Connected to ground and to the other terminal of each secondary is a valve tube 28, 29 of the new construction, the tubes being connected in reverse arrangement, as illustrated. From the points of junction 30, 31 of the transformer secondaries and the tubes are conductors 32, 33 leading, respectively, to the anode 34 and cathode 35 of an X-ray tube 36. The cathode filament of the X-ray tube is heated by current supplied by the secondary 37 of a transformer, and the cathode filaments of the valve tubes 28, 29 are heated by current supplied by the secondaries 38, 39, respectively, of the transformers.

With the circuit described, the connections are such that current at a voltage of 400,000 volts flows through the X-ray tube on successive half waves, part of the voltage being supplied by the output of the transformer secondaries 22, 23, and the remainder by the condensers 24, 25.

When the apparatus of the type illustrated was operated with ordinary valve tubes in the modern compact equipment with the various parts of the apparatus oil-immersed, it was found that the valve tubes degenerated rapidly as a result, apparently, of heavy electronic bombardment of the unshielded parts of the tubes. Valve tubes of the new construction were then installed in the equipment and their operation proved entirely satisfactory. The reason for this is that the shield on each tube maintains an external field in the vicinity of the anode which is of the same order and sign as the potential of the anode, and as a result, destructive electronic bombardment of the unshielded parts of the tube is prevented.

What I claim is:

1. A thermionic rectifier tube for use in a housing of the compact type containing oil in which the tube is immersed, which comprises an envelope, an anode and an electron-emitting cathode within the envelope, the anode acquiring a high negative potential with respect to objects in its vicinity during operation of the device and constituting a source of destructive field currents, and means enclosing the anode end only of the envelope and maintaining in the vicinity of the anode an electric field of the same order and sign as the potential of the anode, said means comprising a metallic shield connected electrically to the anode and extending from the anode end of the tube and terminating between the head of the anode and the cathode, the cathode end of the envelope being unshielded.

2. A thermionic rectifier tube for use in a housing of the compact type containing oil in which the tube is immersed, which comprises an envelope, an anode and an electron-emitting cathode within the envelope, the anode acquiring a high negative potential with respect to objects in its vicinity during operation of the device and constituting a source of destructive field currents, and means enclosing the anode end only of the envelope and maintaining in the vicinity of the anode an electric field of the same order and sign as the potential of the anode, said means comprising a metallic shield conforming to the shape of the envelope and spaced substantially uniformly therefrom, the shield being connected electrically to the anode and extending from the anode end of the tube to terminate between the head of the anode and the cathode, the cathode end of the envelope being unshielded.

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