Feb. 24, 1931. D. A. MULLANEY 1,794,315

ELECTRON DISCHARGE APPARATUS

Filed Oct. 9, 1924

Fig. 1.

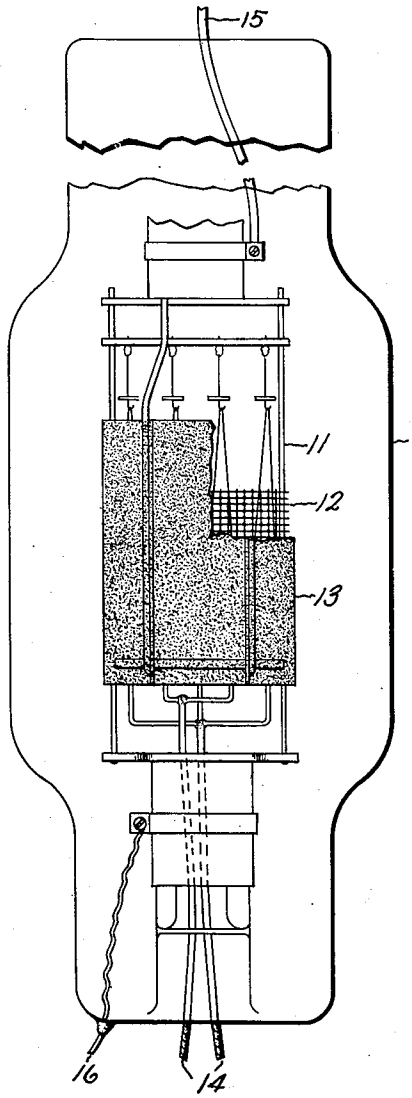
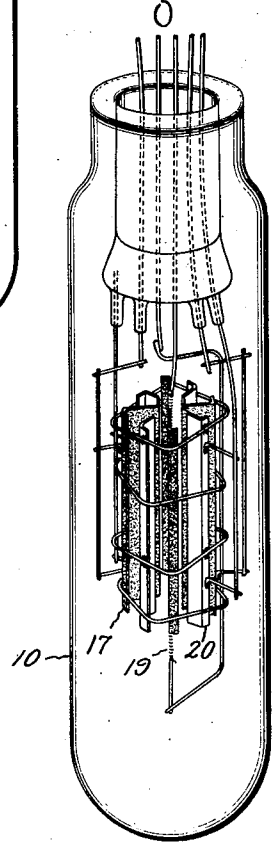


Fig. 2.



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UNITED STATES PATENT OFFICE

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ELECTRON-DISCHARGE APPARATUS

Application filed October 9, 1924. Serial No. 742,684.

My invention relates to improvements in electrical discharge devices of the type comprising an evacuated envelope within which are disposed a plurality of electrodes such as a cathode, an anode, and a control electrode or grid.

The invention relates more specifically to improvements in the anode and grid intended for use in such devices.

The anode of an electron discharge device is usually made of smooth sheet metal such as molybdenum, tungsten, or nickel and disposed in proximity to the grid and cathode in a manner adapted to insure electron responsive action between said electrodes.

The anode may be formed as a plate, either corrugated or plane. In some cases, particularly in the larger sizes of vacuum tubes and especially in the so-called "power tubes" the anode is arranged as a cylindrical or oval tube surrounding the grid or control electrode and its cooperating cathode. The anode may likewise consist of a plurality of metal slats held together by suitable means, said slats radiating outwardly from a central space within which the cathode is disposed.

No matter how constructed the anode becomes very hot during the operation of the tube owing to the heat radiated by its cooperating cathode and the heat produced by electron bombardment. When operating at maximum capacity certain parts of the anode may become white hot and the heated parts may taper down to a dull red at their outer portions and particularly at the supports. This heat is dissipated to a certain extent by radiation from the surface of the anode but enough is retained by the metal and imparted to the supports and structural elements of the tube to decrease the efficiency of the device materially and to shorten its life by engendering destructive stresses in said structural elements.

Attempts have been made to obviate such abnormal heating of the anode by providing radiating ribs or vanes and by corrugating the sheet metal of which the electrode is constructed to provide greater radiating surface. Such constructions have had the objection of relative costliness owing to the greater quantity of metal needed for such corrugated and vane-equipped electrodes as well as the additional labor involved in their production.

Attempts also have been made to blacken the exterior surface of the anode by chemical means in order to increase the radiation capacity in view of the well known theory that the heat emissivity of a body depends upon the nature of its surface and that a poorly reflecting surface is a good radiator of heat. Thus, nickel anodes have been coated with a layer of nickel oxide by suitable chemical treatment in order to provide a poorly reflecting surface. It is, however, costly from the present day manufacturing viewpoint to blacken the surface of metals like molybdenum and tungsten while a further disadvantage resides in the danger of introducing gas into the tube. Hence this expedient for increasing the emissivity of the anode has not found application in the art.

It is an object of my invention to provide an anode or similar electrode which will permit of a ready dissipation of the heat ordinarily retained by the metal without the use of expensive and cumbersome radiating vanes or fins and without necessitating chemical treatment of the surface of the anode.

I have discovered that if the exterior surface of the anode is roughened its heat radiating capacity and hence the efficiency and life of the tube will be materially increased. I have also observed that if the surfaces of other electrodes, notably the grid, are roughened, the undesirable emission of secondary electrons or so-called "dynatron action" will be decreased materially which will likewise contribute to an increase in the efficiency of the space current device.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The method of carrying the invention into effect will be understood best by reference to the following description taken in conjunction with the accompanying drawing in which Figure 1 represents a common form of space current device in which the anode is shown as a tubular structure; Fig. 2 shows

another type of space current device wherein a slat type of anode is used. In the device shown in Fig. 1 an evacuated glass envelope is indicated by 10 with a portion broken away for convenience in illustration. The operating elements of the device consist substantially of a filamentary cathode 11, a grid or control electrode 12 and an anode 13. The cathode 11 is adapted to be heated by an electric current which is supplied thereto by suitable lead-in conductors 14. Both the grid and anode are so arranged with respect to the cathode that they are associated in electron responsive relation therewith. Suitable leads 15 and 16 are provided for the anode and grid respectively. The form of space current device or vacuum tube shown in the drawing is of course merely illustrative and it will be understood that the arrangement of the elements as depicted does not go to the essence of the invention but that the figure is merely intended to illustrate the relative position which an anode modified as hereinafter described occupies in a space current device of the usual type so as to indicate the proximity of the cathode to the anode and the necessity of providing means for insuring an efficient radiation of heat from said anode. Other electrodes may be associated with the elements above described and the disposition of such elements may be adapted to suit the needs of the particular tube under consideration. Thus, the disposition of the electrodes may be horizontal instead of vertical with respect to the axis of length of the tube, or the anode may comprise a plate or other structure instead of a cylinder. Likewise, as shown in Fig. 2 the anode may consist of a plurality of metal slats 20 radiating outwardly from a central space and held together by suitable retaining means, the central space being adapted to contain the grid 17 and cathode 19. In this case the grid is shown roughened and the anode smooth for insuring clearness of illustration but of course both electrodes may be roughened for reasons set forth in detail below.

The roughening of the electrode surface is effected preferably by subjecting the surface of the metal to the action of a blast of abrasive material for example a sand blast. Of course other means for producing a rough surface upon the metal may be used. Thus the surface of the metal may be subjected to the action of oxygen under suitable conditions of temperature and time until a superficial layer of oxide has formed upon the metal. This layer of oxide is then reconverted into metal by subjecting the same to a suitable reducing process such as exposure to hydrogen or other agents under appropriate conditions. The metal layer produced by reduction of the oxide has a very rough surface and is therefore a good radiator of heat. Such a metal layer moreover is metallically integral with the body of the electrode and hence cannot flake or chip off during the operation of the tube.

By thus roughening the radiating surface of the anode its heat dissipating capacity will be increased so that under the same operating conditions it will run cooler than an anode having a smooth surface. The amount of energy radiated will be increased by as much as forty percent. This will result in lessening the stresses upon the supports of the electrode and permit operation of the space current device at increased efficiency. On the other hand, by roughening the surfaces of the grid or control electrode as shown in Fig. 2 the emission of secondary electrons or so-called "dynatron action" will be decreased which will also increase the operating efficiency of the device.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. A control electrode for a space current device having its surface mechanically roughened to decrease the emission of secondary electrons therefrom.

2. In a space current device the combination of a heated cathode, an anode, and a control electrode, said electrodes being disposed in electron responsive relation to each other, the radiating surfaces of the anode being abraded to increase the heat dissipating efficiency thereof and the surfaces of the control electrode being abraded to decrease the emission of secondary electrons.

3. The method of reducing the secondary electron emission from a control electrode of a space current device which consists in mechanically roughening the surface of said electrode by abrasion.

4. A cylindrical anode having a sand blasted exterior surface whereby the heat radiating efficiency of the anode may be increased.

5. An anode having a sand blasted exterior surface whereby the heat radiating efficiency of the anode may be increased.

In witness whereof, I have hereunto set my hand this 8th day of October, 1924.

DUDLEY A. MULLANEY.