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F. L. HUNTER, JR
ELECTRON DISCHARGE DEVICE

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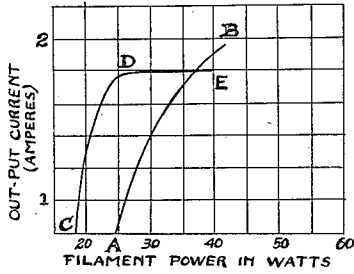


Fig. 9.



Fig. 5.



Fig. 6.



Fig. 7.



Fig. 8.

Fig. 1.

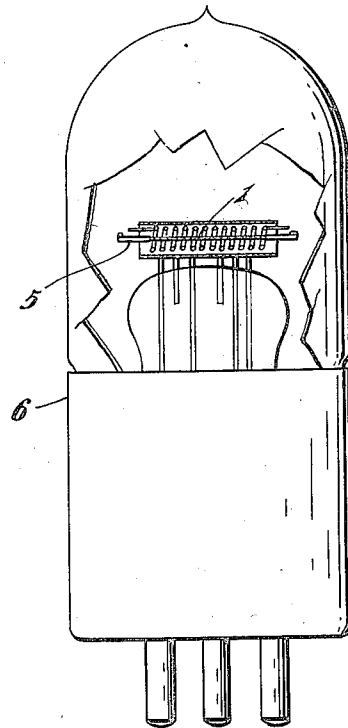


Fig. 2.



Fig. 3.

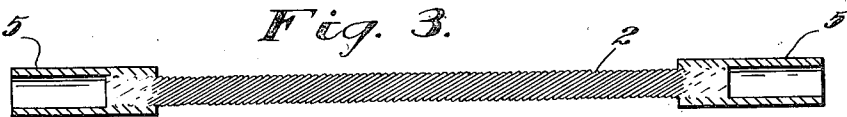
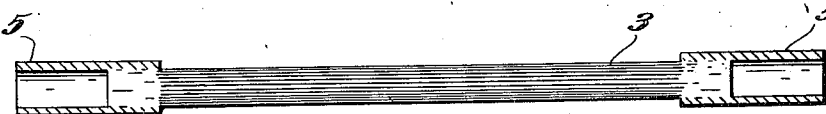


Fig. 4.



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ELECTRON-DISCHARGE DEVICE.

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This invention relates to electron discharge devices and more particularly to the construction of filaments for use in electron discharge devices.

5 The objects of the invention are to provide means for utilizing space charge for regulating emission in electron discharge devices; to increase the rate of emission from a filament of given length; to increase the surface
10 from which emission is to be obtained; to secure the increase in the rate of emission without raising the temperature of the filament over the proper or usual temperature; to provide a filament which will be durable and efficient; to secure simplicity of construction
15 and operation, and to obtain other advantages and results as may be brought out in the following description.

Referring to the accompanying drawing in which like numerals of reference indicates
20 similar parts throughout the several views;

Figure 1 is an elevation of an electron discharge device with parts broken away so as to show my improved filament mounted
25 therein;

Figure 2 is a longitudinal elevation of the preferred embodiment of my invention with the end tabs in section;

Figure 3 is a similar view of a modified construction of filament;

Figure 4 is an elevation of a still further modified construction of filament;

Figure 5 is a cross sectional view of the filament shown in Figure 2;

35 Figure 6 is a similar cross sectional view of the filament shown in Figure 3;

Figure 7 is a cross sectional view of the filament shown in Figure 4;

40 Figure 8 is a cross sectional view of a further modified construction of filament an elevation of which would be the same as Figure 4; and

Figure 9 is a plotted curve showing the relation of emission of a single wire filament and a multiple wire filament constructed in accordance with the present invention.

50 In the art of radiant energy, and particularly in connection with the electron discharge devices employed therein both for receiving, amplifying and transmitting energy, it has been found desirable to obtain in certain instances a reserve supply of emitted electrons in order to meet the demands of an increased current in the output circuit. In

order to obtain this reserve supply, I utilize the electro-physical attribute of electrons
55 that electrons repel each other. In other words, I construct a filament so that when an abnormal demand is made upon the electron discharge device there will be an excess supply of electrons which have been held in suspension by the repellent action of the electrons themselves. It is not practical to obtain this
60 increased emission in a given size of filament by an increase in temperature, because a filament, in order to have a long life, should be heated only to its proper temperature. Heating thoriated or analogous filaments beyond proper temperature will not obtain temperature saturation, but emission goes on up
65 until the thorium "boils off". In Figure 9 I have plotted the emission of an ordinary thoriated filament on curve A—B. On the horizontal axis I have plotted the filament power or its equivalent, temperature, and on the
70 vertical axis I have plotted the high frequency output current. It is to be observed that since the filament is not one which is adapted to keep the electrons in reserve by space charge, electrons are used as fast as they
75 can be emitted, but that not being fast enough the emitting material "boils off" and thorium emission ceases altogether at point B.

Obviously, therefore, it is not practical to obtain increased emission by increasing the
80 temperature, but it is practical, I find, to increase the emission by increasing the emitting surface or by increasing the reserve supply of electrons, or both. For purposes of complete disclosure, I have shown a filament
85 wherein the emitting surface is increased and also in which the reserve supply of electrons is increased, but it is to be understood that I do not confine myself to both being employed
90 together.

95 Where the input of filament power is limited and the temperature is specified, together with a certain requirement for output current, obviously an increase of emission cannot be obtained by an increase of temperature or power in the filament, but must be obtained by having emitted electrons in reserve. Too rapid emission of uncontrolled
100 electrons is not only undesirable but harmful and it is therefore important to control the emission of the reserve supply which is accomplished by space charge or repellent action of the electrons for each other. I pro-
105

vide a device wherein, at temperature saturation, the space charge is so great that further emission is practically stopped until there is a demand for further electrons. A device constructed in accordance with my invention will develop a curve such as C—D—E, the portion D—E being substantially parallel to the horizontal axis so that a constant output current is obtained for a considerable variation of filament power or temperature. It will be appreciated that the filament power is supplemented or subtracted from by the plate current according to which way the filament current is flowing. That is to say, when the filament current and plate current are flowing in the same direction in the filament the filament current is materially increased, but when the filament current and plate current are flowing in opposite directions in the filament, the filament current is materially decreased. So long as the filament power remains within the range of temperature saturation in the present invention, the output current will remain constant.

In the preferred embodiment of the invention illustrated in Figures 2 and 5, I have shown a filament 1 composed of a group or plurality of wires intertwined, woven or braided, so as to form a filament considerably larger than one of the wires and having the advantage of the increased surface of all of the wires for emitting purposes rather than just the surface of a single wire the size of the filament. Obviously, by intertwining, weaving or braiding, the wires, the filament is not only rough on its surface, but utilizes a very considerable length of the constituent wires. Such a filament will accordingly enable a very much increased rate of emission to be obtained because of the increase in the emitting surface of the filament.

Preferably the filament 1 is hollow or tubular as clearly shown in Figure 5, this structure securing an increase in the space charge. I do not wish it to be understood, however, that I limit myself to a woven filament which is hollow. My invention contemplates obtaining space charge by a filament having a roughened surface and also by hollow filament of any kind. For illustrative purposes I have shown a hollow filament and a woven filament as one and the same. It is to be observed that electrons emitted from the outside or exposed portions of the tubular filament and those emitted from the inside surface of the tubular filament are all of the same polarity. As a result, the electrons outside will have a repelling action with the respect to those inside, and I therefore believe have a tendency to prevent the electrons inside from coming out. However, when there is a demand upon the filament for electrons which the exterior surface is unable to supply, the repelling action of the outside electrons is materially reduced because there

are not only less electrons there, but because they are actively attracted away from the filament and the same attraction is operating upon the electrons in the filament. The reserve supply of the electrons accordingly meets the abnormal demand without necessitating any increase in the temperature of the filament.

I preferably construct a filament such that the total emission at the operating temperature is greatly in excess of the normal demand, but so regulate the space charge that the excess is held in reserve. By this means, the uncontrolled or unrepressed emission is practically constant over a considerable range of temperature as may be observed by reference to the portion of curve. This effect is known as temperature saturation. As a concrete example, assuming the filament to be normally operated by an input of 9 to 10 volts, I arrange that the uncontrolled emission is sufficient for operation at 9 volts. From 9 volts to 10 volts and beyond, the device is operating in the temperature saturation part of the curve, that is, the horizontal part of the curve shown in Figure 9, thus obtaining a practically constant electron flow from 9 volts and above.

Instead of weaving or braiding the wires forming the filament the group of wires may be twisted together as illustrated in connection with filament 2 in Figure 3 and 6, or may be extended side by side in parallel relation as shown in Figures 4, 7 and 8, although I have noted the results are not so good as in the woven or braided filament. In Figures 4 and 7 I have shown a filament 3 wherein the parallel wires forming the filament are grouped or bunched together leaving only such hollow spaces as may exist between the several wires. In Figure 8 I have shown parallel wires forming the filament 4 which are assembled in a cylindrical arrangement so as to obtain a tubular or hollow filament. Obviously the wires constituting the twisted filament 2 of Figure 3 may likewise be grouped to substantially fill the cross sectional area of the filament as shown, or may be arranged in a cylindrical grouping so as to form a hollow filament, the cross sectional view of which will be the same as Figure 8.

The filaments are preferably introduced into the tubular end tabs 5 to which they are welded for securing good electrical contact and preventing separation. Any suitable material may be used for the end tabs 5, and any suitable emitting material may be used for the wires constituting the filament, the particular materials employed not being a feature of the present invention.

The filament described above may be employed in any electron discharge device. It may be noted that in the present disclosure I have shown the same in an ordinary receiving tube 6, it not being considered necessary

to also show it in a transmitting or power tube, since both receiving and transmitting tubes are known as electron discharge devices. The fact that the filament is somewhat larger than the usual filament employed in receiving tubes, however, adapts the invention to transmitting tubes wherein a larger filament is employed and wherein a greater current is used, but the principle of the invention is applicable to any electron discharge device.

While I have expounded upon what I believe to be the theory of operation of my improved electron discharge device, it is not my purpose to restrict the invention to any theory of operation, such having been given to enable others to have a better understanding of the invention. Obviously other detail

changes and modifications may be made in the manufacture and use of my improved electron discharge device, and I do not wish to be understood as limiting myself to the exact structure shown except as set forth in the following claims when construed in the light of the prior art.

Having thus described my invention, I claim:

1. A hollow electron emissive filament composed of a plurality of longitudinal wires.

2. An electron emissive filament for use in an electron discharge device comprising a plurality of longitudinal wires in a cylindrical group to enclose and store a reserve electron space charge.

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