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J. SLEPIAN

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INDUCTIVELY HEATED CATHODE TRIODE TUBE

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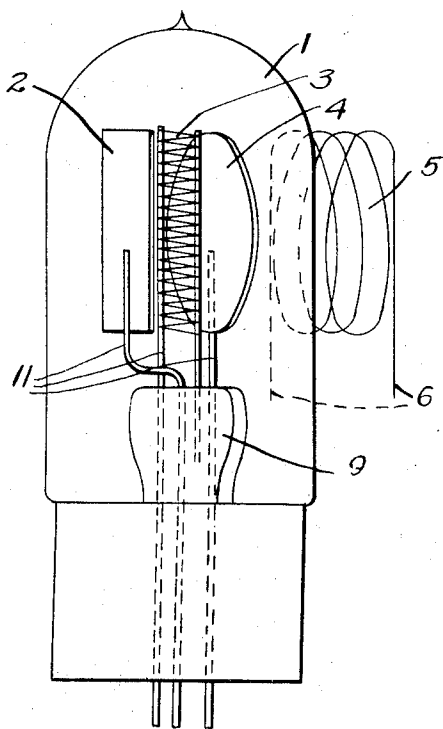


Fig. 1.

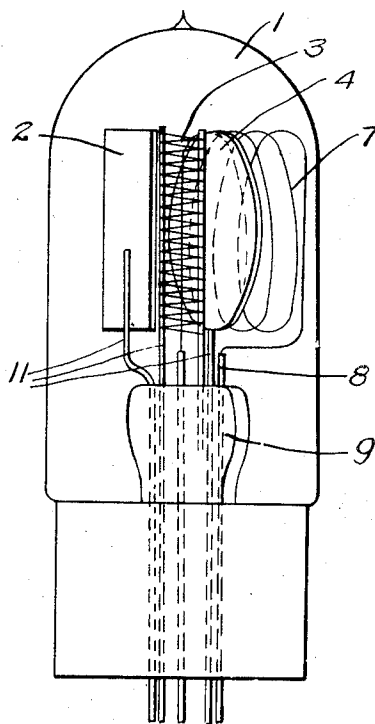


Fig. 2.

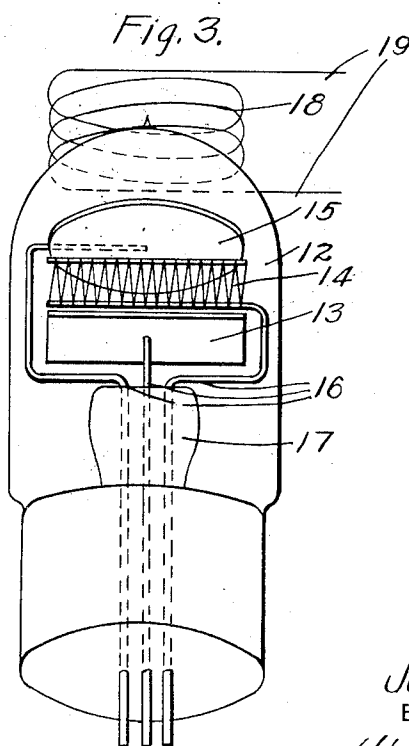


Fig. 3.

WITNESSES:

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INDUCTIVELY-HEATED CATHODE TRIODE TUBE

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My invention relates to hot cathode devices, more particularly to electro-inductive means for heating the cathode.

Broadly speaking, the object of my invention is to provide a heated cathode device in which the cathode structure may be heated by high frequency electromagnetic induction in such way that the lines of magnetic flux are parallel with respect to the direction of flow of the electron stream from the cathode, thereby avoiding the effects caused by magnetic modulation of the electron stream which occurs when the stream and the flux field are at an angle with respect to each other.

More specifically, my invention provides an anode, a control electrode, and a cathode suitably placed in an evacuated container, and an inductor coil carrying high frequency current, placed in a position where its field of flux is substantially parallel with respect to the direction of the electron flow.

In the design and operation of electron discharge tubes, it is very desirable, under certain conditions, to employ a cathode having a truly equipotential surface. It has also become a serious problem in some tubes to conduct the large heating currents required by the cathode through the walls of the tube without damage to the seal or to the enclosing envelope.

With the consideration just outlined, in view, attempts have been made heretofore, to heat the cathodes of electron tubes by inductive means, rather than by conductive means, employing a cathode material that is placed in inductive relation to an inductor, the circuit of which is a relatively small, high-potential, high-frequency current. So far as I am aware, however, all previous devices, constructed for the purpose just stated, have had such an arrangement of parts that the magnetic flux produced by the inductor not only induced heating currents in the cathode but also exerted an objectionable choking effect upon the electron stream. Furthermore, the electrostatic field, concomitant with the high voltage necessary to introduce sufficient high-frequency energy for the heating, produced an equally objectionable choking and distort-

ing effect upon the electron streams of such prior inductively heated electron tubes as have come to my attention.

My invention consists, therefore, in providing means whereby the advantages of inductive heating for the cathode may be retained and the disadvantages previously encountered may be avoided.

Other objects and structural details of my invention will be apparent from the following description and claims when read in connection with the accompanying drawings, wherein

Figure 1 is an elevational view, partly diagrammatic, illustrating a tube embodying my invention, and

Figs. 2 and 3 are similar views illustrating alternative constructions of my invention.

In the drawing is shown a container 1 preferably evacuated and preferably of glass, containing a flat plate anode 2, an adjacent flat grid or control electrode 3 and adjacent to the grid, another flat plate cathode 4. These three elements are spaced apart a suitable distance, to provide desirable tube impedance characteristics, and all three are positioned in parallel planes. The anode and the grid may be of material suitable for receiving and controlling an electron stream as employed by the prior art. The cathode plate 4 may be of tungsten, platinum, nickel or other suitable material and may have the surface facing the anode and grid treated with a suitable earth metal oxide to increase its electron emissivity. On the opposite side of the cathode plate 4 from the anode 2 and the control electrode 3 is positioned an inductor, the coil 5 of which is utilized for inductively heating the cathode plate 4 by means of high-frequency currents.

In the structure just described, the anode 2, the grid 3 and the cathode 4 fulfill the customary functions of analogous parts in typical triode valves. The cathode structure, however, is not suitable for heating by a flow of electric current supplied by leads sealed in the tube structure as is done in the prior art. Instead, it is heated by current induced in it by an alternating magnetic field which is in turn produced by high frequency currents

in the coil 5 of the inductor which is supplied from any suitable source (not shown) through leads 6.

The magnetic flux produced by current flowing in the coil 5 of the inductor causes currents to flow for the most part in a peripheral or circumferential path in the material of the cathode 4. These currents are typical eddy or Foucault currents and they heat the cathode material by reason of its internal resistance. The heating current flowing in the cathode, in turn develops a magnetomotive force in opposition to that developed by the coil 5 and, therefore, the resultant inducing flux is small compared to the total flux which could be produced by the coil 5 in the absence of the plate cathode 4, that is, the presence of eddy currents in the cathode plate 4 and the counter-magnetomotive force produced by these currents directs the working flux into a space position surrounding the plate 4. The resulting effect is similar to that which is obtained when the plate 4 shields the space between the cathode and the anode. Furthermore, such flux as does enter the space between the anode and the cathode enters it in lines parallel to the direction of flow of the electron stream. Flux parallel to the electron stream is without effect on the stream since under those conditions the electron stream is not cutting the flux.

It is clear, therefore, that by placing the grid and anode upon one side of a plate cathode, and the inducing coil 5 upon the other side with its axis perpendicular to the plane of the cathode plate, the space discharge current is caused to flow in a region of reduced magnetic flux and to flow in a direction parallel to such flux as is present. Thereby the magnetic flux is caused to have a negligible effect upon the electron stream. Furthermore, it is evident that the electron emitting surface of the cathode 4 is a unipotential surface, even though it has current flowing in it. In any given circular path of current flow, it is evident that the entire developed potential is absorbed in resistance since the current will rise to a value determined by the total developed potential and the total resistance. Since both current and resistance are uniform it is evident that, in any given segment of a specific circular path, the potential developed is absorbed by the resistive drop and there is, therefore, no difference in potential between adjacent portions even though these portions be infinitely small. The entire surface of the cathode is, therefore, at a single potential.

Fig. 2 shows a slightly different arrangement of parts embodying my invention. The tube has a container 1, an anode 2, a grid 3 and a plate 4 similar to that shown in Fig. 1. The coil 7 of the inductor is, however, supported inside of the container 1, on leads 8 that are sealed in a press 9 along with the

leads 11 to the anode, the grid and the cathode.

Fig. 3 shows another slightly different arrangement of parts in which a tube 12 contains an anode 13, a grid 14 and a cathode 15 that are mounted in a horizontal position on leads 16 which are sealed in a press 17. An inductor coil 18 having leads 19 is mounted above the tube 12, likewise in a horizontal position. In both of the modifications just described, the anode, the grid and the cathode perform the customary functions of corresponding parts of a typical triode tube of the prior art and in both the cathode is heated as in the preferred modification by means of induced high frequency currents. This cathode, as before, has a unipotential surface and serves in effect to keep the magnetic and electrostatic fields of the inductor coil away from the electron stream, thereby allowing the electron stream to pass, free from the choking effect produced upon it when it cuts the magnetic field.

By such constructions as have been hereinabove described, and by other constructions which will readily be apparent, it is a relatively simple matter to obtain a hot cathode device in which the cathode is heated by induced currents, under conditions which permit a separation of the electron stream from the magnetic and electrostatic fields which are necessarily present by reason of the inducing element. I have thus produced a device which has the advantages of an inductively heated cathode, but which avoids the disadvantages previously encountered in regard to the choking effect of the magnetic fields upon the electron stream.

While I have shown only three typical embodiments of my invention in the accompanying drawings, it is obvious that many changes and modifications may be adopted without departing from the spirit thereof. It is desired, therefore, that only such limitations shall be imposed upon my invention as are indicated in the prior art or set forth in the appended claims.

I claim as my invention:

1. A space discharge device, comprising a disc cathode member, an inductor coil associated therewith for heating said cathode member to electron emitting temperature, and an anode means centrally spaced from said disc to receive the electrons emitted therefrom, said cathode disc member being disposed intermediate said anode and said inductor coil perpendicular to the axis of said coil, and means for controlling said electron current in accordance with relatively weak energy impulses.

2. In an electron discharge device, a cathode disc, means for producing a magnetic flux for inductively heating said cathode to a temperature of electron emission, said cathode

disc being placed substantially perpendicular to the magnetic flux path.

3. In an electron discharge device, a disc cathode for producing an electron stream, a coil for producing a magnetic flux to inductively heat said cathode to a temperature of electron emission, said cathode being so positioned relatively to said magnetic flux that the electron stream is substantially coaxial with said coil.

4. An electron-discharge device comprising, a cathode disc, a coil coaxial with said disc for producing a magnetic field to inductively heat said disc to a temperature of electron emission, and an anode disposed on the side of the disc opposite said coil, said disc being of such area as to effectively cover one end of the coil whereby the electron stream is substantially shielded from the flux induced by the coil.

5. A space-current device comprising at least the following parts in combination: a coil, a cathode disposed in a plane which is transverse to an extension of the axis of said coil and which is spaced axially from said coil, and an anode so disposed that a still further extension of said axis passes through substantially the center of said anode, characterized by the fact that said cathode provides eddy-current paths substantially concentric to said axis-extension, the number and maximum radial dimension of said eddy-current paths being such, relative to the radial dimensions and axial distances of said coil and anode, that said cathode operates substantially as a shield producing, in effect, a shadow shading said anode from the magnetic influence of said coil.

6. The invention as defined in claim 5, characterized by the fact that a grid is disposed between said cathode and said anode, and within said shadow of said cathode.

In testimony whereof, I have hereunto subscribed my name this 2nd day of May 1923.

JOSEPH SLEPIAN.