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ELECTRON DISCHARGE DEVICE

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FIG. 1

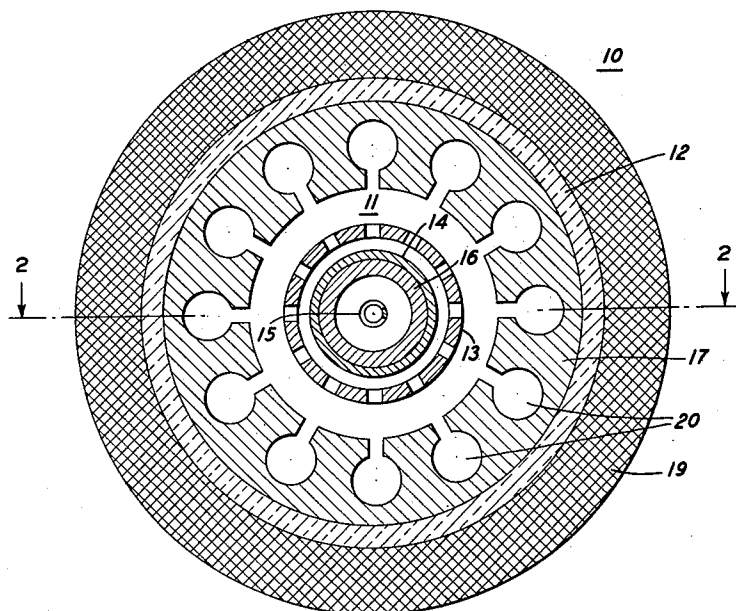
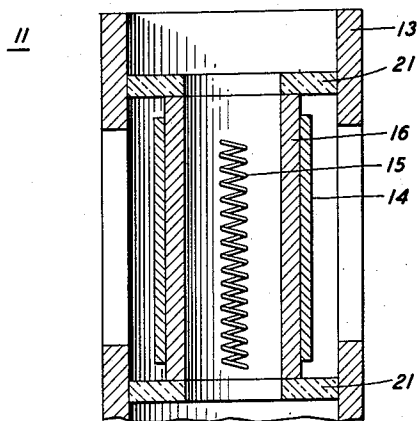


FIG. 2



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ELECTRON DISCHARGE DEVICE

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13 Claims. (Cl. 315—39.71)

This invention relates to cathode structures for electron discharge devices and, more particularly, to cathode structures for magnetrons.

Magnetrons, as heretofore constructed, have included composite cathode structures which utilize the phenomenon of secondary emission for the production of the major part of the anode-cathode electron stream.

It is an object of the present invention to improve composite magnetron cathode structures utilizing this phenomenon.

Another object of this invention is to provide an improved electron discharge device and particularly an improved cathode structure for an electron discharge device.

These and other objects of the present invention are realized in a specific illustrative embodiment of the present invention wherein in a magnetron a composite cathode structure is positioned within and along the axis of the central cavity of a metallic anode block. The cathode structure or assembly comprises three concentric and coaxial cylindrical members the middle one of which is a directly or indirectly heated cathode capable of thermionic emission. The outermost cylindrical member or cold cathode is formed of a material which is a good secondary emitter, and has slots therein to permit thermionically emitted electrons to pass therethrough. The innermost cylinder or sleeve is of a magnetic material and is designed to facilitate the escape of electrons from the intercathode region in the presence of the axial magnetic field present in all magnetrons.

Thus, a feature of this invention is a magnetron comprising an anode, a secondarily emissive cathode within the anode, a thermionic cathode within the secondarily emissive cathode, the anode and the cathodes having a common axis, a member for producing a magnetic field parallel to the axis, and an element for shunting the field from the inter-cathode region.

Another feature of this invention is a magnetron cathode structure having an inner directly or indirectly heated cathode, an outer slotted secondarily emissive cathode, and a sleeve of a magnetic material, the cathodes being coaxially and concentrically positioned and the magnetic sleeve being within the inner cathode.

A complete understanding of this invention together with the above noted and other features thereof may be gained from consideration of the following detailed description and accompanying drawing, in which:

Fig. 1 shows in cross section a plan view of a magnetron employing a cathode constructed in accordance with this invention; and

Fig. 2 is an elevation view in section of the cathode of the device of Fig. 1.

Referring to Fig. 1, there is shown a high frequency generating device 10 of the magnetron type having therein a specific illustrative embodiment of the present invention. A cylindrical envelope 12 contains therein a composite cathode structure 11 which comprises a hollow slotted cylindrical non-thermionic or cold cathode 13 located along the axis of the magnetron and a similarly positioned

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thermionic, or hot, electron emissive cathode 14. The emissive cathode 14 may be directly heated, but it is shown in Figs. 1 and 2 as being heated by a heater element 15 which is longitudinally disposed along the axis of the structure 11. A cylindrical element 16 made of a magnetic material is advantageously positioned between the heater element and the thermionic cathode. Surrounding the cathode structure 11 and also positioned within the envelope 12 is an anode member 17 having therein a plurality of cavity resonators 20.

A field coil 19, which may or may not employ iron to aid its magnetic effect, surrounds the envelope 12 and functions to produce an intense and constant magnetic field whose flux lines run through the envelope 12 in a direction substantially parallel to the axis of the composite cathode structure 11.

In Fig. 2 the relative positioning of the heater 15, the magnetic sleeve 16, the thermionic cathode 14 and the secondarily emissive cathode 13 is clearly shown. Also shown in Fig. 2 are spacers and insulators 21, advantageously made of a ceramic material, which are used to form part of the supporting structure for the herein described composite cathode 11.

The cathode 13 is made of a material which will emit sufficient electrons when it is bombarded with a small number of primary electrons, i. e., electrons from the inner cathode 14, to generate the power output for which the device 10 is designed. The cathode 13 may advantageously be made of beryllium copper, a good secondarily emissive material, i. e., one in which an impinging electron causes a plurality of electrons to be emitted. Alternatively, but less advantageously, the cold cathode 13 may be made of a suitable material coated with a secondarily emissive oxide of an earth material e. g., barium or strontium oxide.

A cylindrical element having inside and outside diameters, respectively, of 0.160 inch and 0.209 inch, a length of 0.25 inch and containing 6 slots is used in one specific illustrative embodiment of this invention to form the outer cathode element 13 in an X band magnetron tube. Each slot may be 0.040 inch by 0.2 inch (the longer dimension being measured in a direction parallel to the main axis of the composite cathode 11).

The inner cylindrical cathode 14, preferably made of an oxide matrix, may have inside and outside diameters, respectively, of 0.141 inch and 0.121 inch and may be 0.2 inch in length. The inner cathode may advantageously be bonded to the magnetic sleeve by any suitable adhesive material. The magnetic sleeve, advantageously made of Permendur, an alloy comprising equal parts of iron and cobalt, may be 0.25 inch in length, approximately 0.020 inch thick and have an inside diameter of 0.081 inch.

The successful operation of a high power device employing a composite cathode structure depends to a great extent upon the ability of a large number of primary or thermionic electrons to escape through the slots in the secondarily emissive cathode and to strike the outer surface thereof so as to supply a large anode-cathode current.

If a proper source of potential is connected between the cathodes 13 and 14, and between the cathode 13 and the anode 17, an electron emitted from the inner cathode 14 moves in a generally circular path in the inter-cathode space, and in the anode-outer cathode region, due to the resultant action of the mutually perpendicular electric and magnetic fields. The emitted electron should describe a path which will carry it through an outer cathode slot and then onto the surface of the outer cathode to cause the emission of secondary electrons therefrom.

In specific prior art devices employing composite cathodes, the high value of canode-cathode magnetic flux

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needed for proper operation thereof also existed in the inter-cathode space. Thus, it was found that an extremely large potential difference was required between the cathodes to obtain an electron path radius that would result in secondary emission from the outer cathode. This is due to the fact that the radius of an electron's path in an interaction space is directly proportional to the square root of the velocity of the electron in volts and inversely proportional to the magnetic flux density in the interaction space.

The magnetic sleeve 16 of the present invention acts as a magnetic shunt to decrease the inter-cathode magnetic field without affecting the strength or configuration of the anode-cathode magnetic field. As a result of this novel structure, electrons emitted from the inner cathode escape through the slots of the secondarily emissive cathode and impinge upon the outer surface of the cathode 13 with a minimum of potential difference connected between the two cathodes. In one specific illustrative embodiment of the present invention, no inter-cathode potential difference was required, the penetration of the anode electrostatic field through the outer cathode slots sufficing to obtain starting current. Thus, embodiments of this invention provide highly reliable high power operation with minimum power supply requirements.

Additionally, the present invention makes possible a thermally superior cathode design. The inner cathode structure may be designed for good thermal insulation so that a minimum of heater power is required, while the slotted outer cathode may be designed for good thermal conduction. The resultant cooler operation of the outer cathode reduces arcing in the anode-cathode main interaction space, particularly when an oxide coated outer cathode is not used, and so provides an extremely long life cathode. To maintain the cleanliness of the secondarily emissive surface it may be desirable to have it attain a temperature of several hundred degrees centigrade in steady state operation. One would, of course, then reduce the thermal conduction of the outer cathode to achieve that end.

The small potential difference connected between the cathodes of illustrative embodiments of the present invention may be employed as a means of controlling the start of magnetron oscillations by determining the time at which electrons are able to escape through the outer cathode slots. Also, by synchronizing the small inter-cathode voltage with the anode-outer cathode voltage, a degree of control over the mode selection process in a magnetron is realized.

It is to be understood that the above-described arrangement is illustrative and not restrictive of the principles of the present invention. Other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a magnetron cathode structure, an inner cathode,

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an outer cathode, and a member of a magnetic material, said cathodes being coaxially and concentrically positioned, and said magnetic member being within said inner cathode.

2. A magnetron cathode structure as in claim 1 wherein said outer cathode is a cylindrical member.

3. A magnetron cathode structure as in claim 1 wherein said outer cathode is slotted.

4. A magnetron cathode structure as in claim 1 wherein said outer cathode is a slotted cylinder.

5. A magnetron cathode structure as in claim 1 wherein said outer cathode is of beryllium copper.

6. A magnetron cathode structure as in claim 1 wherein said outer cathode is a slotted cylinder made of a secondarily emissive material.

7. A magnetron cathode structure as in claim 1 wherein said outer cathode is a slotted cylinder made of molybdenum.

8. A magnetron cathode structure as in claim 1 wherein said magnetic member is made of an alloy comprising equal parts of iron and cobalt.

9. In a composite cathode structure, a heater, an inner cathode, an outer cathode, and a member of a magnetic material, said cathodes being coaxially and concentrically positioned, said magnetic member being within said inner cathode, and said heater being within said magnetic member.

10. In combination in a magnetron, an anode block having therein a central aperture, means for establishing magnetic flux in said aperture, and a composite cathode structure within said aperture, said cathode comprising an inner thermionic cathode, an outer slotted cathode, said cathodes being concentrically and coaxially positioned with respect to each other, and means for shunting the magnetic flux from the inter-cathode space without affecting the magnetic flux in the anode-outer cathode space.

11. In a magnetron, a plurality of concentrically arranged electrodes comprising an anode, a slotted cold cathode within the anode, and a thermionic cathode within the cold cathode, means for providing a magnetic field parallel to the axis of said electrodes, and means for shunting a portion of said field from between said cathodes comprising a member of magnetic material.

12. A magnetron as in claim 10 wherein said shunting means is positioned within said thermionic cathode.

13. In a magnetron, an anode, secondarily emissive cathode means within said anode, thermionic cathode means within said secondarily emissive cathode, said anode and said cathodes having a common axis, means for producing a magnetic field parallel to said axis, and means for shunting said field from the inter-cathode region.

No references cited.

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