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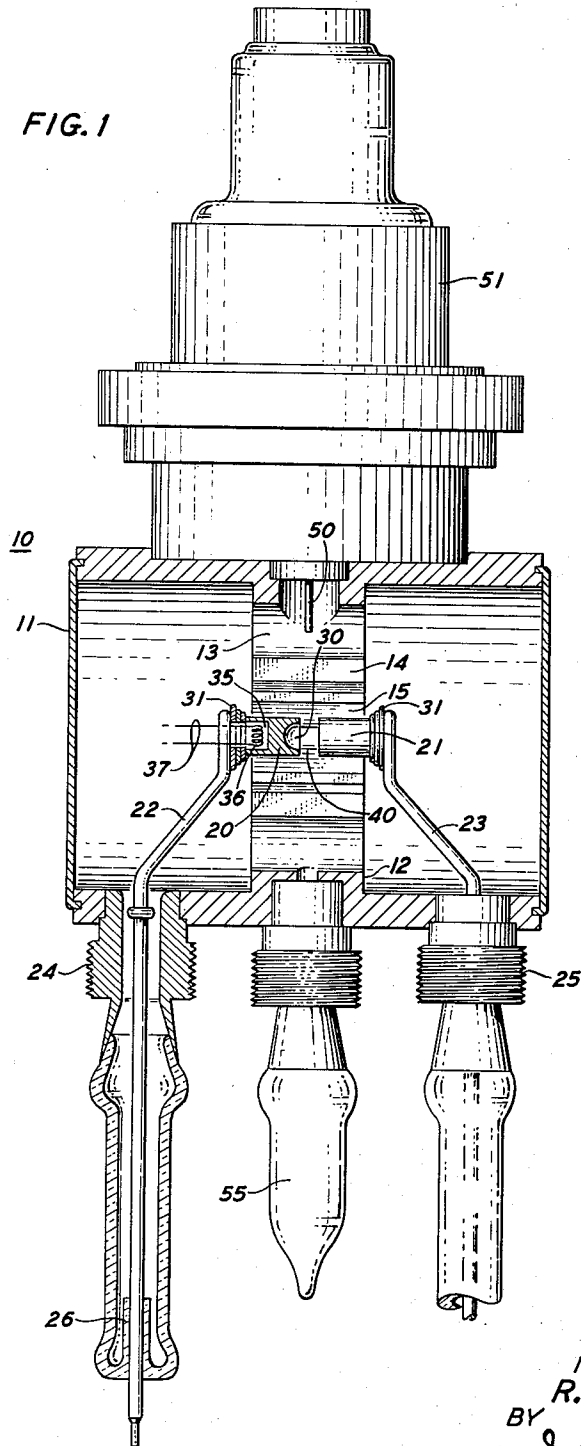
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CATHODES FOR ELECTRON DISCHARGE DEVICES

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2 Sheets-Sheet 1



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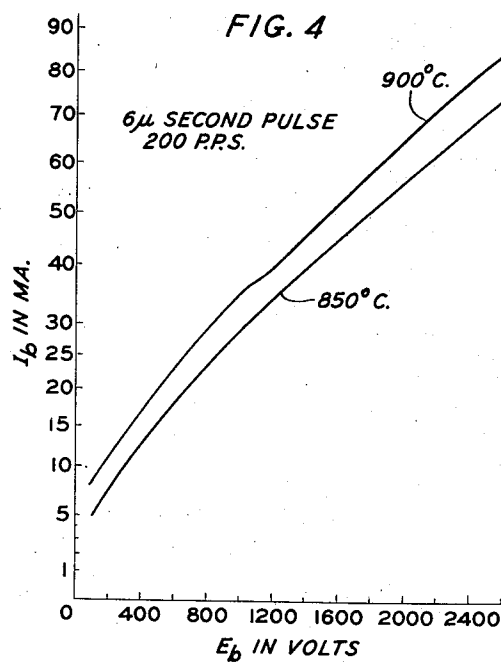
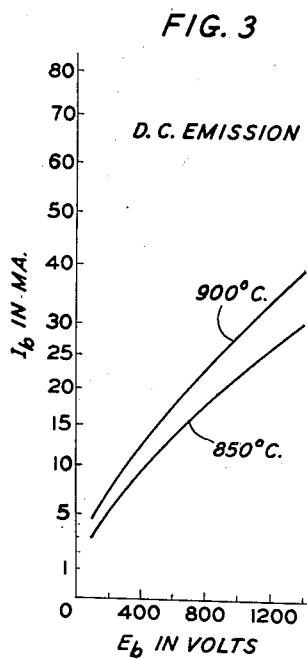
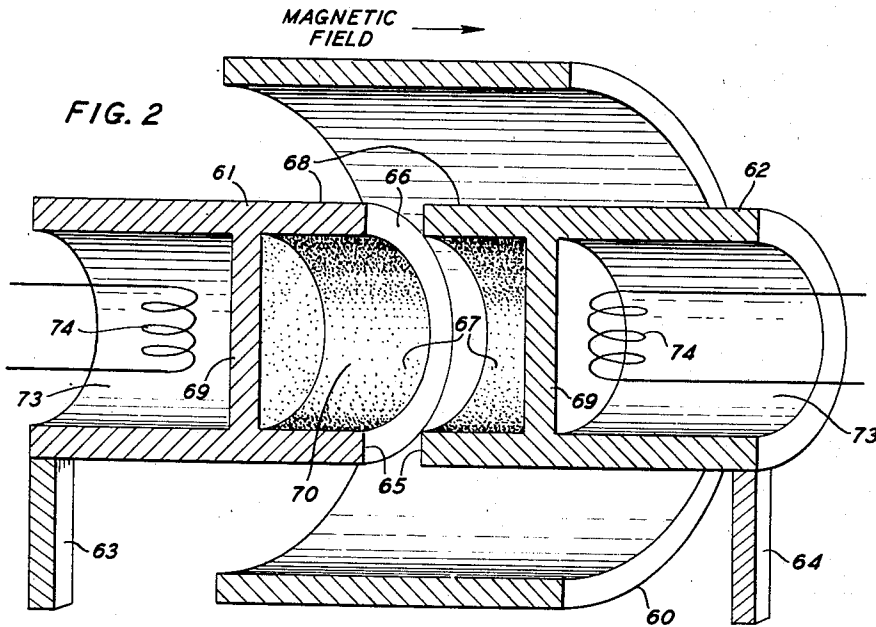
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CATHODES FOR ELECTRON DISCHARGE DEVICES

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2 Sheets-Sheet 2



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CATHODES FOR ELECTRON DISCHARGE DEVICES

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10 Claims. (Cl. 313-346)

This invention relates to electron emitters for electron discharge devices and more particularly to emitters capable of producing a copious supply of electrons in high-power, high-vacuum devices suitable for use in ultrahigh-frequency systems.

In such devices, particularly those of the magnetron type, the requirements placed upon the electron emitter or cathode are particularly severe. The emitter must be able, during operation of the magnetron, to supply an electron current of several amperes per square centimeter continuously or in pulses; it must contain sufficient emissive material to supply the current requirements over a substantial life; it must secure the emissive material in such a manner that there is low interface resistance and so that portions of the coating will not be "sparked" or burst from the surface during operation; it must be capable of dissipating or conducting away large amounts of heat energy from bombardment by positive ions and anode decomposition products and must minimize deactivation of the emissive coating due to such bombardment. The severity of the cathode requirements has generally resulted in that electrode being the determining factor in the life of the magnetron.

The design of magnetron cathodes in the past has been predicated upon a compromise which offers the optimum combination of electron current supplied, life, interface resistance, resistance to sparking, and heat dissipating qualities. A compromise was necessitated, since a cathode which would excel in one respect suffered from a deficiency in at least one other requirement. For example, a cathode capable of supplying a high electron current density and with a low interface resistance has been characterized by large surface area coated with emissive material exposed to the anode. Such a combination is subject to pronounced cathode sparking, coating deactivation, poor heat dissipation, and generally short life.

With the difficulties of the prior art and the requirements imposed upon such electron emitters in mind, it is a general object of this invention to improve electron emitters.

More specific objects of this invention are to obtain an electron emitter capable of producing high electron currents and with a substantial life; to provide an electron emitter for magnetron use in which virtually none of the electron-emissive coating is subject to back bombardment or ion deactivation; to facilitate the dissipation of heat energy by the electron emitter; and to eliminate the harmful sparking of electron emitters.

Since the electron emitters of this invention find particularly advantageous application in magnetrons, an exemplary embodiment is described as a magnetron cathode. One such device constituting a conventional magnetron comprises generally a highly evacuated container incorporating an anode structure having an axial bore and a plurality of resonator chambers communicating therewith. In one of the resonator chambers and communicating with the exterior is an output coupling loop. Aligned within the axial bore is the cathode of

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this invention comprising a pair of aligned spaced metal cylinders including facing recessed portions, thereby defining a hollow chamber or cavity. A passage substantially annular in shape communicates between the interior of the aligned bodies and the cavity. The cavity wall is coated with electron-emissive material. The aligned cylinders are supported independently by individual supports in the anode bore. The emissive coating of each part is raised to emissive temperature by individual heaters associated with each cylinder.

In accordance with one feature of this invention two distinct bodies define a single electron source which includes an electron-emissive coating substantially completely shielded from the anode.

According to another feature of this invention a cathode structure presents an uncoated exterior surface to back bombardment from the anode, the uncoated surface being capable of efficiently conducting away substantial quantities of heat.

According to still another feature of this invention an annular passage between the metallic bodies is the apparent electron source to the anode, which is subject neither to bombardment heating nor deactivation.

These and other features of this invention may be found in the following detailed description and with reference to the drawing in which:

Fig. 1 is an elevational view, partly in cross section of a magnetron incorporating a cathode of this invention;

Fig. 2 is an enlarged, simplified representation of magnetron electrode assembly shown in cross section

Fig. 3 is a graphical representation of the direct current electron-emission characteristics of the cathode of this invention; and

Fig. 4 is a graphical representation of the pulsed electron-emission characteristics of the cathode of this invention.

Referring now to Fig. 1 may be seen a magnetron including a housing 11 containing an anode 12 including a plurality of resonator chambers 13 and passages communicating with an axial bore 15. Axially aligned within the bore 15 and in spaced end-to-end array is a pair of cathode cylinders 20 and 21 mounted by individual supports 22 and 23 which pass through respective outlets 24 and 25 and vitreous seals, one of which numbered 26, is shown.

Cathode cylinder 20 is shown in cross section to indicate its construction in detail. In the end adjacent cylinder 21 there is a recess 30, shown as hemispherical. The recess 30 is coated with electron-emissive material such as a mixture of the carbonates of barium, strontium and calcium which in the process of activating the device are reduced to the profuse electron-emitting mixture of oxides. At the opposite end of cathode cylinder 20 is a plurality of metallic discs forming an end hat 31 which serves to confine the emitted electrons to the interaction space, i. e., the area lying between the cathode and anode. The support 22 is secured as by welding to the end hat 31 forming a rigid mount for the cathode cylinder 20 as well as serving as a means for conducting heat from the cathode structure. The cathode cylinder also includes a heater recess 35 in the end opposite recess 30 containing heater coil 36 which serves to raise the emissive coating to electron-emission temperature. Heater coil 36 is energized from a power source not shown in the drawing through leads 37 passing through the housing 11.

Cylinders 20 and 21, advantageously of nickel, are impermeable. Only annular passage 40 between the cylinders offers communication for electrons between the recess 30 and the interaction space. Both cylinders 20 and 21 present uncoated exterior surfaces to the anode, as may be seen on cylinder 21.

Completing the electrically active elements of the magnetron, in addition to anode 12 and cathode cylinders 20 and 21, is a coupling loop 50 positioned in resonator chamber 13 and adapted to conduct high-frequency energy from the magnetron to an external circuit through connector 51 to which either a wave guide or coaxial transmission line is customarily connected.

As shown in Fig. 1, the housing 11 of magnetron 10 includes an additional appendage in the form of exhaust tubulation 55 through which the housing 11 is evacuated during manufacture and then sealed.

Referring now to Fig. 2, a cathode-anode assembly of a magnetron in simplified form may be seen. The assembly comprises tubular anode 60 encompassing cathode parts 61 and 62, each supported independently by mounts 63 and 64. The cathode parts 61 and 62 each include an outer imperforate wall 68 of sufficient thickness for efficient heat conduction to mounts 63 and 64. End surfaces 65 of cathode parts 61 and 62 define an annular passage 66 through which electrons are emitted. The actual electron source is the coating 67 upon the inner surface of walls 68 and end walls 69 which define cylindrical cavity 70. On the opposite side of end walls 69 are heater enclosures 73 and heaters 74. The entire anode-cathode-heater assembly shown in Fig. 2, of course, is enclosed in a highly evacuated enclosure such as is shown in Fig. 1.

In operation the heater coils are both energized, bringing the electron-emissive coating up to a temperature of 850° centigrade or thereabouts, at which temperature copious quantities of electrons are emitted from the surface of the coating 67 into the cavity 70. Upon the application of a positive potential to the anode 60 electrons emitted from the coating are drawn through the annular passage 66 between end surfaces 65 and influenced by a longitudinal electromagnetic field in the direction of the arrow supplied by a magnet structure adjacent the magnetron and not shown in the drawing. The electrons emerging from the cathode describe curvilinear parts of configuration depending upon the intensity of the electromagnetic field and magnitude of the anode-accelerating voltage, as is well known in the art. In accordance with this invention the electron current produced by the cathode is comparable in magnitude to that produced by magnetron cathodes heretofore available, to wit, several amperes per square centimeter without the disadvantages encountered heretofore.

In the copending application Serial Nos. 361,527, 361,623, and 361,663, of D. MacNair, filed June 15, 1953, it is taught that extremely high density electron beams can be produced by interiorly coated hollow or cavity cathodes having an orifice of prescribed size relative to the cavity. The electron beam so formed is discrete and unidirectional and so has been properly described as a "pencil of electrons." Such a form of electron emission is particularly suited for beam-type devices such as cathode ray and traveling wave tubes. For magnetron use requiring electron emission radially from the cathode toward the encompassing anode a beam-type cathode finds limited utility. According to this invention, the high electron density emission of cavity cathodes is obtained in the required radial pattern. The electron-emission orifice comprises the annular space between independent cathode parts which define a single cavity therebetween. Emission from the orifice is omnidirectional, generally parallel to the plane of the surfaces bounding the annular orifice.

Over and above the enhanced emission of hollow cathodes, which certainly is advantageous in magnetrons, the cathodes of this invention overcome the limitations of short life, susceptibility to sparking, coating deactivation, and heat dissipation. These limitations are all avoided where the emissive coating is shielded from the anode. Any positive ions or other deactivating particles drawn to the cathode impinge upon its outer surface or pass

through the annular passage without contacting the emissively coated cavity walls. Furthermore, the sparking of particles of the emissive coating from the cathode to the anode owing to extreme current demands from a particular portion of the emissive coating is avoided, since the electrostatic field of the anode at the coating need not be great to obtain sufficient operating current; and even if a particular portion of the coating is subjected to a high electric field, any particles burst from the surface tend to be redeposited upon other portions of the cavity wall without any loss of emissive material. Therefore, the emissive coating protective features of this invention are twofold in shielding the emissive coating from chemical deactivation and from physical loss.

Instead of presenting an emissively coated surface to the anode, cathodes of this invention incorporate a bare exterior surface adjacent the anode, imperforate except for the electron-emission passage. The cathode parts having the uncoated exterior wall provide efficient heat conducting means through the wall, end hats, and supports through which the heat energy incident upon the cathode by bombardment from the anode is dissipated. Figs. 1 and 2 both incorporate comparatively heavy wall sections which offer a ready heat conduction path.

The advantageous design of these magnetron cathodes is reflected in longer life, since the danger of coating deactivation is minimized and since the cathode is capable of dissipating substantial quantities of heat. From the operational viewpoint the cathode supplies copious electron emission, both under direct current or pulsed operation.

Referring now to Figs. 3 and 4 may be seen the accelerating voltage (E_b)-cathode current (I_b) relationships for constant voltage and pulsed operation, respectively. As shown in both Figs. 3 and 4, there is no evidence of saturation, a leveling off of the emission curves, nor any evidence of cathode deactivation which would appear as a fall in emission current with increases in anode voltage. Moreover, the direct current emission is nearly equal to the pulsed emission for the same accelerating voltage affording interchangeable direct current and pulsed operation by the same cathode without sacrifice in current available.

It is to be understood that the above-described arrangements are merely illustrative of the application of the principles of the invention. Numerous 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. A high-density radial electron beam producing electrode assembly for magnetrons comprising a pair of aligned longitudinally spaced metallic cathode cylinders including corresponding recesses in adjacent ends defining a cavity, a coating of electron-emissive material on the recessed ends of said metallic cylinders, said ends of the cylinders also defining a restricted circumferential passage communicating between said cavity and the exterior of the cathode cylinders, an anode positioned opposite said restricted circumferential passage, and means for heating said coating to electron-emission temperature.

2. A cathode anode assembly for producing a high-density electron beam having an initial radial velocity comprising a pair of metallic cathode bodies each including a substantially planar surface having a generally central recess, means mounting said bodies with said planar surfaces and recesses in spaced juxtaposed relationship thereby defining a cavity having an annular passage leading therefrom, a coating of electron-emissive material on the surfaces of said bodies defining the recesses, an anode encompassing said cathode bodies and positioned opposite said annular passage, and means for heating said coating of electron-emissive material, whereby electrons emitted from said coating may emanate radially from said passage.

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3. A cathode in accordance with claim 2 wherein said metallic bodies are imperforate in the region of said planar surfaces and recesses.

4. A cathode in accordance with claim 2 wherein the planar surface comprises the edge of a wall of said body in efficient heat conduction relationship to said mounting means.

5. A cathode in accordance with claim 2 wherein the exterior surface of said bodies comprises a bare metallic surface.

6. A magnetron electrode assembly comprising an anode including an axial bore, a cathode comprising a pair of metallic bodies each including a generally centrally recessed surface, means mounting said metallic bodies in spaced relationship coaxially within said anode bore with the recessed surface of one of said metallic bodies adjacent the recessed surface of the other of said metallic bodies thereby defining a cavity, said cavity enclosed except for a passage between said bodies communicating between the cavity and the exterior of said bodies in the region of said anode, a coating of electron-emissive material on the recessed surface of at least one of said bodies defining said cavity and means for heating said coating of electron-emissive material.

7. A magnetron electrode assembly comprising an anode including an axial bore, a cathode comprising a pair

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of metallic cylinders each including a generally central end recess, means mounting said metallic cylinders in spaced relationship coaxially within said anode bore with said end recesses in spaced juxtaposition thereby defining a cavity and an annular passage communicating between said cavity and the exterior of said metallic cylinders, a coating of electron-emissive material on the surfaces defining said cavity, and means for heating said coating of electron-emissive material.

8. A magnetron electrode assembly in accordance with claim 7 wherein said means mounting said metallic cylinders and the cylindrical wall of the metallic cylinders are in efficient heat conduction relationship.

9. A magnetron electrode assembly in accordance with claim 7 wherein said metallic cylinders are imperforate in the region of said anode.

10. A magnetron electrode assembly in accordance with claim 7 wherein said cylinders present a bare metallic surface to said anode.

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