

[54] ELECTRON GUN WITH MASKED
CATHODE AND NON-INTERCEPTING
CONTROL GRID

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313/348, 315/3.5

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[58] Field of Search 313/298, 299, 338, 348,
313/82; 315/3.5

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[57] ABSTRACT

An electron beam generating cathode having a mask-
ing structure in its electron emitting face with its
masking element aligned with the elements of a beam
current control grid prevents accelerated electrons
from damaging or destroying the control grid elements
by over heating.

1 Claim, 5 Drawing Figures

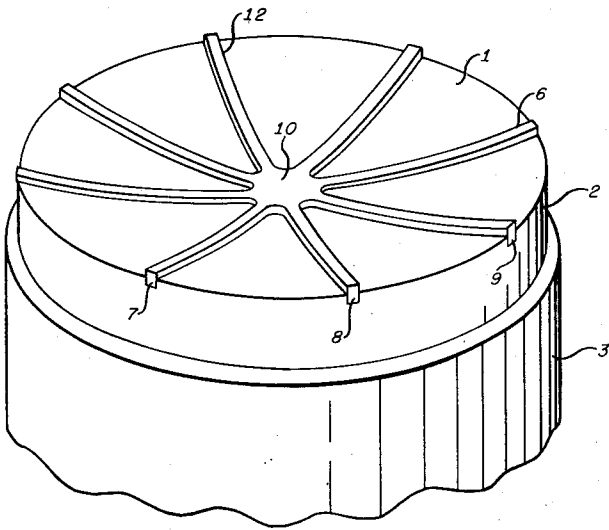


FIG. 1.

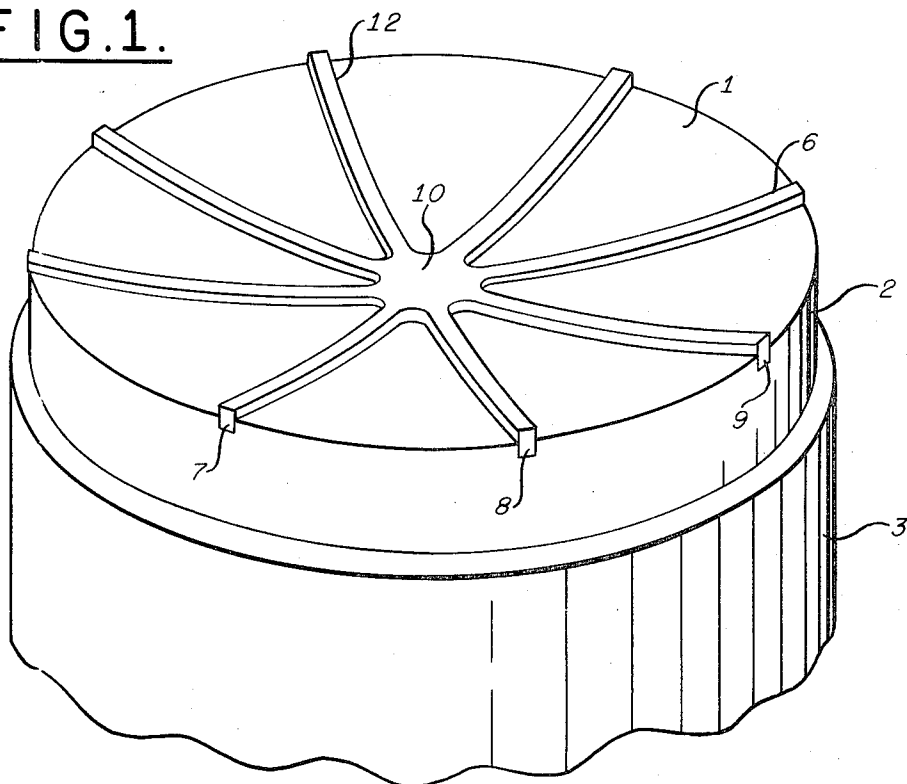
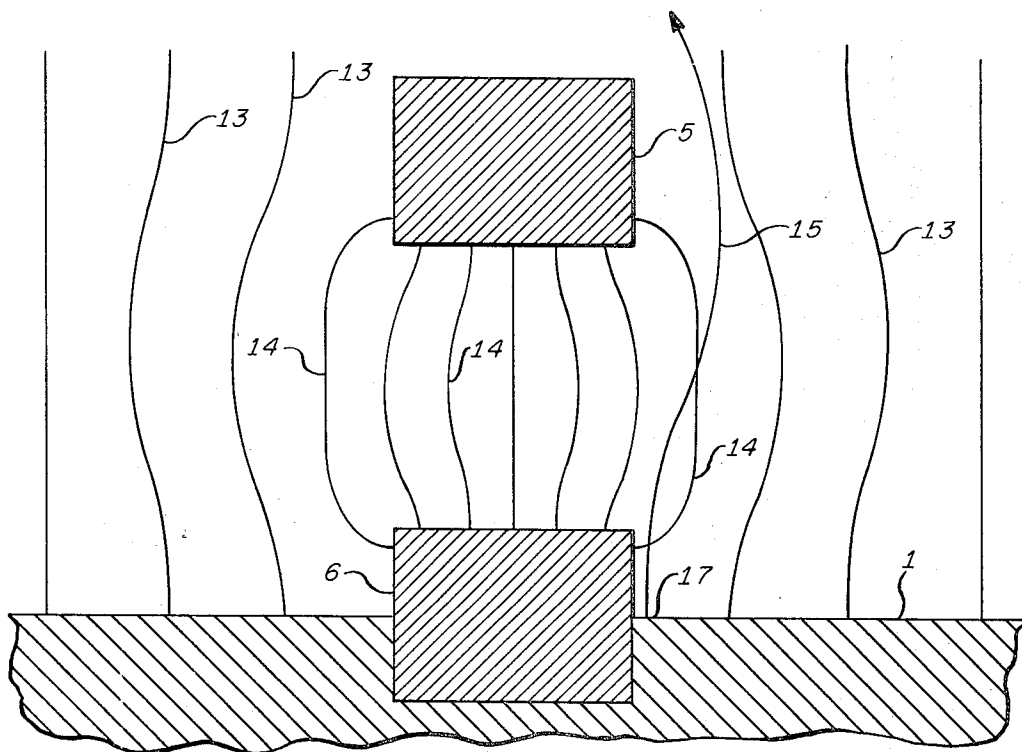


FIG. 2.

FIG. 3.

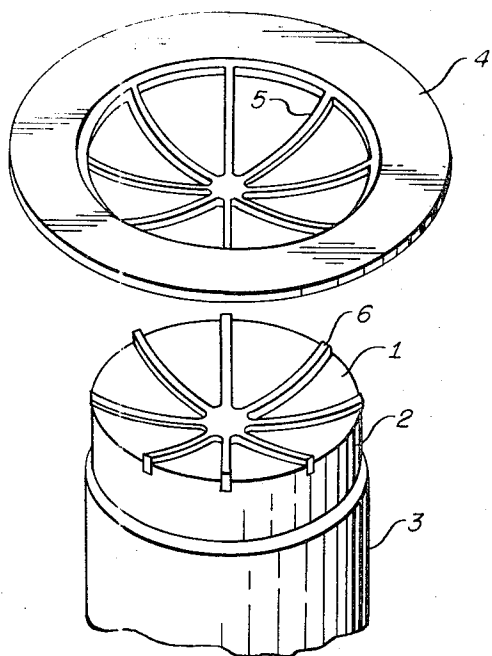
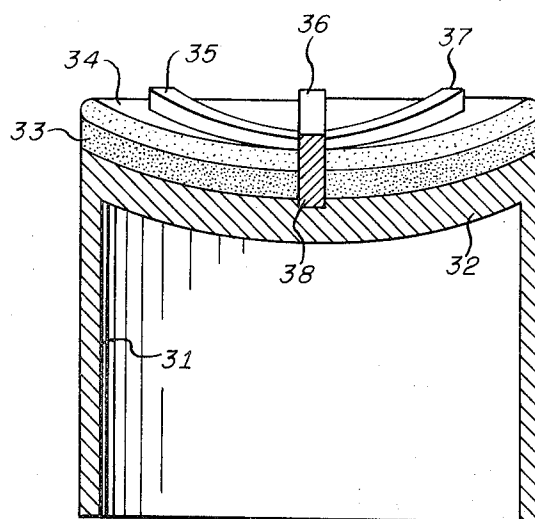


FIG. 5.

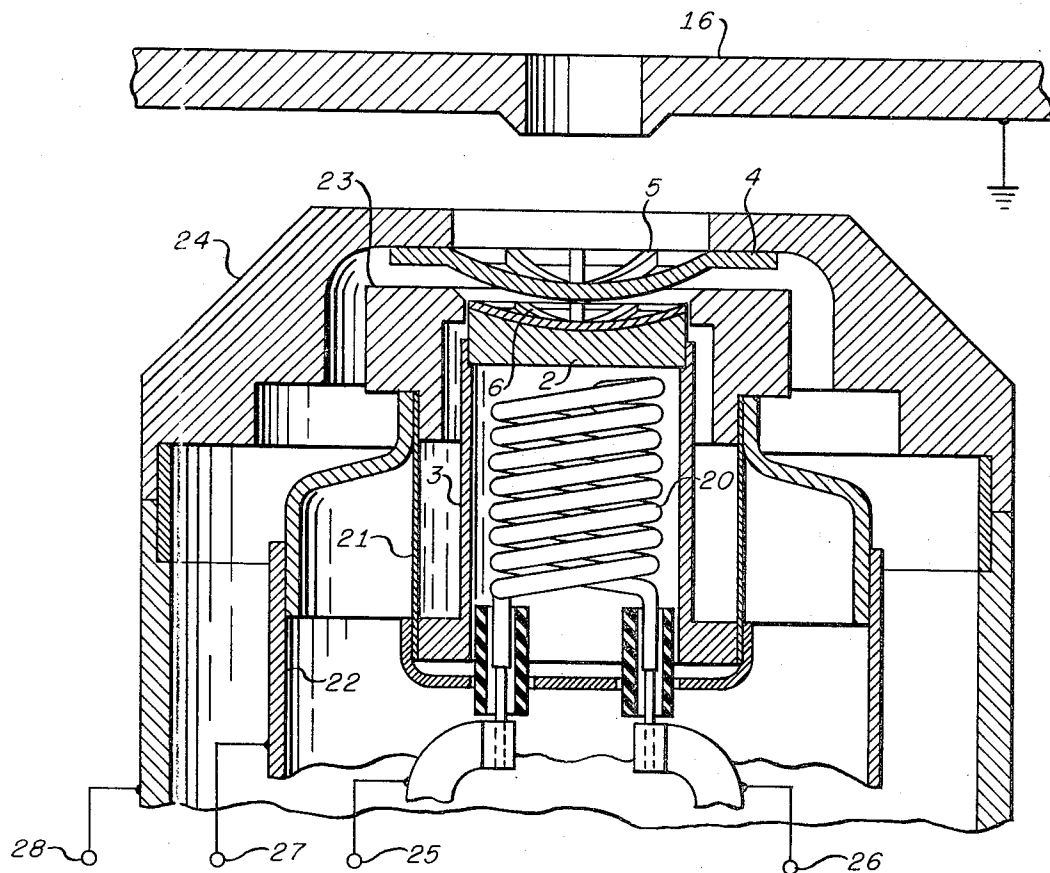


FIG. 4.

ELECTRON GUN WITH MASKED CATHODE AND NON-INTERCEPTING CONTROL GRID

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention pertains to electron beam generating cathodes and to electron permeable control grids associated with them for controlling the total beam current over a relatively wide range of magnitudes and more particularly concerns an electron beam generating cathode having a masking non-emitting structure projecting from its emitting surface and having its masking elements aligned with elements of the beam current control grid.

2. Description of the Prior Art

It has been past practice in the construction of lineal electron beam tubes of the velocity modulation types to employ an electron permeable control grid relatively closely spaced to the cathode electron emitting surface so as to effect easy control over the magnitude of the total beam current. A small change in the voltage level of the control grid has been found to change the total electron beam current over a considerable range. However, even though the control grid is near the cathode surface and may be supplied with relatively effective low impedance heat transfer paths, heating of the grid elements is by the nature of the structure unavoidable. The experience is that such prior art control grids often give trouble as emitters of undesired primary electrons, or may become so over heated that they sag or are even melted entirely away.

SUMMARY OF THE INVENTION

The present invention relates to electron beam generation cathodes and electron beam controlling grids associated with them for controlling the magnitude of electron beam current projected into the high frequency interaction region of a velocity modulation tube, for example. According to the invention, the electron emitter surface of the cathode is provided with a mask made of a metal having a high work function, the mask closely resembling the pattern of the control grid to be protected. The mask not only prevents generation of electrons at the cathode surface which would normally bombard and overheat elements of the control grid, but also has a corrective focussing effect on the trajectories of electrons emitted closely to the elements of the mask, guiding such electrons away from the control grid elements.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the electron emitting end of the novel cathode.

FIG. 2 is a cross section view showing part of the cathode of FIG. 1 and an associated current control grid element in cross-section useful in explaining operation of the invention.

FIG. 3 is a perspective view of the cathode and an associated beam current control grid.

FIG. 4 is a cross section view of the invention, showing how elements of the electron gun are supported with respect to each other.

FIG. 5 is a cross section view of an alternative form of the cathode of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. 1, 2, and 3, the electron emitter surface 1 of the novel electron beam source is the spherically concave end surface of a relatively short circular cylinder 2 forming what is conventionally known as a dispenser cathode element or pellet. The dispenser cathode cylinder 2 is conventionally made of a refractory metal such as sintered tungsten in the form of a porous pellet with a supply of electron emitter material stored in its pores and available there for migration to surface 1 as it is required when the dispenser cathode cylinder 2 is heated by conventional means. Dispenser cathode cylinder 2 may be supported in a thin-walled tube 3 of molybdenum, for example, as will be described.

In the present invention, the electron beam source of FIG. 1 is intended, as indicated in FIGS. 2 and 3, to operate with an electron permeable control grid 4 having a plurality of radial grid forming elements or vanes such as radial vane 5. As in beam tube electron guns of usual configurations, electrons from emitter surface 1 are projected through control grid 4 and then through an anode aperture into the high frequency interaction region of a velocity modulation tube such as a klystron or traveling wave tube. Such an electron beam permeable control grid 4 is generally located relatively close to the cathode emitter surface 1 and control of its potential makes it readily possible to vary the total cathode electron current over a relatively wide range with only a relatively small variation of the voltage on control grid 4. However, in prior art designs, the control grid vanes 5 of such grids directly intercept a significant portion of the electron beam. This interception is undesirable, since the kinetic energy of the intercepted electrons is thereupon converted into heat, seriously raising the operating temperature of grid vanes or grid forming elements 5. The elevated temperature has been found to produce undesirable primary electron emission and distortion of the control grid vane shape or even melting and complete loss of grid vanes. The result is that the intercepted beam current and the consequent heating of the grid elements of vanes 5 of grid 4 set an undesirably low limit on the operating power level of the vacuum tube.

As shown in FIGS. 1, 2, and 3, the invention provides novel means for preventing undesired electron bombardment of the vanes or grid elements 5 of control grid 4 in part by directly preventing formation of electrons in regions of cathode surface 1 which normally have electron trajectories such that they strike vane 5. Referring particularly to FIG. 1, the porous dispenser cathode pellet 2, already provided with its concave surface 1 and with electron emitting materials within its volume, has its surface 1 cut with diametral slots, such as slots 7, 8, and 9, all intersecting adjacent the central region 10. A conventional metal milling cutter may be used to generate the slots, cutting into the surface 1 for a depth, for example, of 0.0085 inches. The slots may be about 0.006 inches wide, for example.

A cathode mask element 12 is constructed of sheet hafnium metal having a plurality of radial elements such as radial arm 6 and such that the mask element 12 may be fit precisely into the slots 7, 8, 9, etc. The hafnium mask 12 may be formed from 0.010 inch sheet hafnium metal using a conventional electrical discharge machining process, after which it is vacuum

fired at a temperature of substantially 1,000° C for about 1 hour. Upon cooling, the mask 12 may be pressed into the slots 7, 8, 9, etc. and the ends of the radial arm 6 trimmed to match the periphery of emitter pellet 2. While the mask 12 may readily be fashioned so that it fits tightly within the slots of surface 1, its fixed position may be positively assured by using a conventional laser welding technique in an inert atmosphere such as argon to fix the ends of the radial arm 6 to the periphery of pellet 1. Hafnium may be readily welded by a laser beam in argon with the benefit that the weld areas are quite localized and the cathode requires no additional cleaning or firing after the laser welding step. The completed cathode, after being brazed in the conventional manner with a high temperature alloy within molybdenum tube 3, has the general appearance of FIG. 1, the radial mask elements 6 each projecting slightly above surface 1 for a distance of 0.001 to 0.002 inches, for example.

When assembled in a vacuum tube, as in FIGS. 2, 3, and 4, each radial mask arm 6 of the mask 12 is placed directly below a corresponding radial vane or grid forming element 5 of the control grid 4. In operation, the electrons of the electron stream emitted by cathode surface 1 rise as in FIG. 2 toward the electron beam permeable anode 16 of FIG. 4.

In the region between emitter surface 1 and control grid 4, the electrons are subjected to an accelerating electric field as represented generally by the lines 13 of FIG. 2. In the vicinity of a representative mask radial arm 6 and of an associated control grid vane or element 5, the lines of electric field tend to go from radial arm to vane, as illustrated by the lines 14. The hafnium mask arm 6, having a high work function, tends to emit no electrons and even electrons emitted from cathode surface 1 near radial mask arm 6, such as from location 17, tend to move out and around the vane 5, avoiding impact with it.

Electrons emitted from a location such as location 17 near mask radial arm 6 first encounter a component of electric field away from radial arm 6, as suggested by the electric field line 14. As an electron moves away from surface 1 along a typical trajectory 15 in the general direction of electron beam permeable anode 16, the electron is influenced by radial vane 5 and thereupon encounters an oppositely directed electric field component, tending to force the electron toward vane 5. However, the electron has gained kinetic energy in traveling along trajectory 15, so that the oppositely directed electric field component has relatively smaller influence, and the trajectory 15 readily passes at an increased distance from grid vane 5. Accordingly, the masking element 12 beneficially improves the useful life of grid 4 not only because electrons which would most certainly bombard the vanes 5 of grid 4 are not generated at the surface of mask 12, but also because the extension of the radial mask arms 6 of mask 12 above emitter surface 1 has a corrective lens effect on electrons emitted close to the mask 12. The net effect is that the radial vanes 5 of control grid 4 intercept very few electrons and are not excessively heated.

In FIG. 4, the novel cathode-control grid system is seen installed in a generally conventional electron gun support system, the cylindrical cathode emitter pellet 2 being heated by a conventional resistive heater element 20 within support tube 3. Tube 3 is supported in concentrically disposed tubes 21 and 22 that are ar-

ranged in a generally conventional manner to provide a high impedance heat transfer path to the outer parts of the vacuum tube, and also are arranged to support the conventional focusing electrode 23 disposed in concentric relation about cathode pellet 2. The control grid 4 is supported with its radial vanes 5 aligned with the arms 6 of mask 12 in the conventional field smoothing electrode 24 adjacent anode 16.

By applying an appropriate voltage to heater terminals 25 and 26, the emitter surface 1 and mask 12 may be heated to a temperature of 1,080° C, for instance; while emitter surface 1 when heated emits a copious flow of electrons, the hafnium material has a high work function even at elevated temperatures and refuses to emit electrons. A high negative voltage is applied via terminal 27 to emitter surface 1 and a potential slightly positive with respect to the emitter surface 1 is applied to control grid 4 via terminal 28. This latter voltage may be adjustable in magnitude about 3 per cent of the potential between emitter 1 and anode 16, which latter electrode is placed at ground potential.

It will be appreciated by those skilled in the art that the invention is not limited to use with the particular radial vane control grid illustrated in the drawings, and that grids having many other configurations or matrices of grid elements may be employed, such as control grids in which the individual grid apertures are generally square or are of other convenient shapes. Masking elements having similar configurations may readily be applied to cathode emitter surfaces such that they match in position such other types of grid, protecting them from loss or damage due to over heating according to the concepts of the present invention.

Additionally, it will be apparent that the invention may be employed with emitters other than of the dispenser type including, for instance, the matrix emitter cathode of the C. E. Rich, C. K. Trace, U.S. Pat. No. 3,238,596, issued Mar. 8, 1966, for a "Method of Fabricating a Matrix Cathode" and assigned to the Sperry Rand Corporation.

Referring to FIG. 5, the matrix emitter cathode may consist of a nickel tube 31 on one end of which is integrally formed a spherically concave end wall 32 on which a sintered nickel matrix layer 33 is formed according to the method taught by Rich and is then compacted after its pores are filled with an electron emitting material. The article is then treated as previously described to form slots such as slot 38 through matrix layer 33 extending part way into the nickel end wall 32. The hafnium mask is formed as before and is placed in slots 38. Laser welding of the radials 35, 36, 37 of the mask at the periphery of the nickel end wall 32 is then practiced. The cathode is completed by temporarily masking the hafnium mask surfaces in a conventional manner, and it is then provided with a thin activating layer 34 of an electron emitter material. The layer 34 is then allowed to dry and the temporary masking is removed from the hafnium mask before final installation of the cathode in a vacuum tube.

While the invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than of limitation and that changes within the purview of the appended claims may be made without departing from the true scope and spirit of the invention in its broader aspects.

We claim:

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1. An electron beam vacuum tube comprising:
anode means having an electron beam permeable ap-
erture,
electron beam permeable current-density control
grid means adjacent said aperture having a prede- 5
termined pattern of radially extending grid forming
vane elements subject to damage by electron bom-
bardment,
concave dispenser cathode electron beam emitting
means formed of plural sectoral emitter elements 10
comprising porous sintered refractory metal having
a surface facing said electron beam permeable cur-
rent-density control grid means, and
masking element means composed of non-electron-
emitting hafnium metal having a pattern of centra- 15
lly joined radial arm elements embedded at said

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electron emitting surface,
said predetermined pattern and said masking element
means pattern being in aligned orientation for pre-
venting electrons from bombarding said grid form-
ing elements,
said masking element means embedded at said elec-
tron emitting surface extending above said electron
emitting surface for cooperating with said electron
beam permeable current-density control grid
means in directing electrons arising adjacent said
masking element means away from said grid form-
ing element,
said radial arm elements being welded to said elec-
tron beam emitting cathode means at the periphery
of said electron beam emitting surface.

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