United States Patent

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[54] **ELECTRIC DISCHARGE VESSEL ELECTRODE STRUCTURE OF PYROLYTIC CARBON DISCS**
12 Claims, 2 Drawing Figs.

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[51] Int. Cl. H01j 1/02, H01j 1/38
[50] Field of Search 313/311, 355, 217, 218, 326, 332, 334, 352, 353; 29/25.14; 315/3.5

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ABSTRACT: A high frequency power tube is provided with an electron gun in which the thermally heavy-duty electrodes and other parts thereof are provided as carbon bodies made of pyrolytical carbon interconnected in the form of discs which are coated with rhenium, and which for better conductivity are additionally coated with a metal of high electrical conductivity, preferably copper or silver.

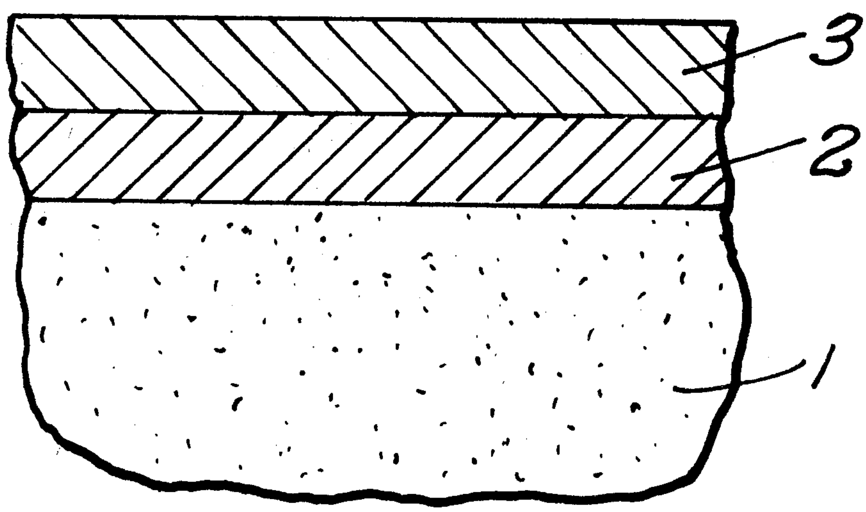

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Fig-1

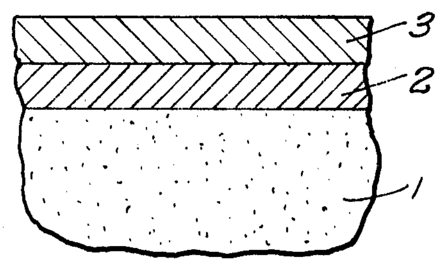
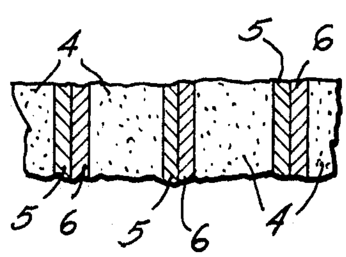


Fig-2



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ELECTRIC DISCHARGE VESSEL ELECTRODE STRUCTURE OF PYROLYTIC CARBON DISCS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to electric discharge vessels, and more particularly to electrode structures for electric discharge vessels which are provided with an electron gun, for example high frequency power tubes, wherein the electrodes, parts of electrodes, or other parts of the electron gun which are located within the tube comprise carbon.

2. Description of the Prior Art

In high frequency tubes for power applications it is of extreme importance that the heat generated during the operation on the electrodes, portions of the electrodes or other parts of the tube, for example, on the collector, caused by greatly varying thermal loads, can be radiated outwardly as rapidly as possible. It is therefore not sufficient to consider only the total thermal load of a tube, but to take into account the particular density distribution as thermal loading occurs, for example, in accordance with the individual distribution of the discharge current among the components of the tube. Even in metals having a good heat conductivity, such as copper, local overheatings may occur under such conditions which lead to evaporation and, thus, to trouble during the operation of the discharge vessel in question.

Carbon, however, is a material which withstands the highest temperatures and which has a high melting point as well as a low vapor pressure. In addition, carbon has a very high radiation capacity which is not far from the radiation capacity of a black body. Hence, carbon bodys can be heated locally to very high temperatures and the heat thereof may be dissipated to the neighboring region through radiation. Moreover, a highly annealing body can also work as an excellent grid when provided with a suitable coating of a metal such as zirconium at points particularly suitable therefore. Additionally, the secondary emission of carbon bodies is very small, particularly when their surfaces are roughly finished. Also, it is easy to process carbon mechanically and to provide carbon elements in practically any desired shape.

It is therefore the object of the present invention to employ carbon as a working material for thermally heavy-duty electrodes or other tube components, more particularly to employ a type of carbon improved by special technological processes with respect to its material properties such that care is taken not only for an increased heat transfer in the desired direction, but also for a sufficient electrical conductivity.

SUMMARY OF THE INVENTION

According to the invention, the above objects are fulfilled by the provision of an electric discharge vessel wherein an electron gun is provided with heavy-duty electrodes, parts of the electrodes or other parts made of carbon, these parts comprising pyrolytic carbon with anisotropic properties with respect to heat conductivity such that the good heat conductivity occurs outwardly in the direction of the exterior of the tube, particularly at right angles to the axis of the tube. The carbon bodies with dimensions greater than 10 mm. in the direction of poor heat conductivity comprise a plurality of thin discs which are interconnected by interlinings of metal rings and/or metal foils of molybdenum or tantalum which have high melting points.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, its organization, constriction and operation will be best understood from the following detailed description taken in conjunction with the drawings, in which:

FIG. 1 is a fragmentary sectional view of an embodiment of an electrode according to the invention; and

FIG. 2 is a fragmentary sectional view of another embodiment of electrode construction according to the invention.

In FIG. 1 a base 1 of carbon carries a metal layer 2 which is preferably rhenium because of its ease of deposition, high density, high melting point and its advantage of not forming a carbide with the carbon base 1. A second metal layer 3, preferably copper or silver, increases the electrical conductivity of the electrode.

FIG. 2 illustrates the construction of an electrode from a plurality of carbon bodies 4. Interlayers 5, 6 of molybdenum or tantalum are electron welded to bond the carbon bodies 4 together. If desired, the electrode so formed may have on its outer surfaces (not shown) layers of rhenium and/or other high conductivity material.

Generally, pyrolytic carbon or graphite is defined herein to mean carbon which is deposited in layers by thermal heating on hot surfaces of suitable carbon compounds, more particularly hydrocarbons. Pyrolytic carbon shows such a pronounced anisotropy with respect to its capacity for thermal conduction that the thermal conduction in one direction approximates at least the thermal conduction of copper, while thermal conduction is much smaller in the other direction. The extent of anisotropy approximates the value of 200.

Thus, through the particular selection of carbon bodies for electrodes, parts of the electrodes or other tube components, it is advantageously achieved that, for example, the heat generated perpendicular to the axis of the tube is dissipated much more rapidly by the shortest route to the outside of the tube or to a cooling medium than along the axis of the tube. The extremely high heat carrying capacity, in other words, the high melting point as well as the low vapor pressure of the carbon, is thereby a particular advantage. It has been determined that the pyrolytic carbon according to its entire layer construction can very easily be made in discs if the direction of poor thermal conductivity lies in the direction of the disc axis (thickness), whereby the practical thickness of the disc is in the range of approximately 3 to 10 mm.

Electrodes, or parts of electrodes, having a dimension greater than 10 mm. in the axial direction, that is in the direction of the poor thermal conductivity, are therefore constructed with interlining metal rings or metal foils from a corresponding number of discs. These rings are welded together, particularly by means of an electron beam of an electron gun to form a vacuum-tight structure. Thus, discs with corresponding, particularly varying, dimensions can be employed in order to provide a predetermined inner or outer contour of the electrode in question.

Furthermore, when such pyrolytic carbon is employed in delay-lines it must be taken into consideration that the electrical resistance in the plane of the layer, that is, in the direction of good heat conductivity, with approximately 200 $\mu\Omega$cm. is larger than that of copper by approximately the factor 100. Consequently, in all cases where a higher electric conductivity is required, and according to an advantageous further feature of the invention, the pyrolytic carbon on the points in question can be provided on the surfaces with a metal layer, preferably of rhenium.

Other metal layers can likewise be applied in similar fashion as rhenium, which have a still better electrical conductivity. Compared with these other metals, however, rhenium is preferred in that it has the substantial advantage that it does not form a carbide with the carbon body as a foundation material, so that it does not need an additional interlining. It can easily be deposited in a chemical reductive process and, above all, it produces very dense layers. Hence, other metal layers to be provided, which have a higher electric conductivity, are most advantageously additionally applied on a surface already coated with rhenium, for example, by electrolysis. Although it may be particularly advantageous to employ copper because of its high electric conductivity, this step nevertheless has a substantial advantage over the direct use of copper, since during operation of the tube, if there is an undesirable impact of the electron beam, only the copper layer is destroyed but not the base. Therefore, the rhenium and the carbon are not altered and a destruction of the form of the apparatus cannot occur. Small regions of insignificant conductivity may arise, however, such small regions do not affect the function of the tube.

Although I have described my invention by reference to specific illustrative examples, many changes and modifications thereof will become apparent to those skilled in the art without departing from the spirit and scope of my invention as defined in the appended claims.

What I claim as my invention is:

1. An electrode structure for use within an electric discharge vessel, said structure being subjected to operation under high temperature conditions, the improvement comprising the provision of said structure as comprising a carbon base having a longitudinal axis and a thermal anisotropic characteristic which provides for good heat conductivity in a direction of short distance to the outside of the vessel perpendicular to said axis and having poor heat conductivity in the direction parallel to said axis, said carbon base comprising a plurality of adjacently disposed carbon discs each of which includes at least one surface which faces a similar surface of an adjacent carbon discs, and a plurality of metal interlinings bonding said facing surfaces.

2. The improvement according to claim 1, wherein said carbon base comprises pyrolytic carbon.

3. The improvement according to claim 1, wherein said metal interlinings comprise molybdenum.

4. The improvement according to claim 1, wherein said metal interlinings comprise tantalum.

5. The improvement according to claim 1, comprising a metal layer carried on parts of the outer surface of the carbon base for increasing the electrical conductivity thereof.

6. The improvement according to claim 5, wherein said metal layer comprises rhenium.

7. The improvement according to claim 6, comprising a second metal layer carried on said metal layer of rhenium and having a higher electrical conductivity than that of rhenium.

8. The improvement according to claim 7, wherein said second metal layer comprises copper.

9. The improvement according to claim 8, wherein said second metal layer comprises silver.

10. The improvement according to claim 1, wherein means are provided for connecting said carbon discs in vacuumtight relation to form a vacuumtight structure.

11. The improvement according to claim 1, wherein said structure including said carbon base forms a delay-line structure for use in a traveling wave tube.

12. The improvement according to claim 1 wherein said structure has dimensions greater than 10 mm. in the direction of poor heat conductivity of said carbon base.