July 17, 1962 J. R. BUTLER 3,045,147

MAGNETRON ELECTRODE STRUCTURES

Filed Nov. 16, 1959 2 Sheets-Sheet 1

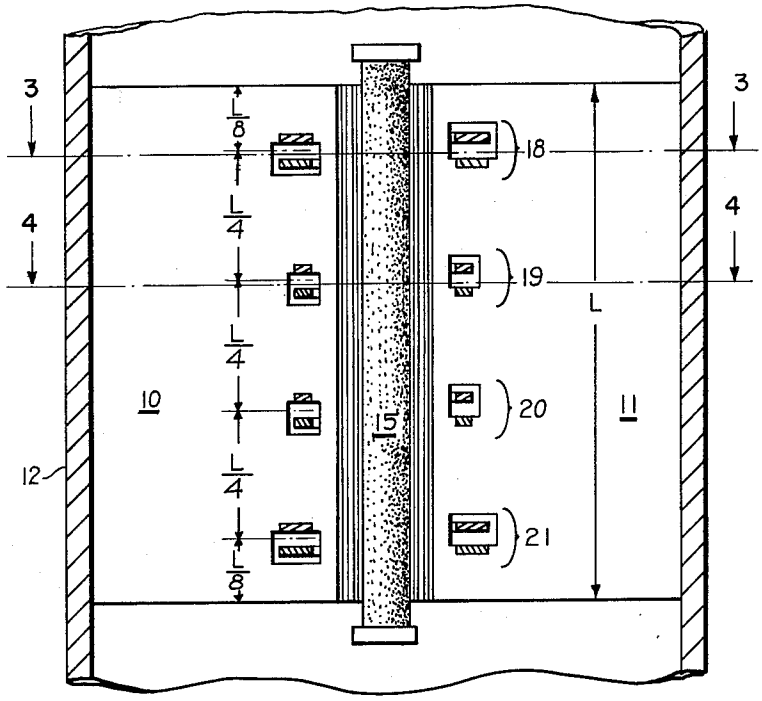


FIG. 1

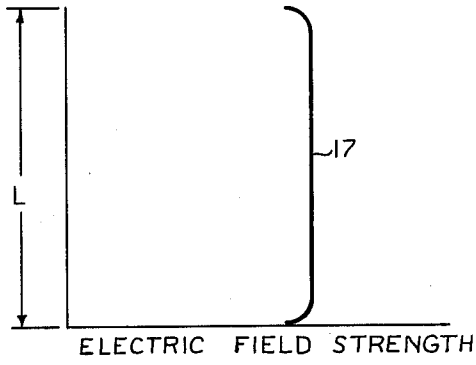


FIG. 2

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FIG. 3

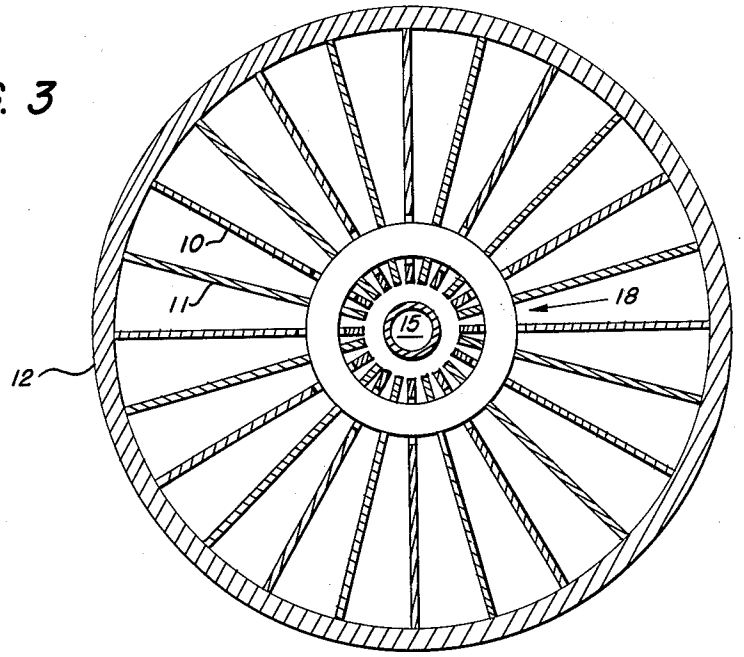
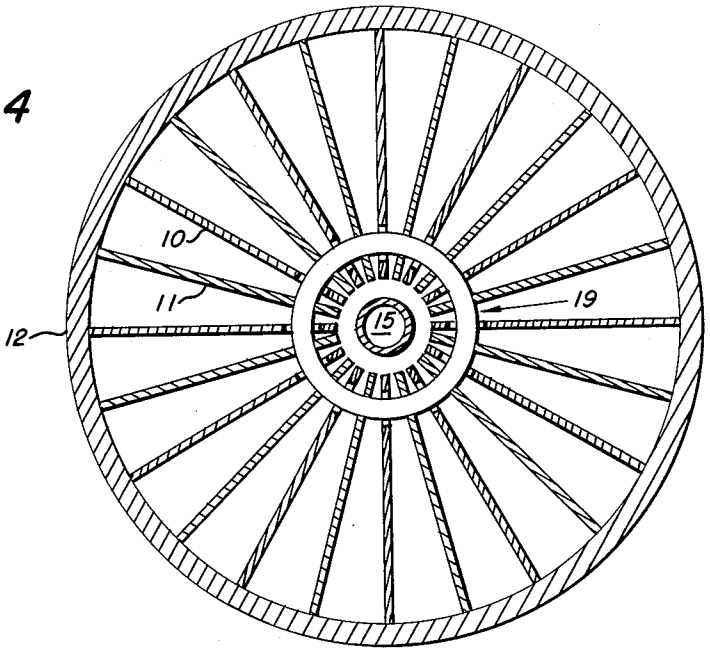


FIG. 4



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MAGNETRON ELECTRODE STRUCTURES

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9 Claims. (Cl. 315—39.69)

This invention relates generally to magnetron structures and, more particularly, to magnetron electrode structures utilizing strapped anode vanes which provide a uniform distribution of electric field along the lengths of said anode vanes so that high output power can be obtained without the occurrence of arcing between the vanes and the electron emitting surface of the magnetron cathode.

Output power in magnetrons is dependent upon the transfer of energy between the electrons from the cathode and the RF electric field of the anode. The stronger the electric field, the greater is the current density and power transfer which occurs. In conventional strapped magnetrons which utilize a pair of straps positioned either at the upper or lower ends of the anode vanes or at both ends, a non-uniform distribution of the RF electric field exists along the anode vanes in the direction of the longitudinal axis of the magnetron and is greatest in those areas of the anode adjacent the strap pairs. If the anode voltage is increased to provide an increase in total current and output power, a value of current density is ultimately reached near the regions where the straps are placed, which causes arcing to occur between the cathode and the anode vanes. The arcing and high current density result in tube instability, erosion of the vane tips, and damage to the emitting surface of the cathode.

The central portions of the vanes of the type of anode structure described above absorb only a small current density and, hence, the total current and power output being generated at the level of operation at which arcing occurs will be relatively low in an anode the RF field of which has maxima at the ends of the vanes.

It is, therefore, desirable to obtain an anode structure in which the electric field distribution along the anode vane is uniform. In such a structure the anode current may be increased to a greater value before arcing occurs at any point along the vane. Thus, full advantage of the energy transfer all along the vane is obtained. Prior art anode vane structures do not provide such a uniform electric field distribution.

This invention provides a uniform distribution of electric field energy along the anode vanes of a magnetron in the direction of the longitudinal axis of the tube. This uniform distribution is achieved in a preferred embodiment of the invention by utilizing a plurality of strap pairs positioned at selectable points along the lengths of the anode vanes. The strap pairs near the upper and lower ends of the anode vanes are arranged to have a greater D.-C. capacitance than those provided at the central regions of the vanes. Such a construction assures a uniform electric field distribution. In one particular embodiment of the invention, the strap pairs are substantially symmetrically placed along the lengths of the anode vanes so that the distance from each end of the anode vanes to the nearest strap pair is substantially equal to half the distance between the strap pairs themselves.

The invention may be more easily described with the help of the drawing wherein:

FIG. 1 shows a cross-sectional view of a portion of a magnetron electrode structure utilizing a preferred embodiment of the invention;

FIG. 2 shows a graph of the electric field strength along the length of the anode vanes of the structure of FIG. 1; and

FIGS. 3 and 4 show cross-sectional views of the anode structure of the invention.

FIGS. 1, 3 and 4 show a preferred embodiment of the invention wherein a plurality of strap pairs are positioned so that they are substantially aligned along the length of the anode vanes in the direction of the longitudinal axis of the tube. In these figures there is shown a pair of anode vanes **10** and **11** oppositely disposed with respect to a cathode **15**. Vanes **10** and **11** represent two of a plurality of similar vanes radially spaced about cathode **15** in accordance with conventional magnetron structure. The radially spaced anode vanes are attached at their outer ends to an anode cylinder **12**, a portion of which is shown in the figures.

If the length of anode vanes **10** and **11** as measured along the longitudinal axis of the tube is denoted by "L," a pair of straps **18** is placed at a distance substantially equal to

$$\frac{L}{8}$$

from the upper ends of vanes **10** and **11**. Additional strap pairs **19**, **20** and **21** are positioned along the anode vanes so that the distances between strap pair centers is substantially equal to

$$\frac{L}{4}$$

and the distance from strap pair **21** to the lower ends of vanes **10** and **11** is substantially equal to

$$\frac{L}{8}$$

The upper straps of each pair are connected to alternating anode vanes and the lower straps of each pair are connected to intermediate anode vanes as is conventional in magnetron anode structures. In the figures, vane **10** represents one of the alternating vanes to which the upper straps are connected and vane **11** represents one of the intermediate vanes to which the lower straps are connected.

As is evident in the figures, the size of strap pairs **18** and **21** near the upper and lower regions of the vanes is greater than the size of strap pairs **19** and **20** positioned in the central regions of the vanes. Hence, greater D.-C. capacitance is provided by the straps near the upper and lower ends of the vanes. In the preferred embodiment shown in FIGS. 1, 3 and 4 the D.-C. capacitance of straps **18** and **21** is substantially twice the D.-C. capacitance of straps **19** and **20**. This unequal distribution of the weight of the strapping assures a uniform distribution of electric field energy along the lengths of the anode vanes. If equal weights of strapping are utilized for the strapped pairs, a non-uniform distribution would occur and a greater field strength would exist in the central regions of the vanes than at the ends.

The electric field energy distribution for the structure of FIG. 1 is shown in FIG. 2 wherein solid curve **17** represents the electric field strength plotted along the length L of the vanes.

The configuration shown in FIGS. 1, 3 and 4 does not necessarily represent the only embodiment of the invention inasmuch as other embodiments will occur to those skilled in the art without departing from the scope of the invention. A number of strap pairs other than the four shown in the figures may be used depending upon the size of the anode structure desired and the wavelength of the resonant frequency of the anode. It should be realized that the weight of strapping utilized should be distributed to provide a uniform field and that such a distribution generally requires heavier strapping near the ends of the vane structures.

In some applications the distance between strap pairs

need not necessarily be symmetrical and the straps at each end may be placed directly at the upper and lower end surfaces of the anode vanes rather than positioned inwardly from the ends as shown. Although the specific embodiment shown utilizes strap pairs wherein the straps are placed one above the other, it is obvious that the straps may be alternatively positioned side by side in accordance with a conventional radial orientation. Hence, the invention is not to be construed as limited to the specific structure shown and described herein except as defined by the appended claims.

What is claimed is:

1. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes attached to said anode cylinder and radially spaced about a cathode; a plurality of conducting strap groups, a first quantity of each of said strap groups being connected to alternating ones of said anode vanes and a second quantity of each of said strap groups being connected to intermediate ones of said anode vanes, a first number of said strap groups having D.-C. capacitances different from the D.-C. capacitances of the remaining strap groups.

2. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes attached to said anode cylinder and radially spaced about a cathode; a plurality of conducting strap pairs, a first strap of each of said strap pairs being connected to alternating ones of said anode vanes and a second strap of each of said strap pairs being connected to intermediate ones of said anode vanes, a first group of said strap pairs having D.-C. capacitances different from the D.-C. capacitances of the remaining strap pairs.

3. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes attached to said anode cylinder and radially spaced about a cathode; a plurality of conducting strap pairs, a first strap of each of said strap pairs being connected to alternating ones of said anode vanes and a second strap of each of said strap pairs being connected to intermediate ones of said anode vanes, a first group of said strap pairs positioned near the ends of said anode vanes having D.-C. capacitances different from the D.-C. capacitances of the remaining strap pairs.

4. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes attached to said anode cylinder and radially spaced about a cathode; a plurality of conducting strap pairs, a first strap of each of said strap pairs being connected to alternating ones of said anode vanes and a second strap of each of said strap pairs being connected to intermediate ones of said anode vanes, a first group of said strap pairs positioned near the ends of said anode vanes having D.-C. capacitances greater than the D.-C. capacitances of the remaining strap pairs.

5. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes attached to said anode cylinder and radially spaced about a cathode; a plurality of conducting strap pairs symmetrically positioned along the lengths of said vanes, a first strap of each of said strap pairs being connected to alternating ones of said anode vanes and a second strap of each of said strap pairs being connected to intermediate ones of said anode vanes, said nearest ones of said strap pairs adjacent said ends having D.-C. capacitances greater than the D.-C. capacitances of the remaining strap pairs.

6. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes attached to said anode cylinder and radially spaced about a cathode; a plurality of conducting strap pairs positioned along the lengths of said vanes, the distance between said strap pairs being substantially twice the distance from the upper and lower ends of said vanes to the nearest adjacent ones of said strap pairs, a first strap of each of said strap pairs being connected to alternating ones of said anode vanes and a second strap of each of said strap pairs being connected to intermediate ones of said anode vanes, said nearest ones of said strap pairs positioned near the ends of said anode vanes having D.-C. capacitances greater than the D.-C. capacitances of the remaining strap pairs.

7. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes attached to said anode cylinder and radially spaced about a cathode; a plurality of conducting strap pairs positioned along the lengths of said vanes, the distance between said strap pairs being substantially twice the distance from the upper and lower ends of said vanes to the nearest adjacent ones of said strap pairs, a first strap of each of said strap pairs being connected to alternating ones of said anode vanes and a second strap of each of said strap pairs being connected to intermediate ones of said anode vanes, said nearest adjacent ones of said strap pairs having D.-C. capacitances equal to substantially twice the D.-C. capacitances of the remaining strap pairs.

8. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes attached to said anode cylinder and radially spaced about a cathode, a plurality of conducting strap pairs positioned along the lengths of said vanes, the distance between said strap pairs being substantially twice the distance from the upper and lower ends of said vanes to the nearest adjacent ones of said strap pairs, a first strap of each of said strap pairs being connected to alternating ones of said anode vanes and a second strap of each of said strap pairs being connected to intermediate ones of said anode vanes, said nearest adjacent ones of said strap pairs having D.-C. capacitances equal to substantially twice the D.-C. capacitances of the remaining strap pairs.

9. In an electron discharge device, an electrode structure comprising an anode cylinder; a plurality of anode vanes each having a length L, said vanes being attached to said anode cylinder and radially spaced about a cathode, four conducting strap pairs positioned along the lengths of said vanes, the distance between said strap pairs being substantially equal to

$$\frac{L}{4}$$

and the distance from the upper and lower ends of said vanes to the nearest adjacent ones of said strap pairs being substantially equal to

$$\frac{L}{8}$$

a first strap of each of said strap pairs being connected to alternating ones of said anode vanes and a second strap of each of said strap pairs being connected to intermediate ones of said anode vanes, said nearest adjacent ones of said strap pairs having D.-C. capacitances equal to twice the D.-C. capacitances of the remaining two strap pairs.

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