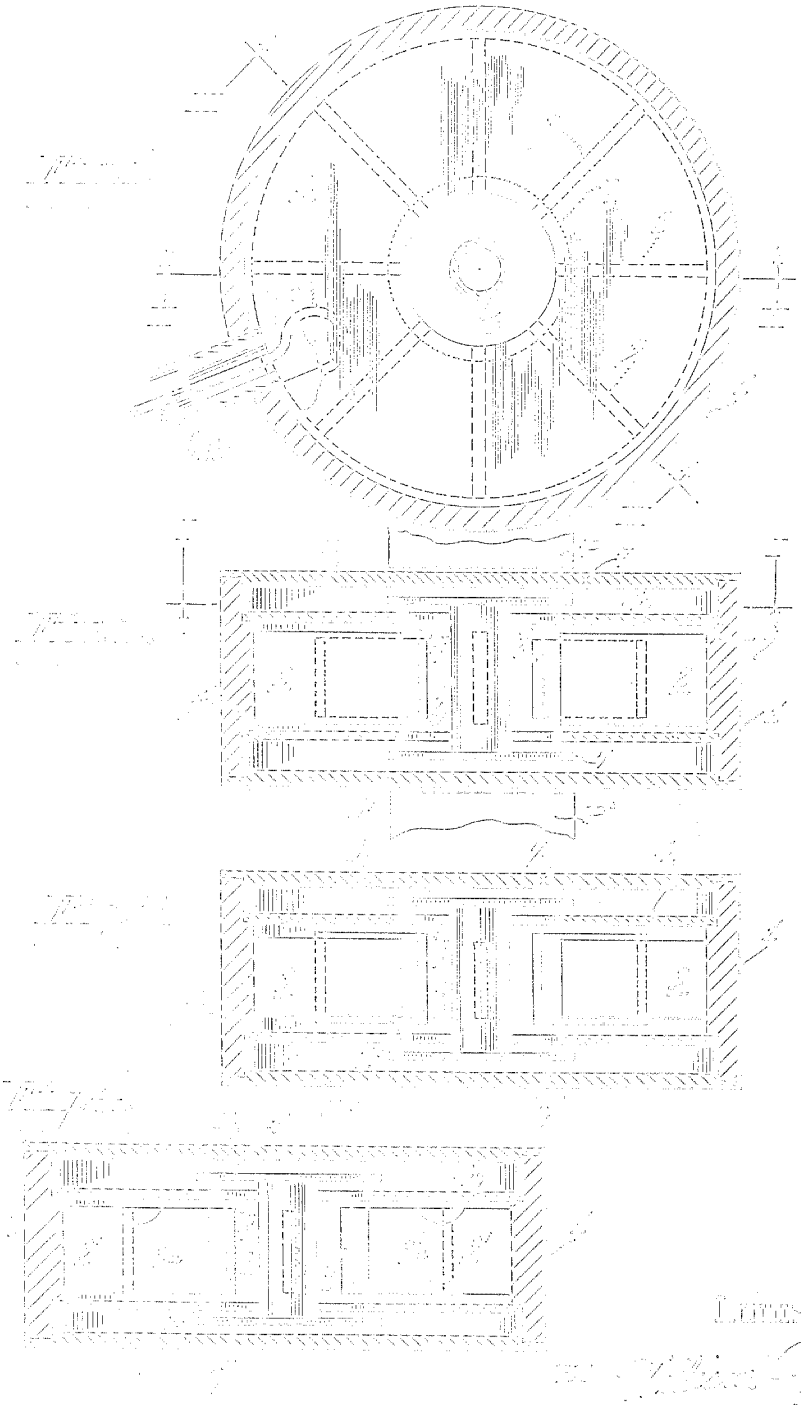


Witnesses
Thos. Mayo

UNITED STATES PATENT OFFICE

2,637,004

ELECTRON DISCHARGE DEVICE, INCLUDING CAVITY RESONATORS

Louis Malter, Brooklyn, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application October 6, 1948, Serial No. 53,800

17 Claims. (Cl. 315—40)

This invention relates to improvements in electron discharge devices including cavity resonators, and particularly such devices of the multi-cavity magnetron type.

It is well known that conventional multi-cavity magnetron oscillators with similar cavities or cavity resonators operate in any one of a number of different modes. Each of the different modes of operation involves a different instantaneous phase difference between the oscillations generated in adjacent cavities. It has been found that as a rule the most efficient and desirable mode of operation is that referred to as the "π-mode," in which the oscillations in adjacent cavities of the magnetron oscillator are 180° or π radians out of phase with each other, or, in other words, one set of alternate anode elements coupled to the cavities is at the maximum positive potential when the other or intermediate set of alternate anode elements is at the maximum negative potential. In order to achieve π-mode operation in conventional multi-cavity magnetrons, it is customary to electrically connect alternate anode elements together by means of low impedance conductors or "straps," to lock alternate anode elements and alternate cavities together into the same phase. One effect of these straps is to shift the oscillation frequencies of the various undesirable modes away from the frequency of the π-mode without affecting the latter, thus facilitating the elimination of the undesirable modes by causing the electric and magnetic field conditions suitable for the generation of the undesirable modes to lie far away from those which favor the π-mode. While the provision of such straps results in improved operation, it involves a considerable increase in the complexities of the device and in its mode of construction.

The primary object of my invention is to provide a multi-cavity magnetron with an improved structure for favoring π-mode operation.

Another object is to provide such a structure in which strapping is not required.

A further object is to provide a magnetron anode structure favorable to π-mode operation which is simple and easy to manufacture.

In accordance with my invention, the magnetron anode structures forming the cavities, instead of being alike, are constructed of two dissimilar forms arranged alternately along the periphery of the anode. The desired π-mode operation of the cavities may be achieved in the type of magnetron having the cavities open on two sides by making the two sets of alternate vanes or partitions separating the cavities of different axial width or of different edge configurations adjacent the open sides.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing, in which

Figure 1 is a top section view, taken on the line I—I of Figure 2, of a multi-cavity electron discharge device incorporating one embodiment of my invention;

Figures 2 and 3 are axial section views taken on the lines II—II and III—III, respectively, of Figure 1; and

Figure 4 is a section view similar to Figure 2 of a modification of Figures 1–3.

Referring first to Figures 1 to 3, I have shown a multi-cavity magnetron having an anode structure composed of a hollow cylinder 1 in the interior of which are mounted by suitable means an even number of radially-extending anode vanes 2 and 3 forming cavity resonators therebetween.

The vanes are uniformly distributed around the inner periphery of the cylinder 1 and terminate short of the central axis to provide an annular series of anode elements surrounding a central cathode space. Each pair of adjacent vanes cooperates with the cylinder to form an anode cavity resonator closed at the outer end and open on two sides and at the inner end. All of the resonators are electromagnetically coupled together around the side edges of the vanes.

If desired, in each end of the cylinder 1 a disc 4 having a central aperture of approximately the same diameter as the cathode space may be provided in spaced relation to the adjacent sides of the vanes 2, 3 and seated on annular shoulders 5 in the cylinder wall, to restrict the electromagnetic coupling between adjacent cavity resonators at the sides thereof.

In accordance with my invention, the vanes separating the cavity resonators are constructed of two different widths, the alternate vanes 3 having a smaller dimension parallel to the longitudinal axis of the cylinder 1 than the intermediate vanes 2, as shown in Figures 2 and 3.

A conventional indirectly-heated cylindrical cathode 6, having end shields or "hats" 7, is axially mounted within the cathode space, to supply electrons therein for exciting the anode resonators during operation of the device. The vacuum envelope is completed by end plates 8 sealed to the ends of the cylinder 1. The cylinder 1, vanes 2 and 3 and discs 4 are made of good conducting

metal, such as copper. It will be understood that suitable means for maintaining a constant magnetic field parallel to the cathode within the cathode space will be provided. Such means may consist of permanent magnet poles P, P' positioned closely adjacent the outer faces of the end plates 8, as shown in Fig. 2, or an electromagnet coil coaxially disposed with respect to the cathode axis. High frequency energy may be taken out of the magnetron by any suitable means such as a coupling loop 9 linked with the axial magnetic flux of the electromagnetic field set up in one of the resonators and forming a continuation of the center conductor of a coaxial transmission line 10, as shown in Figure 1.

In operation, the anode structure and the cathode are connected to the positive and negative terminals, respectively, of a source of direct current potential and the radial electric field thus produced cooperates with the axial magnetic field to cause the electrons supplied by the cathode to form a rotating space charge within the cathode space in the usual magnetron fashion. This space charge sweeps past the anode elements formed by the inner edges of the vanes 2 and 3 inducing high frequency voltages therein and setting up high frequency fields in the resonators. The high frequency magnetic flux of this field within each cavity links with that of the adjacent resonators around the sides of the vanes. The use of two different widths of the vanes 2 and 3 produces a structure which is essentially symmetrical for the π-mode but strongly non-symmetrical for the other modes. This tends to cause the oscillator to operate in the desired π-mode in which the dissimilar adjacent resonators are 180° out of phase and the similar alternate resonators are in phase.

Figure 4 shows a modification of the structure of Figures 1 to 3 wherein the overall width of all of vanes is the same and the dissymmetry of the vanes is produced by cutting away a portion of the side edges of alternate vanes 2' to provide notches 2a. The magnetron structure is otherwise the same as in Figures 1 to 3. The effect of the notches 2a in alternate vanes is similar to that of making the vanes of different width.

It is apparent that the structure of my invention achieves substantially the same results as conventional strapping in favoring π-mode operation, in a structure that is obviously much simpler and easier to manufacture than a strapped magnetron.

While I have indicated only a few embodiments of my invention, it will be apparent that my invention is by no means limited to the exact forms illustrated or use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

I claim:

1. An electron discharge device having an anode structure providing a series of adjacent anode cavity resonators of equal depth closed at one end and open on two sides and at the other end and separated by conducting wall portions, and a pair of conducting walls adjacent to the open sides of said resonators but spaced from all of said conducting wall portions to permit electromagnetic coupling between adjacent resonators at the sides of said wall portions, alternate ones of said wall portions having a predetermined form and the remaining wall portions having a different predetermined form, whereby the resonator wall dissymmetry thus produced favors π-mode operation of the device.

2. An electron discharge device having an anode structure comprising a cylindrical conducting wall and an annular series of spaced conducting radially-extending vanes of equal radial dimension defining a central cathode space at their inner ends, each pair of adjacent vanes and said wall providing a cavity resonator closed at its outer end and open on two sides and toward said cathode space, and a pair of conducting walls adjacent to the open sides of said resonators but spaced from all of said vanes to permit electromagnetic coupling between adjacent resonators at the sides of said vanes, alternate ones of said vanes having a predetermined form and the remaining vanes having a different predetermined form, whereby the vane dissymmetry thus produced favors π-mode operation of said device.

3. A magnetron comprising an elongated cathode, an anode structure including an annular series of spaced radially-extending vanes of equal radial dimension concentric with said cathode and a conducting wall surrounding the outer ends of said vanes and providing with each pair of adjacent vanes a cavity resonator closed at its outer end and open on two sides and toward said cathode, and means for establishing a constant magnetic field parallel with the axis of said cathode and said anode, and a pair of conducting walls adjacent to the open sides of said resonators but spaced from all of said vanes to permit electromagnetic coupling between adjacent resonators at the sides of said vanes, alternate ones of said vanes having a predetermined form and the remaining vanes having a different predetermined form, whereby the vane dissymmetry thus produced favors π-mode operation of said device.

4. An electron discharge device having an anode structure comprising a series of adjacent cavity resonators closed at one end and open on two sides and at the other end and separated by conducting wall portions, and a pair of conducting walls adjacent to the open sides of said resonators but spaced from all of said conducting wall portions to permit electromagnetic coupling between adjacent resonators at the sides of said wall portions, alternate ones of said wall portions having a predetermined width, and the other wall portions having a substantially different predetermined width.

5. An electron discharge device having an anode structure comprising a cylindrical conducting wall and an annular series of spaced vanes extending radially inwardly from said wall and defining a central cathode space at their inner ends, said cylindrical wall and each pair of adjacent vanes providing a cavity resonator closed at its outer end and open on two sides and toward said cathode space, and a pair of conducting walls adjacent to the open sides of said resonators but spaced from all of said vanes to permit electromagnetic coupling between adjacent resonators at the sides of said vanes, alternate vanes having a predetermined width and the other vanes having a substantially different predetermined width.

6. A magnetron comprising an elongated cathode, an anode structure including an annular series of spaced radially-extending vanes concentric with said cathode and a conducting wall

surrounding the outer ends of each pair of adjacent vanes and providing with said vanes a cavity resonator closed at its outer end and open on two sides and toward said cathode, and a pair of conducting walls adjacent to the open sides of said resonators but spaced from all of said vanes to permit electromagnetic coupling between adjacent resonators at the sides of said vanes, and means for establishing a constant magnetic field parallel with the axis of said cathode, alternate ones of said vanes having a predetermined width and the other vanes having a substantially different predetermined width, whereby π-mode operation of said magnetron is favored.

7. An electron discharge device having an anode structure providing a series of adjacent cavity resonators closed at one end and open at the other end and separated by conducting wall portions of the same width, alternate ones only of said wall portions being partially cut away, whereby the vane dissymmetry thus produced favors π-mode operation of the device.

8. An electron discharge device having an anode structure comprising a cylindrical conducting wall, an annular series of spaced conducting vanes of the same width extending radially inwardly from said wall and defining a central cathode space at their inner ends, said vanes and each pair of adjacent walls forming a cavity resonator closed at its outer end and open toward said cathode space, alternate ones only of said vanes being partially cut away, whereby the vane dissymmetry thus produced favors π-mode operation of the device.

9. A magnetron comprising an elongated cathode, an anode structure including an annular series of spaced radially-extending vanes of the same width concentric with said cathode and a conducting wall surrounding the outer ends of each pair of adjacent vanes and forming with said vanes a cavity resonator closed at its outer end and on two sides and open on the other two sides and toward said cathode, and means for establishing a constant magnetic field parallel with the axis of said cathode, alternate ones only of said vanes being partially cut away, whereby the vane dissymmetry thus produced favors π-mode operation of the magnetron.

10. An electron discharge device having an anode structure providing a series of adjacent cavity resonators of equal depth closed at one end and open on two sides and at the other end and separated by conducting wall portions, alternate ones of said wall portions having a predetermined form and the remaining wall portions having a different predetermined form, all of said resonators being electromagnetically coupled together around the side edges of said wall portions.

11. An electron discharge device having an anode structure comprising a cylindrical conducting wall and an annular series of spaced conducting radially-extending vanes of equal radial dimension defining a central cathode space at their inner ends, each pair of adjacent vanes and said wall providing a cavity resonator closed at its outer end and open on two sides and toward said cathode space, alternate ones of said vanes having a predetermined form and the remaining vanes having a different predetermined form, all of said resonators being electromagnetically coupled together around the side edges of said vanes.

12. A magnetron comprising an elongated cathode, an anode structure including an annular series of spaced radially-extending vanes of equal radial dimension concentric with said cathode and a conducting wall surrounding the outer ends of said vanes and providing with each pair of adjacent vanes a cavity resonator closed at its outer end and on two sides and open on the other two sides and toward said cathode, and means for establishing a constant magnetic field parallel with the axis of said cathode and said anode structure, alternate ones of said vanes having a predetermined form and the remaining vanes having a different predetermined form, all of said resonators being electromagnetically coupled together around the side edges of said vanes.

13. An electron discharge device having an anode structure comprising a series of adjacent cavity resonators closed at one end and open on two sides and at the other end and separated by conducting wall portions, alternate wall portions having a predetermined width and the other wall portions having a substantially different predetermined width, all of said resonators being electromagnetically coupled together around the side edges of said wall portions.

14. An electron discharge device having an anode structure comprising a cylindrical conducting wall and an annular series of spaced vanes extended radially inwardly from said wall and defining a central cathode space at their inner ends, said cylindrical wall and each pair of adjacent vanes providing a resonator closed at its outer end and open on two sides and toward said cathode space, alternate vanes having a predetermined width and the other vanes having a substantially different predetermined width, all of said resonators being electromagnetically coupled together around the side edges of said vanes.

15. A magnetron comprising an elongated cathode, an anode structure including an annular series of spaced radially-extending vanes concentric with said cathode and a conducting wall surrounding the outer ends of said vanes and providing with each pair of adjacent vanes a cavity resonator closed at its outer end and on two sides and open on the other two sides and toward said cathode, and means for establishing a constant magnetic field parallel with the axis of said cathode, alternate ones of said vanes having a predetermined width and the other vanes having a substantially different predetermined width, all of said resonators being electromagnetically coupled together around the side edges of said vanes.

16. An electron discharge device comprising a cylindrical conducting wall closed at its ends by end walls to form an evacuated envelope, an anode structure including an annular series of spaced conducting vanes extending radially inwardly from said cylindrical wall, the inner edges of said vanes forming an annular series of anode elements defining a central cathode space, an elongated cathode mounted axially within said space, each pair of adjacent vanes together with said cylindrical wall forming a cavity resonator connected between adjacent anode elements and closed on two sides and the outer end and open on the other two sides and toward said cathode, and a conducting plate mounted within said cylindrical wall between said vanes and one of said end walls, said plate being spaced from the sides of said vanes to permit electromagnetic coupling between adjacent resonators at the sides thereof, alternate ones of said vanes having a predetermined form and the remaining vanes having a different predetermined form, where-

by the same discriminatory thus produced from each point of the device.

20. An electron discharge device according to claim 18, further including a second conducting plate similarly mounted between said vanes and the other end wall and spaced from the sides of said vanes.

LOUIS MALTER.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
1,802,185	Read	Apr. 21, 1931
2,410,172	Smith	Apr. 15, 1947
2,429,291	Okress	Oct. 21, 1947
2,473,390	Spencer	June 14, 1949
2,583,341	Nordsieck	Sept. 26, 1950