April 14, 1953 F. H. CRAWFORD ET AL 2,635,211

TUNABLE MAGNETRON

Filed March 5, 1946

FIG. 1

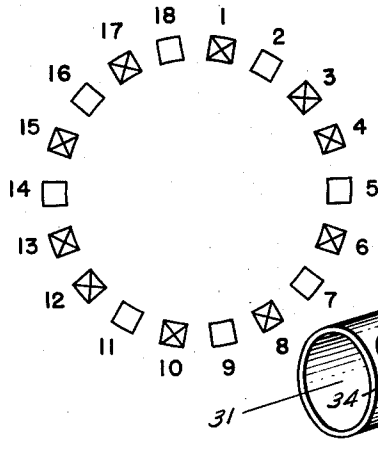


FIG. 5

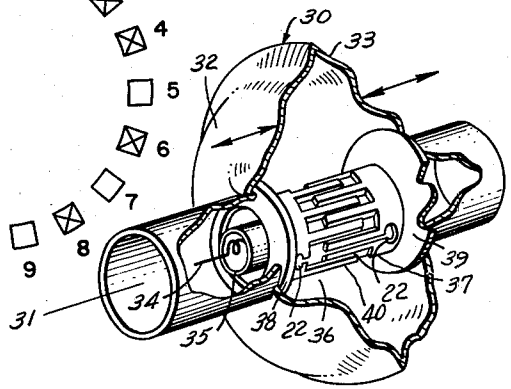


FIG. 2

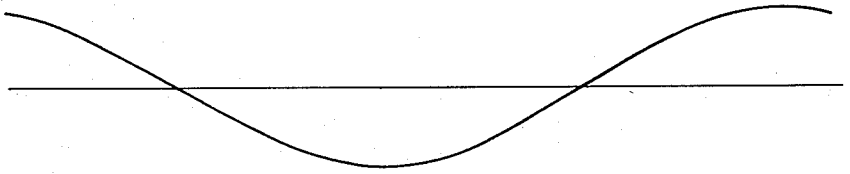


FIG. 3

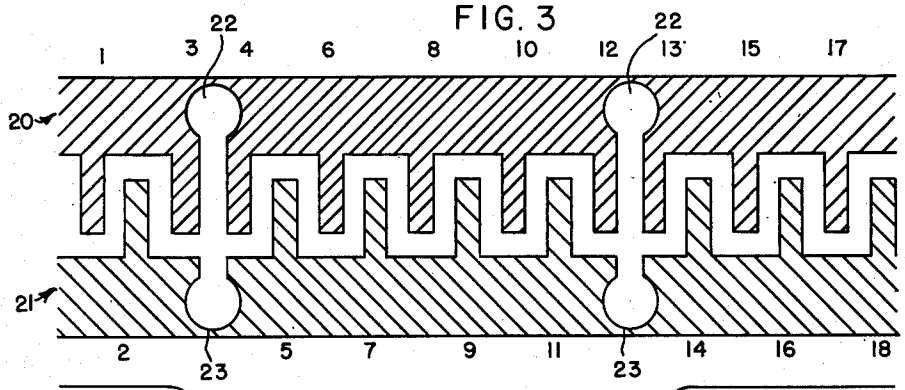


FIG. 4

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TUNABLE MAGNETRON

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Application March 5, 1946, Serial No. 652,187

5 Claims. (Cl. 315—40)

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This invention relates to electrical apparatus and more particularly to improvements in magnetrons.

One type of magnetron radio frequency oscillator is the so-called "squirrel cage" magnetron. The squirrel cage magnetron is generally constructed as a substantially cylindrical cavity resonator within which is placed an axially aligned cathode structure. Concentrically arranged about this cathode and within the cavity resonator is a ring of interleaving anode fingers. Adjacent fingers are connected at one end thereof to one of two opposite annular anode halves which are connected in turn to the opposite end closures of the cavity resonator. A magnetic field is maintained parallel to the magnetron axis in the usual fashion. The term "squirrel cage" is derived from the appearance of the cylindrical ring formed by the two sets of interleaving anode fingers. Such a magnetron is described in the patent application of Franzo H. Crawford and Milton D. Hare for "Tunable Magnetron," Ser. No. 641,839, filing date January 17, 1946, issued as Patent No. 2,505,529 on April 25, 1950.

Such a magnetron with a slightly modified anode structure is described in the patent application of Franzo H. Crawford, Milton D. Hare, and Carl G. Hok for Magnetron, Ser. No. 652,186, filing date March 5, 1946. This modified anode structure improves the efficiency of the magnetron and decreases moding. The modification involves the rearrangement of the anode fingers so that adjacent anode fingers at every point in the ring of interleaving fingers have instantaneously opposite polarities. The rearrangement is applied at two diametrically opposite points in the ring. In one embodiment, the two adjacent anode fingers at each of the two points are connected to the same anode half, the remainder of the fingers being rearranged to be alternately connected to opposite anode halves. In another embodiment, these two pairs of two adjacent fingers are each replaced by a single wide finger having a circumferential dimension substantially that of two ordinary anode fingers plus the spacing between fingers. In a third embodiment, the two pairs of fingers are omitted entirely. These two diametrically opposite irregular finger arrangements are termed the "phase-reversing" fingers.

Laboratory tests indicate that for the desired mode of oscillation, a standing wave of radio frequency potential is set up around the circumference of the ring of interleaving anode fingers. The magnitude and relative phase of the radio frequency voltages in this standing wave may be represented by a single sine wave around the 360° of the circumference. In the modified anode structure described in the aforementioned application of Crawford, Hare, and Hok, the voltage

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nodes of the sine wave occur at the two phase-reversing fingers. Because of the sine wave distribution of the radio frequency potential, the overall efficiency of the magnetron is somewhat decreased. It would be desirable to flatten out the sine wave distribution so as to approach a square wave distribution, and to have a more uniform radio frequency field around the circumference of the ring of interleaving anode fingers.

Accordingly an object of the present invention is to further increase the efficiency of a squirrel cage magnetron having phase-reversing fingers.

Other objects and advantages of the invention will be apparent during the course of the following description.

In essence, the efficiency of the magnetron having phase-reversing anode fingers may be increased by flattening the sine wave distribution of radio frequency potential. This may be done by increasing the length of the radio frequency current path in the vicinity of the phase-reversing anode fingers, at which two points the radio frequency voltage nodes occur. The increase of the electrical path in the vicinity of the voltage nodes serves to increase the radio frequency potential of the anode fingers adjacent to the nodes. The increase of the radio frequency current path may be effected by using a deep slot in each anode half at each of the phase-reversing fingers.

In the accompanying drawing forming a part of this specification,

Fig. 1 is a symbolic representation of the anode finger connections for one embodiment of the present invention;

Fig. 2 is a representation of the magnitude and phase of the standing wave of radio frequency potential around the circumference of the ring of interleaving anode fingers for previous magnetron designs;

Fig. 3 is a development in the plane of the paper of the anode structure of the present invention corresponding to Fig. 1;

Fig. 4 is a representation of the magnitude and phase of the standing wave of radio frequency potential around the circumference of the improved magnetron anode of Fig. 3, and

Fig. 5 is a simplified isometric view, partly broken away, of a squirrel-cage magnetron of the type represented schematically in Figs. 1 and 3.

In Figs. 1 and 3, numerals 1—18 designate individual anode fingers forming a ring of interleaving anode fingers. Numerals 20 and 21 designate upper and lower anode halves. In Fig. 1 the anode fingers having an X-mark indicate anode fingers which are connected to the upper anode half 20, while the blank anode fingers indicate anode fingers which are connected to the lower anode half 21. Anode fingers

3, 4 and anode fingers 12, 13 are termed the phase-reversing fingers.

Numerals 22 and 23 designate holes or slots extending into the upper and lower annular anode sections 20 and 21 respectively, said holes being continuous with the spaces between the phase-reversing anode fingers 3, 4 and 12, 13. In previous magnetron designs all of the slots between the anode fingers are of the same depth. Fig. 2 shows the sine wave distribution of radio frequency potential around the circumference of the ring of anode fingers for such previous magnetron designs. The holes 22 and 23 extend the radio frequency current path in the vicinity of the voltage nodes and result in a more uniform distribution of radio frequency potential as shown in Fig. 4.

In Fig. 5 numeral 30 designates a cavity resonator, partly broken away to reveal the anode structure. Cavity resonator 30 may have any of the customary cavity resonator shapes, and in general will be a figure of revolution circularly symmetrical about an axis 31—31. The cavity resonator 30 has two opposing flexible diaphragm-like walls or end closures 32 and 33.

Axially aligned along axis 31—31 are a filament 34 and cathode 35. A ring of interleaving anode posts or fingers 40 is concentrically arranged about cathode 35 and within cavity resonator 30. Alternate anode fingers 40 are generally connected to end closure 32 by being attached at one end to an annular anode section 36 and end plate 38 fixed to wall 32. The other anode fingers 40 are connected to the end closure 33 by being attached at one end to another annular anode section 37 and end plate 39 fixed to wall 33. At two diametrically opposite points of the ring of interleaving fingers 40, two adjacent fingers are connected to anode section 37. The slot or space between these two fingers extends beyond the spaces between other fingers connected to anode section 37 and this slot terminates in a circular hole 22. A similarly shaped hole 23 in juxtaposition to hole 22 is formed in anode section 36. The magnetron is tuned by flexing walls 32 and 33, as indicated by the arrows, so as to move the anode sections together or apart and thereby vary the capacity between the anode sections.

The radio frequency output of the magnetron may be taken off in the customary manner by any suitable coupling, not shown, to cavity resonator 30.

It is to be understood that various other means may be employed for increasing the radio frequency current path in the vicinity of the voltage nodes.

This type of anode structure requires some attention to the details of anode cooling, inasmuch as the bottom of the holes 22 and 23 may be some distance from external anode cooling coils, not shown. Consequently it is necessary to cool that portion of the anode near the bottom of holes 22 and 23 as well as the remainder of the anode to prevent excessive heating.

It will be apparent to those skilled in the art that many modifications of our invention as described above and shown in the drawing can be made, and therefore the specific embodiment described in this application should be considered merely illustrative of the principles of our invention.

What is claimed is:

1. A magnetron anode including two annular anode sections, each of said anode sections having two substantially diametrically opposite holes opening on one face thereof, said annular anode sections being disposed coaxially with the openings of the holes facing one another and axially aligned, and a ring of interleaving anode fingers mounted circumferentially about the axis of said annular anode sections, adjacent fingers being connected at one end thereof to opposite anode sections, excepting two sets of two adjacent anode fingers, said two sets being substantially diametrically opposite each other, each two adjacent fingers of said sets being connected at one end thereof to the same anode section and the spaces between the two adjacent fingers of said sets being aligned and continuous with the holes of said anode sections.

2. A magnetron anode including two annular anode sections disposed coaxially and opposite one another, and a ring of interleaving anode fingers mounted circumferentially with substantially uniform spacing about the axis of said annular anode sections, adjacent fingers being connected at one end thereof to opposite annular anode sections, each of said anode sections having two substantially diametrically opposite holes opening on one face thereof, with the openings of said holes facing one another and axially aligned.

3. A magnetron anode as defined in claim 2 wherein said holes in each of the anode sections extend in an axial direction beyond the spaces between the anode fingers.

4. A magnetron anode including two annular anode sections disposed coaxially and opposite one another and a ring of interleaving anode fingers mounted circumferentially about the axis of said annular anode sections, adjacent fingers being connected at one end thereof to opposite annular anode sections, one of said anode sections having two substantially diametrically opposite holes opening on one face thereof and extending axially between adjacent anode fingers.

5. A magnetron anode including two annular anode sections, one of said anode sections having two substantially diametrically opposite holes opening on one face thereof, said annular anode sections being disposed coaxially, and a ring of interleaving anode fingers mounted circumferentially about the axis of said annular anode sections, adjacent fingers being connected at one end thereof to opposite anode sections, excepting two sets of two adjacent anode fingers, said two sets being substantially diametrically opposite each other, each two adjacent fingers of said sets being connected at one end thereof to the same anode section, and the spaces between the two adjacent fingers of said sets connected to said one anode section being aligned and continuous with the holes of said one anode section.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,128,237	Dallenbach	Aug. 30, 1938
2,144,222	Hollmann	Jan. 17, 1939
2,147,159	Gutton et al.	Feb. 14, 1939
2,409,222	Morton	Oct. 15, 1946
2,508,280	Ludi	May 16, 1950