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COAXIAL MAGNETRON WITH ROTATABLE TUNING MEANS

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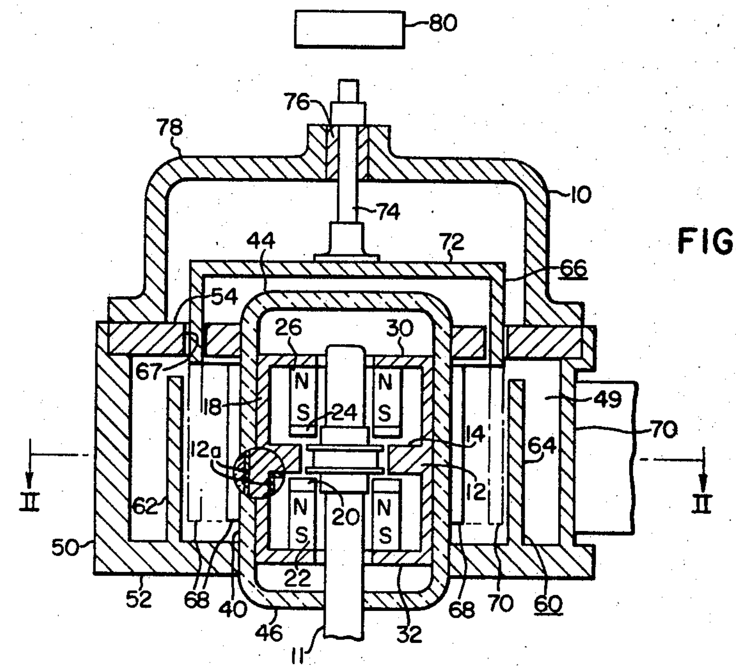

FIG.1.

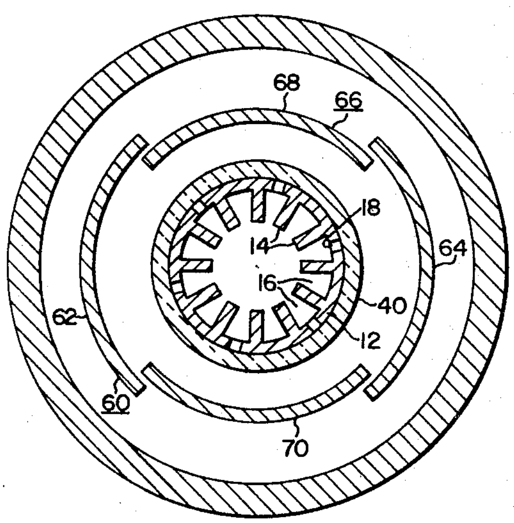

FIG.2.

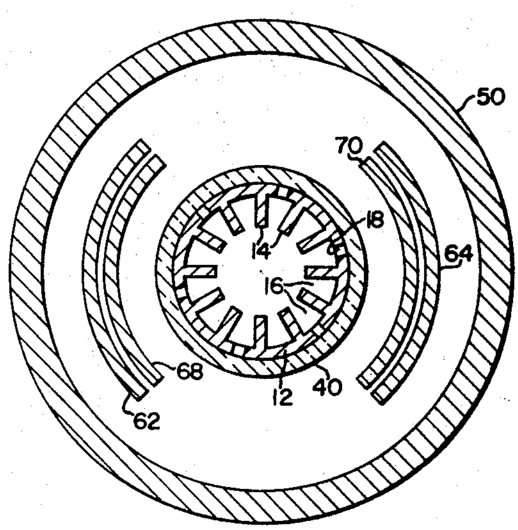

FIG.3.

WITNESSES

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COAXIAL MAGNETRON WITH ROTATABLE TUNING MEANS

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ABSTRACT OF THE DISCLOSURE

A coaxial magnetron is described in which tuning of the magnetron is accomplished by rotation of a tuning member relative to a fixed tuning member within the outer cavity resonator of the magnetron whereby the frequency of the magnetron is modulated due to modifying the electric field within the outer cavity resonator by cooperation between the fixed and movable tuning members.

This invention relates to magnetrons and more particularly to coaxial cavity magnetrons. A coaxial magnetron structure comprises an inner and outer resonant system. The inner resonant system includes a cylindrical anode wall together with a plurality of anode vanes radially extending inwardly therefrom. These vanes define a circumferential array of inner, or anode cavity resonators. An outer cavity resonator is defined between an outer cylindrical wall and the cylindrical anode wall. The two systems are coupled together by a circumferential array of uniformly spaced slots through the cylindrical anode wall which connects the outer resonant system with selected anode cavity resonators. The inner resonant system is designed to oscillate in a pi-mode, while the outer system is designed to oscillate in the TE_{011} mode. The coaxial magnetron is more fully described in U.S. Patent 2,854,603, issued Sept. 30, 1958, to R. J. Collier et al.

The coaxial magnetron configuration overcomes many disadvantages inherent in the prior art type of magnetron. More particularly, the coaxial magnetron arrangement permits the realization of substantially higher frequency stability and efficiency simultaneously under varying input and load conditions, The tuning function of the coaxial magnetron may be provided within the outer cavity resonator in a manner such as described in copending application Ser. No. 298,775, by H. P. Peasley et al., filed July 30, 1963, now U.S. Patent 3,263,118 and assigned to the same assignee as this invention. The tuning is accomplished by a movement of the end cover of the outer cavity resonator. It is normally necessary to tune symmetrically in order to preserve mode stability. In those applications where fast tuning of the coaxial magnetron is necessary, the above copending application has several limitations. In order to reverse the tuning, a considerable amount of mass reversal is required. A long tuner stroke is required and flexing of a mechanical bellows. It is also necessary to provide a high force for acceleration.

It is accordingly an object of this invention to provide an improved coaxial magnetron.

It is another object to provide an improved tuning system for a coaxial magnetron.

Briefly, the present invention provides a coaxial magnetron in which tuning is accomplished by rotary motion of a tuning member within the outer cavity resonator of the coaxial magnetron. Tuning is accomplished by providing two toothed cylindrical members concentrically arranged in the cavity resonator with one set of teeth fixed and the other set capable of being rotated within the cavity resonator to thereby modify the electrical field therein.

Further objects and advantages of the invention will become apparent as the following description proceeds and features of novelty which characterize the invention will be pointed out in particularity in the claims annexed to and forming a part of the specification.

For a better understanding of the invention, reference may be had to the accompanying drawings, in which:

FIGURE 1 is a sectional view of a coaxial cavity magnetron embodying the present invention;

FIG. 2 is a sectional view taken along II—II of FIG. 1 illustrating maximum tuning; and

FIG. 3 is a sectional view taken along II—II of FIG. 1 illustrating minimum tuning.

Referring now to the drawings, the specific embodiment of the invention comprises a coaxial magnetron **10** having a cylindrical cathode **11** surrounded by a cylindrical anode **12**. Extending inwardly from the anode **12** are a plurality of anode vanes **14** which define therebetween a plurality of anode cavity resonators **16**. A plurality of slots **18** extend through the anode **12** along a major portion of its length and the slots **18** are parallel to the vanes **14**. In the specific embodiment shown, the slots **18** communicate with alternate ones of the anode resonators **16**.

Positioned at one end of the anode **12** is a magnetic pole piece **20** which is annular in shape. The cathode **11** extends into an aperture provided in the pole piece **20**. The pole piece **20** may be of any suitable magnetic material such as iron. An annular magnet **22** is provided in contact with the pole piece **20**. The polarity of the magnet **22** is indicated in the drawing with the north pole adjacent the pole piece **20**. Positioned at the opposite end of the anode with respect to the pole piece **20** is an annular pole piece **24** which is again of a suitable magnetic material and in contact with an annular magnet **26** in which the south pole is adjacent the pole piece **24**.

The cylindrical anode **12** is closed off by end plates **30** and **32** which are secured to the magnets **26** and **22** respectively and to the anode **12**. The end caps **30** and **32** as well as the anode **12** must be of a suitable magnetic material or include magnetic material such as iron to provide the return path for the magnetic field from the magnets **22** and **26**. The anode **12** must be provided with electrically conductive material on both the inner and outer surfaces for proper electrical characteristics within the magnetron. Accordingly, the anode **12** may be constructed utilizing a body of a suitable magnetic material such as iron with a suitable electrically conductive coating **12*a*** of a material such as copper provided on the inner and outer surfaces.

Encompassing the cylindrical anode **12** is a ceramic cylindrical envelope member **40** transmissive to the electromagnetic energy generated within the anode cylinder **12**. The cylindrical member **40** may be closed off at the ends by dome members **44** and **46** to provide an envelope suitable for evacuation. Suitable leads may extend through one of the dome-like members **44** or **46** to provide suitable voltages to the electrodes. Alternately, the ceramic cylinder **40** may be terminated in a metal to ceramic seal which may be attached to the end plates **30** and **32**.

An outer cavity resonator **49** surrounds the member **40**. The cavity resonator **49** is defined by a cylindrical outer member **50**, a bottom end plate **52**, an upper end plate **54** and the anode **12**. This cavity resonator **49** is designed to operate in the TE_{011} mode.

The turner mechanism consists of a fixed tuning member **60** comprised of at least two arcuate portions or teeth **62** and **64** extending from the end plate **52** in a vertical direction as illustrated. The member **60** may be of any suitable material such as a dielectric or any other suitable material that will concentrate the electric field. The other portion of the tuning mechanism is the rotary member **66** which is essentially a tubular member extending through an annular opening **67** in the end plate **54**. The rotary tuner **65** also is comprised of at least two arcuate portions or teeth **68** and **70** which extend into the cavity resonator **49** adjacent the fixed tuning portions **62** and **64**. The upper portion of the rotary tuner member **66** includes a top portion **72** to which a shaft **74** is attached. A bearing **76** for the shaft **74** is supported by a cap member **78**. A motor means **80** is provided for rotating the rotary member **66**.

In the operation of the device, the cathode is periodically biased at a negative potential with respect to the rest of the device by means of a suitable source of potential. The electrons are then emitted from the cathode **11** and follow a circular path between the cathode **11** and the anode **12** by the cross field focusing action of the electric field between the cathode and the anode and the magnetic field between the pole pieces **20** and **24**. The electron beam excites an electric field in the anode resonators **16**. The magnetron oscillates in the pi-mode at a characteristic frequency determined by the anode resonators **16**. This energy is then coupled to the outer cavity resonator **49** by means of the coupling slots **18**. The cylindrical member **40** is transmissive to the electromagnetic energy. The electric field produced in the resonator **49** oscillates in a TE_{011} mode at a frequency determined by the position of the tuning members **60** and **66**. The output resonator **49** is connected by suitable transformer means **70** in a well known manner to an output waveguide section to which the output energy of the magnetron is transmitted to external circuitry.

As shown in FIG. 2, the two tuning members **60** and **66** are concentrically arranged within the cavity **49**. The tuner member **60** is fixed to the tube body and the other tuner **66** is free to rotate and is attached to the rotating shaft **74**. The motor **80** drives the rotary tuner **66** so as to rotate the member **66** to any desired degree. With the teeth not aligned as illustrated in FIG. 2, the electric field in the cavity resonator **49** is warped and is concentrated and hence maximum tuning is obtained. This is the lowest frequency. In FIG. 3 the teeth are in alignment and minimum warping of the electric field is obtained. A higher frequency is obtained in this position.

In the specific embodiment shown, the tuning teeth are positioned vertically in the cavity. It is also obvious that two horizontal tuning members could be provided within the cavity with one of the members fixed and the other capable of rotating about its axis. In this modification tuning would be accomplished by warping the electric field in a vertical direction rather than in a radial direction as illustrated in FIGS. 2 and 3. It is found that with full warping as illustrated in FIG. 2 that the lowest frequency of the magnetron would be obtained while a higher frequency would be obtained with regard to the minimum warping illustrated in FIG. 3.

While there have been shown and described what are presently considered to be the preferred embodiments of the invention, modifications thereto will readily occur to those skilled in the art. For example, while a design illustrated provides for the tuning mechanism to be provided external of the evacuated envelope, it is obvious that the tuning mechanism could be provided within the vacuum envelope.

It is not desired, therefore, that the invention be limited to the specific arrangement shown and described and it is intended to cover in the appended claims all such modi-

fications as fall within the true spirit and scope of the invention.

I claim as my invention:

1. A coaxial magnetron comprising a cylindrical cathode, a cylindrical anode surrounding said cathode and coaxial therewith, an array of anode vanes extending radially inward from said anode wall and defining a plurality of anode resonators, an outer coaxial cavity resonator surrounding said anode wall, coupling slots provided in said anode for coupling energy from said anode resonators to said outer coaxial cavity resonator, tuning means provided within said outer coaxial cavity resonator, said tuning means comprising a fixed tuning member having a plurality of portions projecting within said coaxial cavity resonator and a movable tuning member within said outer cavity resonator and operatively associated with said fixed tuning member, said movable tuning member having a plurality of portions capable of rotation within said cavity resonator to modify in cooperation with the fixed tuning member the electric field within said coaxial cavity resonator and thereby vary the frequency of said coaxial magnetron.

2. A coaxial magnetron comprising a cylindrical cathode, a cylindrical anode surrounding said cathode and coaxial therewith, an array of anode vanes extending radially inward from said anode wall and defining a plurality of anode resonators, an outer coaxial cavity resonator surrounding said anode wall, coupling slots provided in said anode for coupling energy from said anode resonators to said outer coaxial cavity resonator, tuning means provided within said outer coaxial cavity resonator, said tuning means comprising a fixed tuning member secured within said cavity having a plurality of projections and a movable tuning member within said outer cavity resonator, said movable member having a plurality of projections and capable of rotation within said cavity resonator to effect warping of the electric field within said cavity resonator to thereby vary the frequency of said coaxial magnetron.

3. A coaxial magnetron of claim **2** in which said projections are of an electric field concentrating material.

4. A coaxial magnetron comprising a cylindrical cathode, a cylindrical anode surrounding said cathode and coaxial therewith, an array of anode vanes extending radially inward from said anode wall and defining a plurality of anode resonators, an outer coaxial cavity resonator surrounding said anode wall, coupling slots provided in said anode for coupling energy from said anode resonators to said outer coaxial cavity resonator, tuning means provided within said outer coaxial cavity resonator, said tuning means comprising a first tuning member and a second tuning member, and means for providing relative rotational motion of said first and second tuning members to modify the electric field within said cavity resonator and thereby vary the frequency of said coaxial magnetron.

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