Jan. 6, 1953 E. EVERHART ET AL **2,624,862**

TUNABLE STRAPPED MAGNETRON

Filed May 9, 1945

FIG. 1

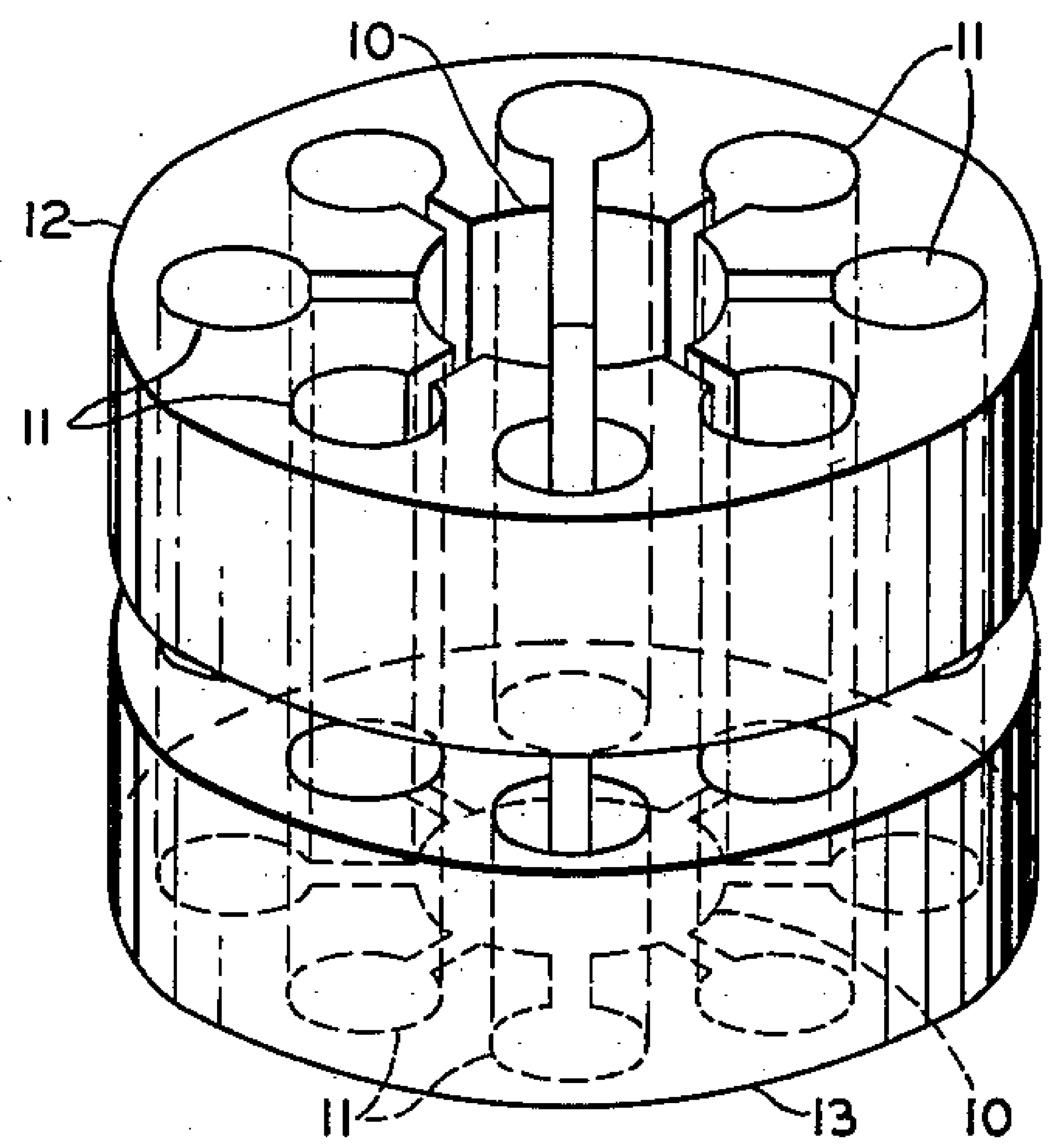


FIG. 2

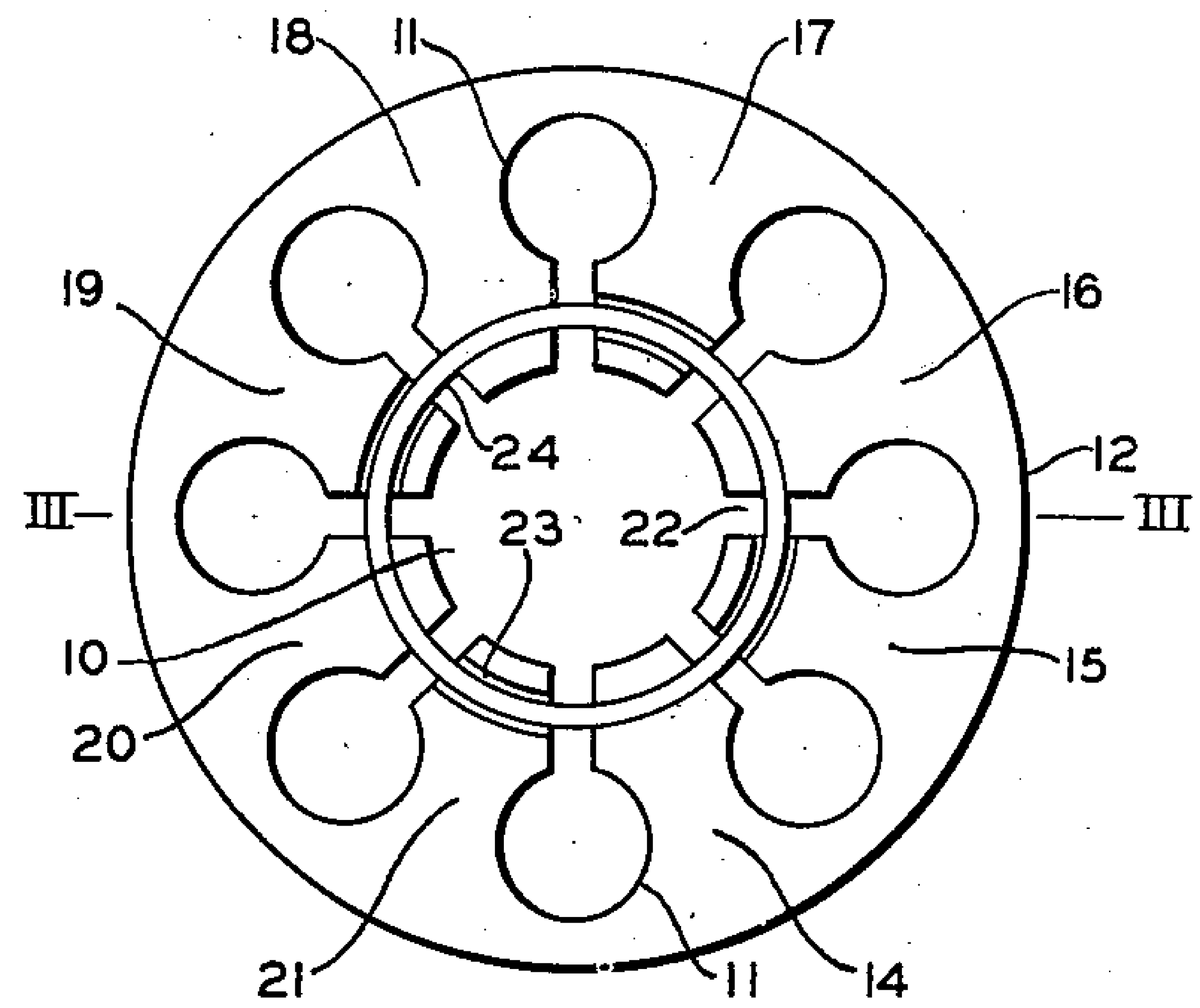


FIG. 2A

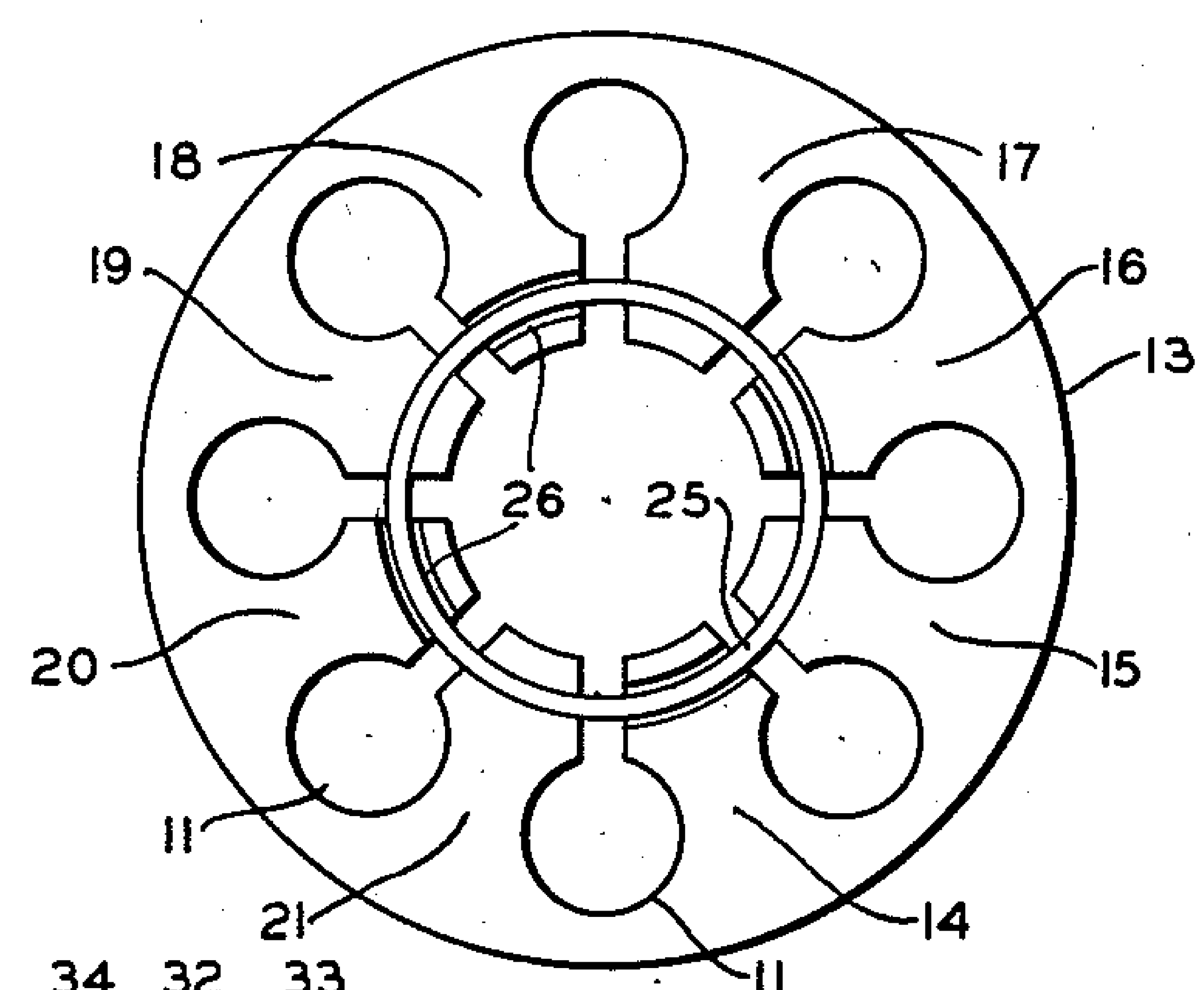
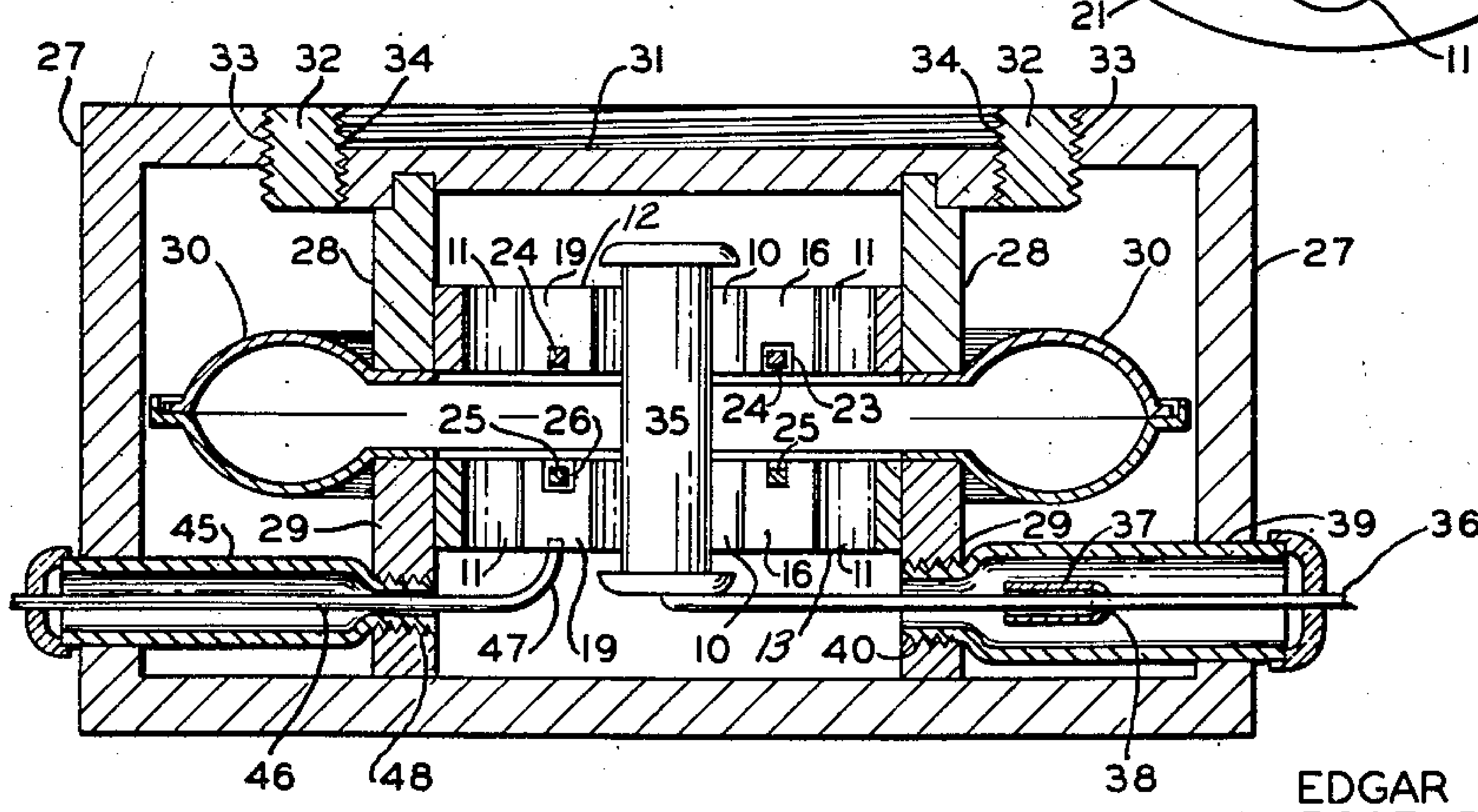


FIG. 3



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TUNABLE STRAPPED MAGNETRON

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21 Claims. (Cl. 315—40)

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This invention relates to a magnetron oscillator and more particularly to an adaptable method of and means for tuning the same.

At present, the anode structure of the magnetron oscillator assumes a variety of forms, the most common being a cylindrical conducting mass containing a centrally located longitudinal hole into which a generally cylindrical electron emitting cathode is adapted to extend. There is also provided in the anode block an even plurality of equi-angularly disposed, radially extending longitudinal slots so proportioned as to constitute small cavity resonators. In lieu of mere radially extending slots, a combination of slots, each terminated by a longitudinal hole, may be employed. In either instance there is formed therebetween a similar number of anode segments or electrodes which cooperate with the cavity resonators to produce an alternating current electric field in the region surrounding the cathode which is of a nature necessary for the production of ultra high frequency energy of the type attainable from magnetron oscillators.

Magnetron oscillators utilizing this sort of anode construction have a tendency to shift from one operating mode to another, an effect detrimental to efficient operation. It has been found, however, that this effect of multiple mode operation can be remedied by electrically securing together all anode segments of the same electrical phase. This feature is commonly referred to as "anode strapping."

It is an object of the present invention to construct a tunable magnetron oscillator.

It is another object of this invention to provide a method of and a means for tuning a strapped magnetron oscillator.

It is another object of this invention to construct a novel type anode electrode for use in magnetron oscillators.

Other objects and features of the present invention will become apparent upon a careful consideration of the following detailed description when taken together with the accompanying drawings, the figures of which represent typical embodiments of the invention and are not to be construed as a definiton of the limits of the invention. Reference for the latter purpose is had to the appended claims.

Fig. 1 is a perspective view of a magnetron anode structure, constructed in accordance with the teaching of the invention;

Fig. 2 is a face view of one-half of the anode structure shown in Fig. 1;

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Fig. 2*a* is a face view of the second half of the anode structure shown in Fig. 1;

Fig. 3 is a half-sectional view of a magnetron oscillator showing one means for tuning the same.

Reference is now had to Fig. 1 wherein is shown a perspective view of an anode structure particularly adaptable to magnetron oscillators and constructed in accordance with the teachings of the present invention. The anode consists of a cylindrical conducting mass made preferably of copper either laminated or solid having a centrally located longitudinal hole **10** cut therein and into which the cathode is adapted to extend. Also provided within the anode is a plurality of equiangularly disposed slot-hole combinations **11** which are so proportioned in dimensions as to constitute individual cavity resonators adapted to oscillate at a desired frequency. The resonators **11** are symmetrically arranged about the center of the anode and define therebetween a similar number of anode segments or electrodes, designated as in Figs. 2 and 2*a* by numerals **14** to **21** inclusive.

Mathematical analysis has shown that the inductance and capacity of the magnetron is in part a function of the number and dimensions of such hole and slot combinations, which in turn determines the operating wave length of the magnetron oscillator. However, the normal operating wave length so determined by the dimensions of the cavity resonators can be varied in either direction by cutting the anode in a plane perpendicular to its axis, as herein shown, to provide two coaxially adjacent sections **12** and **13** which when moved axially relative to one another effect a tuning of the magnetron frequency. This tuning effect is greatly increased by strapping the cophasal anode segments in each section as described in detail below, and incidentally when the segments are strapped the tuning effect from relative movement of the sections is just opposite to the effect when unstrapped.

A number of theories have been advanced on the operation of a magnetron oscillator containing an anode having a plurality of radially extending cavity resonators. One theory, for example, is that a magnetron containing an anode of this variety comprises a plurality of mutually resonant circuits formed by the angularly disposed resonators. The chamber or hole portion of the resonator represents the inductance whereas the opposing edges of the slot, defined by adjacent anode segments, forms the capacitance, the two constituting a parallel resonant circuit whose frequency is a function of the dimensions of the slot and hole. Hence, at any particular instant and in accordance with the theory of cavity resonators, adjacent anode segments will be in electrical phase opposition.

Reference is now had to Figs. 2 and 2*a* wherein there is shown a face view of each of the adjacent ends of the two anode sections 12 and 13 shown in Fig. 1. Here a scheme for strapping together the anode segments or electrodes is displayed which may be referred to as a recessed ring system employing annular grooves 23 and 26 cut respectively in the adjacent flat faces of the anode sections adjacent the wall of the centrally located hole 10. To permit only alternate or in phase anode segments to be conductively connected together, the annular grooves 23 and 26 are cut in the respective anode sections with alternate dimensions of width and depth so arranged that only alternate segments will be held in electrical contact by the respective conducting rings 24 and 25. This precaution is taken to prevent shorting adjacent anode segments and hence the electric field produced thereby, since they are in electrical phase opposition. To achieve this end the continuous conducting rings 24 and 25 respectively, have dimensions of such value as to electrically contact in either anode section 12 or 13 only those segments of one phase. For example, in the upper anode section 12, only even numbered segments are electrically secured, 14, 16, 18, and 20, whereas, in the lower section 13 only odd numbered segments 15, 17, 19, and 21 are connected together. Hence, strap 24 associated with the upper section 12 will, at any particular instant, carry charges of one polarity, while strap 25 of the lower section will at the same instance be carrying charges of opposite polarity thereby constituting, in effect, the plates of a condenser. Because of this polarity difference the straps are indented very slightly below the faces of the sections so that when the sections are brought close together or abutted there will remain a gap between the rings.

It is here to be noted that the particular scheme of strapping to be employed does not necessarily have to conform to the arrangement shown in Figs. 2 and 2*a* so long as the principle of electrically securing only alternate or in phase segments is adhered to.

Turning now to Fig. 3 there is shown a half-sectional view of a typical magnetron oscillator embodying the principles of the present invention. Centrally located within the housing structure 27 is an anode comprising a pair of coaxially adjacent cylindrical sections like 12 and 13, each having a centrally located hole 10 and a plurality of cavity resonators 11 which define therebetween a like number of anode segments, each identical in structure to the diametrically opposite pair 16 and 19 shown here. Also shown is a half-sectional view of the anode strapping arrangement shown in Figs. 2 and 2*a*, comprising rings 24 and 25 positioned in the respective annular grooves 23 and 26 which are cut with alternately varying dimensions in the adjacent end faces of the anode sections 12 and 13. The anode sections 12 and 13 are then brazed to the respective cylindrical support members 28 and 29, the former being conductively secured to a circular disc member 31 which is threaded at the outer periphery thereof and adapted to engage the internal threads of a ring member 32. Member 32 contains internal threads 34 and external threads 33, preferably of a different pitch, communicating with similar threads cut in the disc 31 and the shell member 27, respectively, so as to produce, whenever member 32 is rotated, an axial movement of the disc 31 with a resultant relative axial movement between the anode sections 12 and 13. Between the anode sections an annular Sylphon bellows 30 may be brazed to the respective support members 28 and 29 so as to enable relative axial movement of the anode sections 12 and 13 while maintaining a seal. As previously mentioned, strapping rings 24 and 25 carry opposite charges at any one instant so that they virtually constitute the plates of a condenser. Hence rotation of ring member 32 causes an axial variation in the spacing between strapping rings 24 and 25 with a corresponding change in capacity therebetween. This change in capacity then results in a change in the resonant frequency of the magnetron.

Concentrically arranged within the centrally located anode opening 10 is an indirectly heated cathode 35 which may contain a coating of electron emission substance, such as barium oxide, on the external surface thereof and a conventional filamentary heater (not shown) enclosed therein and having one end thereof tied directly to the cathode shell. To energize the filament another lead, similar to the cathode support lead 36 shown, and entering through another suitable pipe may be connected to the free end of the filament. Line 36, for example, may be brought out of the tube to a given source of potential through a suitable metal housing sleeve 39 which may be secured to the cylindrical anode support member 29 by way of a screw thread engagement 40. To center and support the cathode lead 36 within the metal housing sleeve and to maintain vacuum, a glass seal may be provided. To inhibit radio frequency energy from leaking out of the magnetron along the cathode lead 36, a radio frequency choke may be provided thereon comprising cup-shaped member 37 shorted to the lead 36 at point 38 thereby constituting a quarter-wave line section presenting a high reflected impedance at the mouth of the cup 37.

As essential to the operation of magnetron oscillators, an electric field must be applied between the cathode and the anode as well as an axial constant magnetic field.

In order that an external circuit may utilize the energy developed within the magnetron, a portion thereof must be abstracted therefrom. This operation may be achieved by introducing a suitable coupling loop 47. Loop 47 is then connected to the external circuit by way of lead 46 brought out of the magnetron through a suitable metal outer conductor 45 which communicates with the anode support cylinder 29 by way of the screw thread engagement 48. The output lead 46 is then centered within the sleeve 45 and a seal maintained by a suitable glass seal.

Although only a certain and specific embodiment of the present invention has been shown, it must be understood that many modifications thereof are possible. Therefore this invention is not to be limited except insofar as necessitated by the spirit of the appended claims.

What is claimed is:

1. An anode structure for a tunable magnetron oscillator, comprising a pair of coaxially adjacent cylindrical conducting sections each having a centrally located longitudinal hole and a plurality of radially extending cavity resonators cut therein, and means operatively securing said sections together at the outer peripheries there-

of for permitting axial movement of one of said sections relative to the other of said sections while providing an airtight seal.

2. An anode structure for a tunable magnetron oscillator, comprising a pair of coaxially adjacent cylindrical conducting sections each having a centrally located longitudinal hole and a plurality of radially extending cavity resonators cut therein, an annular metallic bellows operatively securing said sections together at the outer peripheries thereof for permitting axial movement of one of said sections relative to the other of said sections while providing an airtight seal, and means connected to said sections for axially moving said one section relative to said other section.

3. An anode structure for a tunable magnetron oscillator, comprising a pair of coaxially adjacent cylindrical conducting sections each having cut therein a centrally located longitudinal hole and a plurality of radially extending cavity resonators thereby defining a similar number of electrode segments therebetween, a first conducting means electrically securing together in one anode section electrode segments of one phase, and a second conducting means electrically securing together in the other anode section electrode segments having a phase opposite to those electrically secured in said one anode section, each of said conducting means being placed respectively on the adjacent faces of said cylindrical sections.

4. An anode structure for a tunable magnetron oscillator, comprising a pair of coaxially adjacent cylindrical conducting sections each having a centrally located longitudinal hole and a plurality of radially extending cavity resonators cut therein thereby defining a like number of electrode segments therebetween, a first conducting means electrically securing together in one anode section on the face thereof adjacent the face of the other anode section the electrode segments of one phase, a second conducting means electrically securing together in the other anode section and on the face adjacent to the face of said one section the electrode segments having a phase opposite to those electrically secured in said one section and a means operatively securing said anode sections together at the outer periphery thereof.

5. An anode structure for a tunable magnetron oscillator comprising a pair of coaxially adjacent cylindrical conducting sections each having a centrally located longitudinal hole and a plurality of radially extending cavity resonators cut therein thereby defining a like number of electrode segments therebetween, a first conducting means electrically securing together in one anode section and on the face adjacent to the face of said other section the electrode segments of one phase, a second conducting means electrically securing together in the other anode section and on the face adjacent to the face of said one section the anode segments having a phase opposite to those electrically secured in the said one section, and a means conductively securing said anode sections together at the outer periphery thereof, and means connected to said anode sections for axially moving said anode sections relative to one another, whereby the output frequency may be varied in response to such movement.

6. An anode structure for a tunable magnetron oscillator, comprising a pair of coaxially adjacent cylindrical conducting sections each having a centrally located longitudinal hole and a plurality of radially extending cavity resonators cut therein, means operatively securing said sections together, and means connected to said anode sections for axially moving said anode sections relative to one and another.

7. An anode structure for a tunable magnetron oscillator, comprising a pair of coaxially adjacent cylindrical conducting sections each having a centrally located longitudinal hole and a plurality of radially extending cavity resonators cut therein thereby defining a like number of electrode segments therebetween, a first conducting means recessed in the face adjacent to the face of the other section, electrically securing together in the one anode section the electrode segments of one phase, a second conducting means recessed in the face adjacent to the face of said one section, electrically securing together in the other anode the anode segments having a phase opposite to those electrically secured in the said one section, a metallic annular bellows member conductively securing said anode sections together at the outer periphery thereof, and means connected to said anode sections for axially moving said sections relative to one and another, whereby the output frequency may be varied in response to such movement.

8. An anode structure for a tunable magnetron oscillator comprising a pair of coaxially adjacent cylindrical conducting sections, each of said sections being formed with a centrally located longitudinal hole, the wall of said hole being recessed to form an even plurality of cavity resonators, said wall defining between said resonators an even plurality of alternately phased anode segments, each of said segments being formed with a groove on the face thereof adjacent to the other of said sections and also adjacent to the wall of said longitudinal hole, said grooves being symmetrically disposed about said opening and being adapted to receive a conducting ring, alternate grooves of each section being larger in both depth and width than the remaining grooves of the same section, a conducting ring for each of said sections disposed in said grooves and making electrical connection with those anode segments formed with smaller grooves, thereby electrically connecting in a section only those of said segments adapted to have the same polarity at any instant, said anode sections being disposed relative to one another with the smaller grooves of one section positioned opposite the larger grooves of the other section, an annular conducting bellows operatively connecting said sections at their outer peripheries for permitting relative axial mechanical movement of said sections while providing an airtight seal, and means connected to said sections for producing said relative axial movement, whereby the frequency of the oscillation of the output energy from the magnetron may be varied in response to the adjustment of said last-mentioned means.

9. A magnetron structure comprising a pair of coaxially adjacent strapped anode sections, and means connected to said sections for axially moving one of said sections relative to the other.

10. An anode structure for a tunable magnetron comprising, a pair of coaxially adjacent anode sections, each anode section being formed with at least one resonator, and means connected to said sections for axially moving one of said sections relative to the other.

11. A magnetron structure comprising, a plurality of mutually displaced conducting sections,

each formed with a series of electrode segments, said electrode segments defining a plurality of resonators, and means conductively connecting together only alternate electrode segments of each of said conducting sections.

12. A magnetron structure as in claim 11 wherein each of said conducting sections is movable with respect to the other of said conducting sections.

13. A magnetron structure comprising, a plurality of mutually displaced anode sections, each formed with a plurality of circumferentially arranged anode segments, said anode segments defining a plurality of cavity resonators, and a conductive strap for each of said anode sections connecting together only alternate anode segments thereof.

14. A magnetron structure as in claim 13 wherein each of said anode sections is movable with respect to the other of said anode sections.

15. An anode structure comprising, first and second coaxially adjacent cylindrical conducting sections, each being formed with a central, longitudinal hole and a plurality of radially extending resonators defining a similar number of electrode segments, and first and second means conductively securing together only alternate electrode segments of said first and second conductive sections, respectively.

16. A magnetron structure as defined in claim 15 wherein said first and second means are disposed on the adjacent faces of said cylindrical sections.

17. A magnetron structure as defined in claim 15 and means connected to said section and providing for relative movement between said first and second sections.

18. An anode structure for a tunable magnetron comprising a pair of anode sections each being formed with a plurality of cavity resonators therein, and means connected to said sections for moving one of said sections relative to the other of said sections for controlling the frequency of oscillation of said magnetron.

19. An anode structure for a tunable magnetron comprising a pair of similar substantially abutting strapped anode sections coaxially disposed with the straps on mutually directed ends of said sections, and means connected to said sections for adjusting the spacing between said mutually directed ends.

20. An anode structure for a tunable magnetron comprising a pair of coaxially adjacent anode sections, each being formed to enclose a like plurality of cavity resonators, conducting means secured to the mutually directed ends of said sections and coupled to the respective resonators of said sections to provide oscillations of opposing phase at said adjacent ends, and means connected to said sections for adjusting the spacing between said mutually directed ends.

21. An anode structure for a tunable magnetron comprising a pair of cylindrical, coaxially adjacent strapped anode sections disposed with the straps on adjacent faces of said sections, and means connected to said sections for controlling the spacing between said adjacent faces.

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