Oct. 26, 1948. J. W. TILEY 2,452,272

MAGNETRON

Filed Oct. 23, 1944

FIG. 1

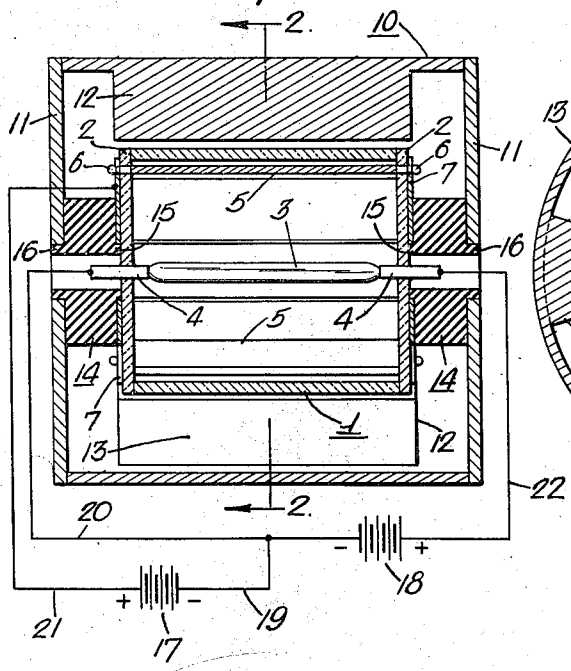


FIG. 2.

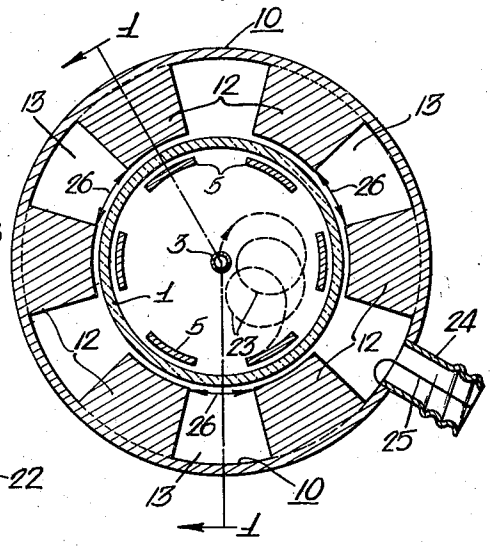


FIG. 3.

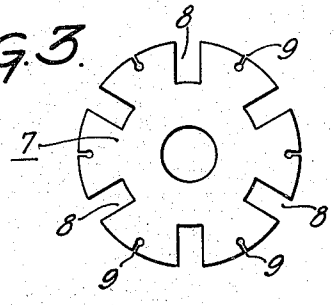


FIG. 4.

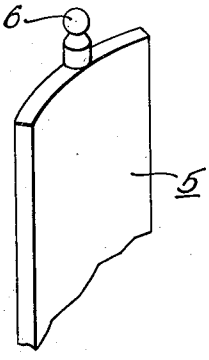


FIG. 5.

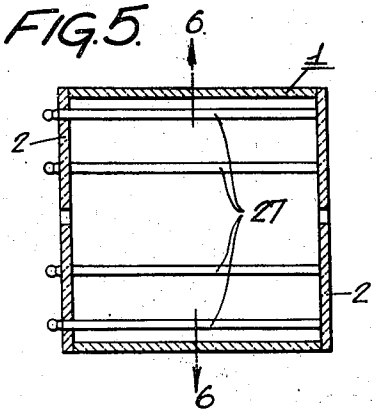
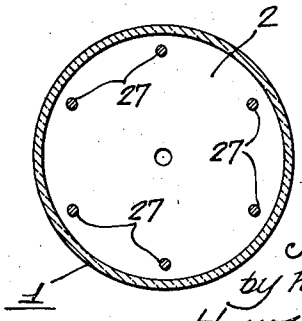


FIG. 6.



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UNITED STATES PATENT OFFICE

2,452,272

MAGNETRON

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7 Claims. (Cl. 250—27.5)

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This invention relates to magnetron oscillators and more particularly to a novel magnetron oscillator adapted for use at ultra-high frequencies.

Prior magnetrons adapted for use at ultra-high frequencies have had inherent limitations as to operating frequency, due to the fact that their frequency-determining elements, such as resonant lines, resonant cavities, etc., have been inaccessible for adjustment or incapable thereof, or their capabilities in this respect have been extremely limited. Such devices have therefore been limited to a particular frequency or to a small range of frequencies. It is desirable in many instances to operate a magnetron over a substantial range of frequencies but this has been impossible with such prior devices.

The principal object of the present invention is to provide a novel magnetron oscillator which is capable of operation over a substantial range of frequencies and which thus overcomes the above-mentioned inherent limitations of prior devices of this character.

Another object of the invention is to provide a novel magnetron structure in which the frequency-determining elements are easily accessible and may be varied or changed to effect operation at different frequencies.

These and other objects are realized, according to the invention, by arranging the frequency-determining elements externally of the electron tube structure. More specifically, there is provided a magnetron comprising an inner electron tube structure and an outer resonant cavity structure surrounding the tube structure. In this way, the cavity structure is made accessible for tuning, and it is also replaceable by another cavity structure having different frequency characteristics. Furthermore, this arrangement makes possible the use of resonant lines externally of the electron tube structure.

The invention may be clearly understood by reference to the accompanying drawing, in which:

Figs. 1 and 2 are longitudinal and transverse sectional views, respectively, of a magnetron embodying the invention, such views being taken along the lines 1—1 and 2—2;

Fig. 3 is a face view of an anode connector element employed in the device;

Fig. 4 is a fragmentary perspective view of one of the anode segments;

Fig. 5 is a longitudinal sectional view of a modified form of the electron tube structure; and

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Fig. 6 is a transverse sectional view taken along line 6—6 of Fig. 5.

Referring to Figs. 1 and 2, there is illustrated a preferred form of the invention in which there is provided an inner electron tube structure having a dielectric envelope composed of a cylindrical shell 1 and end caps or plates 2. These elements may be formed of any suitable dielectric material such as fused quartz. The said envelope forms a highly evacuated chamber within which there is disposed an axial filamentary cathode 3 extending along the longitudinal axis of the tube envelope and supported by metallic pins 4 which are centered and sealed in the end caps 2. The electron tube structure also comprises a segmental anode consisting of a plurality of segments 5 disposed about the cathode 3 so as to receive electrons therefrom. As illustrated, the anode segments 5 are preferably arcuate in cross section and they extend longitudinally of the tube envelope and are sealed in the dielectric end caps 2. Thus, there is provided an electron tube structure comprising diode elements arranged as illustrated and described.

The anode segments 5 are preferably provided with projecting pins 6 of the form clearly shown in Fig. 4, the said pins being located outside the tube envelope at the opposite ends thereof, as shown in Fig. 1. Metallic discs 7, see Fig. 3, serve to interconnect the anode segments 5, and each of these discs is provided with slots or openings of the form shown at 9 in Fig. 3 to receive the pins 6. It will be realized, of course, that the scales employed in the illustrations of Figs. 3 and 4 differ widely, and that the pins 6 and apertures 9 are actually of such dimensions that the pins may be forced into the apertures so as to be retained thereby. The type of connection employed in this instance will be recognized as being of the type commonly known as a "loktal" connector which is employed in the electron tube art. In addition to serving as connectors for the anode segments, the discs 7 are provided with recesses 8 which are equally spaced about each disc, as shown in Fig. 3, and which form quarter-wave lines in the said discs. It is not broadly new to thus provide a resonant line in an element of a magnetron tube, as is well known by those skilled in the art. It is to be noted, however, that the number of quarter-wave lines provided in each of the discs 7 corresponds to the number of anode segments 5. Furthermore, when the discs 7 are attached to the electron tube structure, the quarter-wave lines 8 are aligned with the radial spaces between the anode segments.

These quarter-wave lines serve conjunctively with the anode segments as a plate tank circuit which functions cooperatively with the resonant cavity structure now to be described.

In further accordance with the invention, there is provided an outer cavity resonator comprising a cylindrical shell 10 and end plates 11, which structure surrounds the inner electron tube structure and is readily removable therefrom, as described hereinafter. The shell 10 is formed so as to have inwardly extending segments 12 defining resonant cavities 13 which correspond in number to the anode segments and their associated quarter-wave lines. The cavities 13 are disposed in relation to the anode segments as shown in Fig. 2. The said cavities are designed so as to be resonant at the desired operating frequency. To permit removability of the electron tube and cavity structures from one another, the end plates 11 are preferably secured to the shell 10 by means of removable fastening means, such as screws not shown. Interposed between the ends of the electron tube structure and the cavity end plates 11 are insulating bushings 14, each of which has an inner shoulder 15 to seat the associated disc 7 and an outer shoulder 16 to seat the associated end plate 11.

Each of said bushings may be securely fastened to its respective disc 7, before the positioning of said disc, by means of counter-sunk screws not shown which, after passing through the disc, penetrate into the bushing. The bushings should be made of low-loss material, such as fused quartz, ceramic, or the like. The bushings may also be secured to the end plates 11 by means of screws, not shown, extending through the said end plates. By means of this arrangement, the electron tube structure is supported within the cavity resonator and at the same time the two structures are readily removable from one another simply by removing the fastening screws above mentioned.

Suitable operating potentials may be applied to the tube elements by means of the voltage supply sources represented at 17 and 18. The source 17 applies the necessary potential between the cathode 3 and the anode comprising segments 5. To this end, the negative side of source 17 is connected to the cathode by means of conductors 19 and 20, the latter extending through the central opening in one of the insulating bushings 14. The positive side of source 17 is connected to one of the discs 7 by means of a lead 21, which may extend through one of the end plates 11, as shown in Fig. 1. Source 18 supplies the necessary current to the filamentary cathode and is connected to the supporting pins therefor by means of leads 20 and 22.

In addition to the structure shown, it is necessary to provide a suitable means for creating a magnetic field whose lines of force extend substantially in the direction of the axial cathode, or at a slight angle thereto. For simplicity of illustration, and since the present invention is not concerned with the specific means for producing the required magnetic field, it has been deemed unnecessary to illustrate or describe such means. It suffices to state that the required magnetic field may be produced by the utilization of any conventional means, for example, an electromagnet, employed in conjunction with a magnetron, as well known to those skilled in the art.

While the principles of operation of a magnetron oscillator are well known, it is deemed

desirable to describe briefly the operation of the device provided by this invention, as shown in Figs. 1 and 2. Assuming that the source 17 supplies a predetermined anode-cathode potential for a desired frequency, and assuming also the presence of a magnetic field, as above mentioned, the operation of the device may be explained by reference to Fig. 2 in which there is represented by the broken line 23 the path of an electron emitted from the cathode and received by one of the anode segments. The electron path is generally of helical form and it forms heart-shaped loops which are determined by the magnetic field strength, the anode-cathode potential, and the size of the evacuated chamber formed by the tube envelope. The time which is required for an electron to traverse the path illustrated determines the frequency of the energy which is given up by the electron to the cavities 13. Such energy is transferred to the cavities 13 by the capacitive coupling between the anode segments 5 and their associated cavity segments 12. The cavities 13 are designed to resonate at the desired frequency which is also the resonant frequency of the plate tank circuit above mentioned. Hence, there is a maximum energy transfer from the electron tube to the resonant cavities. Such energy may be derived from the device in any suitable manner. For example, there is shown in Fig. 2, a coaxial cable 24 coupled to one of the cavities 13 by means of a pick-up loop 25.

For the purpose of securing tighter coupling of the generated energy between the electron tube 1 and the resonant cavities 13, "strapping" not shown, but which is well understood by those skilled in the art, may be provided on the discs 7, that is, a set of anodes may be joined together by strapping the alternate segments between the quarter-wave lines 8, and the remaining anodes may be joined by the same procedure on the other disc. An alternate method for producing tighter coupling may be provided by strapping the alternate cavity segments 12.

In the interest of optimum power, the end caps 11 should be positioned at a distance from the ends of the cavities 13 equal to the cavity width 26, as indicated in Fig. 2. In addition, the metallic elements, comprising the anode segments 5, the disc 7 and the cavity structure, should be constructed of low resistance material such as copper. The dielectric and insulating elements of the device may be formed of known materials, such as polystyrene or fused quartz.

By means of the structure provided by the invention, it is possible to vary the operating frequency through a substantial range. The disposition of the resonant cavities 13 makes possible the use of known tuning devices not shown for variation of the operating frequency through a limited range. For example, the resonant frequency of the cavities 13 may be varied by means of variable capacitors on the inside of the end caps 11, or by means of screw plugs or variable vanes, which may be adjusted from outside the cavity structure. Such tuning may be effected without changing the discs 7 because the Q of each resonant cavity 13 is predominant over the Q of its associated tank circuit 8.

If it is desired to effect a large variation in the operating frequency, this may be done by removing the cavity resonator and the discs 7 and by replacing these elements with similar elements having the desired resonant frequency. The structure of the device, as above described, is such

as to permit replacement of the frequency-determining elements, which is an important feature of the invention.

In Figs. 5 and 6 there is illustrated a modified form of the electron tube structure in which the anode elements comprise wires or rods **27** instead of arcuately shaped segments. Aside from this modification, the tube structure may be the same as previously described. In this instance, the anode elements may be connected to their associated cavity segments directly by means of connecting straps. The direct connection will obviate the need for the discs **7**. The omission of these discs is permissible because the impedance across the cavity openings **26**, Fig. 2 at cavity resonance is very high, and the anode elements are isolated from one another at the resonant frequency of the cavities. When employing direct connection of the anode elements to their associated cavity segments, the positive side of the anode supply source may be connected to the cavity resonator.

It will be noted from the drawing that an even number of cavities, quarter-wave lines, and anode elements are employed. This is preferred in the interest of better design and symmetry of the structure.

Although the invention has been illustrated and described with reference to the specific embodiments shown, it is not limited thereto but is capable of various other embodiments and modifications within the scope of the appended claims.

I claim:

1. A magnetron oscillator, comprising an inner electron tube structure comprising an axial cathode element, a segmental anode surrounding said cathode element and an evacuated envelope enclosing said cathode element and said segmental anode, means connected to the anode segments forming a tank circuit for each anode segment, and an outer cavity resonator surrounding said tube structure and coaxial therewith, said resonator having a plurality of resonant cavities corresponding in number to the number of anode segments and circularly located about the anode segments to receive energy therefrom.

2. A magnetron oscillator, comprising an inner electron tube structure comprising an axial cathode element, a segmental anode surrounding said cathode element and an evacuated envelope enclosing said cathode element and said segmental anode, a pair of discs connected to the opposite ends of the anode segments and having recesses forming quarter-wave lines, and an outer cavity resonator surrounding said tube structure and having a plurality of resonant cavities corresponding in number to the number of anode segments and mounted about the anode segments to receive energy therefrom.

3. A magnetron oscillator, comprising an inner electron tube structure of cylindrical form having a cathode and a segmental anode extending longitudinally thereof, means connected to the anode segments forming a tank circuit for each anode segment, and an outer cavity resonator of cylindrical form surrounding said tube structure and having a plurality of longitudinal resonant cavities corresponding in number to the number of anode segments and mounted about the anode segments to receive energy therefrom.

4. A magnetron oscillator, comprising an inner electron tube structure of cylindrical form having a cathode and a segmental anode extending longitudinally thereof, a pair of discs connected to the opposite ends of the anode segments and having recesses forming quarter-wave lines, and an outer cavity resonator of cylindrical form surrounding said tube structure and having a plurality of longitudinal resonant cavities corresponding in number to the number of anode segments and mounted about the anode segments to receive energy therefrom.

5. A magnetron oscillator, comprising an inner electron tube structure of cylindrical form having an axial cathode and a plurality of circularly-spaced anode segments surrounding said cathode and extending longitudinally of said tube structure, and an outer cavity resonator of cylindrical form surrounding said tube structure and having longitudinal cavities corresponding in number and radially aligned with the spaces between said anode segments, said resonator having longitudinal circularly-spaced portions defining said cavities and projecting radially inward into proximate relation with the respective anode segments to afford capacitive coupling between said portions and said segments whereby energy is transferred from said anode segments to said cavities.

6. A magnetron oscillator according to claim 5, said resonator comprising a shell and removable end plates, and means supporting said tube structure from said end plates.

7. A magnetron oscillator, comprising an inner electron tube structure of cylindrical form having an axial cathode and a plurality of circularly-spaced anode segments surrounding said cathode and extending longitudinally of said tube structure, a pair of discs connected to the opposite ends of the anode segments and having recesses forming quarter-wave lines, and an outer cavity resonator of cylindrical form surrounding said tube structure and having longitudinal cavities corresponding in number and radially aligned with the spaces between said anode segments, said resonator having longitudinal circularly-spaced portions defining said cavities and projecting radially inward into proximate relation with the respective anode segments to afford capacitive coupling between said portions and said segments whereby energy is transferred from said anode segments to said cavities.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,115,521	Fritz et al.	Apr. 26, 1938
2,225,447	Haeff	Dec. 17, 1940
2,233,166	Hahn	Feb. 25, 1941
2,241,976	Blewett et al.	May 13, 1941
2,247,077	Blewett	June 24, 1941
2,391,016	Ginzton et al.	Dec. 18, 1945
2,405,175	Anderson et al.	Aug. 6, 1946
2,409,222	Morton	Oct. 15, 1946