Oct. 5, 1948. R. J. BONDLEY 2,450,629

ULTRA HIGH FREQUENCY MAGNETRON GENERATOR

Filed March 14, 1944

Fig.1.

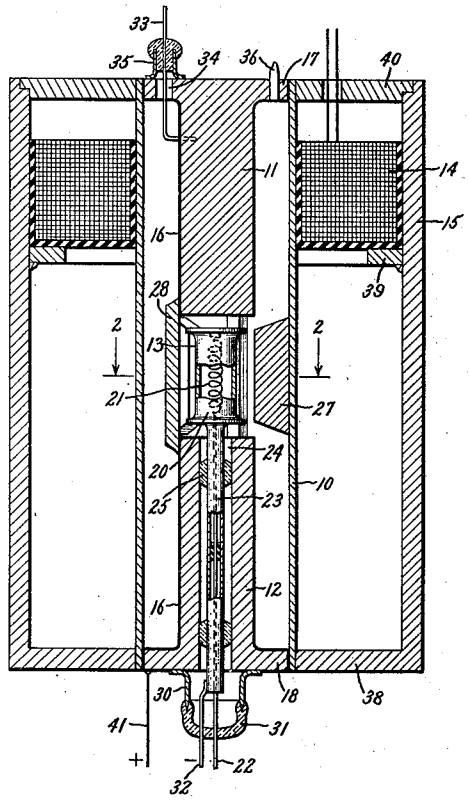


Fig.2.

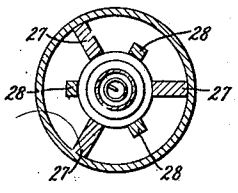
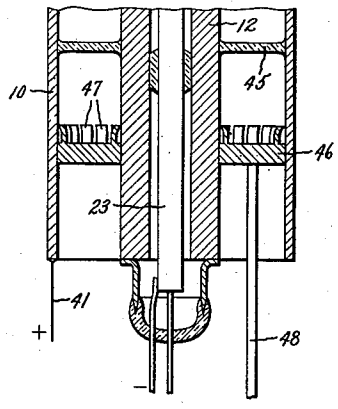


Fig.3.



Inventor:
Ralph J. Bondley.
by Harry E. Dunham
His Attorney.

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ULTRA HIGH FREQUENCY MAGNETRON GENERATOR

Ralph J. Bondley, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

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6 Claims. (Cl. 250—27.5)

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My invention relates to ultra high frequency generators and has for its object to provide a new and improved ultra high frequency generator of the electronic discharge type.

Another object of my invention is to provide a new and improved ultra high frequency electronic tube in which a space resonant cavity is formed integral with the tube structure.

It is another object of my invention to provide an ultra high frequency generator of the magnetron type formed integrally with a concentric line cavity resonator and in which an electric discharge path is established between the conductors of the resonant line.

It is a further object of my invention to provide a new and improved means and method of exciting or resonating a portion of a concentric transmission line.

Briefly stated, my invention employs a resonant cavity of the concentric transmission line type which is excited by a rotating electron field produced by the interaction of an electron discharge perpendicular to the conductors of the transmission line and a uniform magnetic field parallel to the conductors, the frequency of the oscillations established being determined or governed by the length of the concentric transmission line.

In another embodiment of my invention, means are provided for adjusting the frequency of oscillations within the cavity resonator by changing the length of the concentric transmission line without altering the continuity of the magnetic path surrounding the electric discharge between the conductors thereof.

The features of the invention desired to be protected herein are pointed out in the appended claims. The invention itself, together with its further objects and advantages, may best be understood by reference to the following description take in connection with the drawing in which Fig. 1 is a vertical section of a magnetron device suitably embodying the invention; Fig. 2 is a transverse sectional view serving to illustrate the anode structure employed in the device of Fig. 1; and Fig. 3 is a vertical section of a portion of a modification of the invention.

Referring to Figs. 1 and 2 jointly, there is shown a cavity resonator of the concentric transmission line type which comprises a tubular outer conductor 10 and a centrally disposed inner conductor consisting of an upper section 11 and a lower section 12. Disposed between the closed ends of the sections 11, 12 of the inner conductor is a coaxially aligned cathode member 13 which forms part of the means for establishing an electron discharge between the inner and outer conductors of the concentric transmission line and used for exciting the cavity resonator. Rotation of the electrons in the discharge path is effected by means of a magnetizing coil 14 encircling the

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outer conductor 10 which, in conjunction with ferromagnetic material of which inner conductors 11 and 12 are constructed and a magnetic frame 15 external of the cavity resonator, produces a magnetic field perpendicular to the electric discharge path between the cathode 13 and conductors 10 and 12.

The outer conductor 10 preferably consists of a good conductive material, such as copper or silver, formed as a single metal tube. The inner conductors 11, 12, as previously stated, function also as pole pieces and are formed of ferromagnetic material. In order to reduce high frequency losses within the cavity resonator, the outer surfaces of the conductors 11 and 12 are provided with a coating of a good conductor, such as a plating 16 of copper. The ends of the conductors 11 and 12 remote from the cathode 13 are provided with flanged portions 17, 18 which are conductively connected to the outer conductor 10 thus functioning as short-circuiting members at the ends of the cavity resonator.

For the purpose of establishing an electric discharge between the inner and outer conductors of the concentric transmission line at a point substantially equally spaced from the short-circuiting members 17, 18, the cathode 13 is provided and comprises a hollow metal tube 20 provided on its outer surface with an electron emissive coating. The tube 20 is heated by means of filamentary heater 21 positioned within the hollow tube 20. The upper end of the heater 21 is connected to cathode tube 20, while its opposite end is connected to a lead-in conductor 22 which passes through hollow metal tube 23 supporting the cathode 13 between the opposed ends of inner conductors 11 and 12. The tube 23, in turn, passes through a longitudinal opening 24 in conductor 12, being insulated therefrom by means of a plurality of spaced insulators 25.

The anode structure of the electric discharge device disposed within the cavity resonator previously described comprises a plurality of radially extending members 27 formed of a suitable conductive material, such as copper, and a corresponding number of cooperating conductive segments 28 interconnecting the closed ends of inner conductors 11, 12. Radially extending members or fingers 27 are supported on the inner surface of outer conductor 10, the inner edges of the members 27 being spaced from the electron emissive surface of cathode 13 by the same distance as the inner edges of segments 28. Each of the segments 28 is placed diametrically across the center of cathode 13 from a corresponding anode finger 27. Moreover, the members 27, 28 are spaced apart by equal angular distances.

The lower end of the cavity resonator tube thus far described is sealed by a hermetic seal comprising an eyelet member 30 formed of a suitable

conductive alloy, such as an iron-nickel-cobalt alloy, and a vitreous member 31 sealed across the edge of the lower end of the eyelet 30 and formed of suitable dielectric material, such as a borosilicate glass. Extending through the sealing member 31 is the conductor 22 connected to one terminal of heater 21 and a cathode lead 32 connected at the lower end of metal tube 23. Output electrode means for the oscillations developed within the cavity resonator may comprise a conductor 33 which extends through an opening 34 in the flanged portion 17 attached to inner conductor 11. Eyelet 35 surrounds conductor 33 and is hermetically sealed around the opening 34. Tubulation 36 provides means for evacuating and sealing the region within the cavity resonator described.

Magnetic frame 15 for the magnetron comprises a yoke of magnetic material having a cylindrical vertical wall and a bottom yoke member 38. The winding 14 is disposed within frame 15 and may be supported therein on a flange member 39. The magnetic path about the winding 14 is completed by means of a second yoke member 40 seated in a shoulder provided at the upper end of frame 15 and magnetically linking the vertical wall with the flange 17 of inner conductor 11.

In the operation of the ultra high frequency generator, a space charge is assumed to be developed in the space between cathode 13 and the surrounding anode structure by the application of a suitable potential impressed between cathode lead-in wire 32 and an anode lead-in wire 41 connected to the flange 18 joining outer and inner conductors 10, 12, the anode fingers 27 being conductively connected to outer conductor 10 and anode segments 28 being connected to inner conductors 11 and 12. The electrons which compose this space charge are given a spiral or orbital motion by the uniform magnetic field which exists between the pole pieces 11, 12 parallel to the axis of the magnetron generator. The fingers 27, which project inwardly from the conductor 10, see the same space charge conditions as the anode segments 28 connected to the inner conductors. Under oscillating conditions, an alternating voltage exists between the outer conductor 10 and the inner conductors 11, 12 and, therefore, alternate sections of the anode structure are, at any instant, of opposite polarity. Since the anode segments 27, 28 are connected to the conductors, they carry this alternating potential to the space charge region surrounding cathode 13 and superimpose the alternating potential on the unidirectional electromagnetic field already existing between the cathode and the surrounding anode structure. Because of the interleaving of the anode segments 27 and 28, any two adjacent segments are of opposite polarity for alternating currents. The presence of this alternating current field in the space charge region causes the electrons of the discharge to bunch together in groups so that the operation of the device is similar to the operation of a conventional magnetron. The frequency of the oscillations developed within the cavity resonator is determined by the length of the section of transmission line between the short-circuiting members 17, 18. Accordingly, the longest electromagnetic wave which can be established within the magnetron tube has a length which is equal to twice the electrical distance between the short-circuiting flanges 17, 18. Moreover, since the anode segments 27, 28 are all connected to equal potential parts of the resonant cavity, the coaxial tube structure oscillates primarily at the fundamental mode, that is, at a wave length equal to twice the electrical distance between the short-circuiting members 17, 18.

One of the features of the ultra high frequency generator described previously is the simplicity of the structure in which an electronic discharge tube and the cavity resonator circuit are, to a large degree, the same structure. Moreover, due to the concentric line structure of the cavity resonator, substantially no ultra high frequency electromagnetic field exists outside the cavity resonator defined by the inner and outer conductors of the section of concentric transmission line. Such a construction, therefore, eliminates radiation losses which occur at ultra high frequencies.

In the modification of the ultra high frequency generator shown in Fig. 3, a portion of the tube construction is shown in which the resonant frequency of the cavity resonator may be adjusted. The remainder of the tube construction is the same as that shown in Fig. 1. The inner conductor 12 is supported from concentric outer conductor 10 by means of hermetic seal 45 connected between these members and formed of a suitable vitreous material. In the alternative tube structure shown in this figure, moreover, the energizing winding 14 and its attendant magnetic frame 15 are dispensed with and the inner conductors 11 and 12 are both constituted of a magnetizable substance having a high coercive force and a high energy factor, both the pole pieces 11 and 12 being permanently magnetized in such a sense that the north pole of one faces the south pole of the other. Materials which may be used in this connection are alloys formed from aluminum, nickel, and cobalt. The outer conductor 10, which forms the lateral wall of the magnetron structure, consists of a ferromagnetic material, such as cold rolled steel or the like, plated on its inner surface with a conductive coating, such as, for example, copper or silver. In order to provide a low reluctance connection between the inner conductor 12 and outer conductor 10, as well as to provide means for adjusting the frequency of the oscillations within the cavity resonator defined by these conductors, a yoke member or plunger 46 consisting of a ferromagnetic material, such as steel, is provided and is made slidable between the outer surface of inner conductor 12 and the inner surface of outer conductor 10. The plunger 46 is likewise provided with a plurality of contact fingers 47 of good conductive material for providing connection between the opposed surfaces of conductors 10 and 12. The position of tuning plunger 46 between the conductors 10 and 12 may be adjusted by any suitable mechanical means, such as the rod 48.

In the structure of Fig. 3, the region between seal 45 and the opposite end of the cavity resonator is evacuated so that an electronic discharge path, similar to that shown in the tube of Fig. 1, may be included in this region of the cavity resonator. The lower ends of the magnetic and electric circuits are completed by adjustment of the tuning plunger or piston 46, the magnetic material of the piston assuring that the reluctance of the magnetic path is kept to a minimum value. It is evident that, as the position of the tuning plunger 46 is adjusted, the dimensions of the cavity resonator are altered and the cut-off frequency of the resonator is increased or decreased, depending upon the direction of movement of plunger 46.

From the foregoing, it may be seen that my invention provides an improved ultra high frequency generator which is formed integrally with a cavity resonator of the concentric line type and which permits the construction of electronic tubes having magnetron characteristics and yet which have a relatively small diameter. While, in the previous discussion, it has been pointed out that the electric discharge path is centrally located in the cavity resonator, it is apparent that the path may be moved to other positions along the concentric transmission line, the exact position determining the mode of operation of the cavity resonator for optimum output. Thus, for example, conductor 12 may have a length equal to a quarter wave length at the operating frequency and conductor 11 may have a length equal to an odd multiple of a quarter wave length.

Moreover, it will be understood that the length of the coaxial line structure may be made adjustable, as shown in Fig. 3, for a magnetron employing the magnetizing structure of Fig. 1, and that the coaxial line of the permanent magnet type of magnetron shown in Fig. 3 may be of fixed length as shown in Fig. 1.

While the invention has been described by reference to particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art without departing from the invention. I therefore aim in the appended claims to cover all such equivalent variations as come within the true spirit and scope of the foregoing disclosure.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An ultra high frequency generator comprising a section of concentric transmission line having a tubular outer conductor and a centrally disposed inner conductor, spaced conductive means connected between said conductors forming therewith a cavity resonator, said inner conductor comprising a pair of magnetic members having ends within said resonator in spaced relation and of opposite magnetic polarity, a thermally emissive cathode disposed between said ends, an anode disposed between said cathode and said outer conductor comprising a conductive member connected to said outer conductor and a conductive segment connected between said ends, said segment being spaced diametrically across said cathode from said conductive member, means connected to said generator whereby an electron discharge may be established between said anode and cathode, and means forming a part of said generator and including said magnetic members for rotating the electrons of said discharge to excite said cavity resonator and produce traveling electromagnetic waves on said line, the wave length of said waves being determined by the spacing between said conductive means.

2. An ultra high frequency generator comprising a section of concentric transmission line having a tubular outer conductor and a centrally disposed inner conductor, spaced conductive means connected between said conductors forming therewith a cavity resonator, said inner conductor comprising a pair of magnetic members having ends within said resonator in spaced relation, a thermally emissive cathode disposed between said ends, an anode structure comprising a conductive member affixed to said outer conductor opposite said cathode and a conductive member connected between said ends, means connected to said anode structure for imposing a potential thereupon with respect to said cathode, and means forming a part of said generator for establishing a magnetic field between said anode structure and said cathode for generating a rotating space charge capable of exciting said cavity resonator.

3. A generator as in claim 2 in which at least one of said spaced conductive means is adjustably positionable along the length of said line.

4. An ultra high frequency generator comprising a section of concentric transmission line having a tubular outer conductor and a centrally disposed inner conductor, spaced conductive means connected between said conductors forming therewith a cavity resonator, said inner conductor comprising a pair of magnetic members having ends within said resonator in spaced relation, a thermally emissive cathode disposed between said ends, an anode structure comprising a plurality of conductive members affixed to said outer conductor opposite said cathode and a plurality of conductive members connected between said ends, means connected to said anode structure for imposing a potential thereupon with respect to said cathode, and means forming a part of said generator for establishing a magnetic field between said anode structure and said cathode for generating a rotating space charge capable of exciting said cavity resonator.

5. A generator as in claim 4 wherein said first mentioned conductive members are uniformly distributed about the periphery of said outer conductor while said second mentioned conductive members are distributed about the periphery of said inner conductor in intermediate spaced relation between said first mentioned conductive members.

6. A generator as in claim 5 in which at least one of said spaced conductive means is adjustably positionable along the length of said line.

RALPH J. BONDLEY.

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