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MAGNETRON OSCILLATOR

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FIG. 1

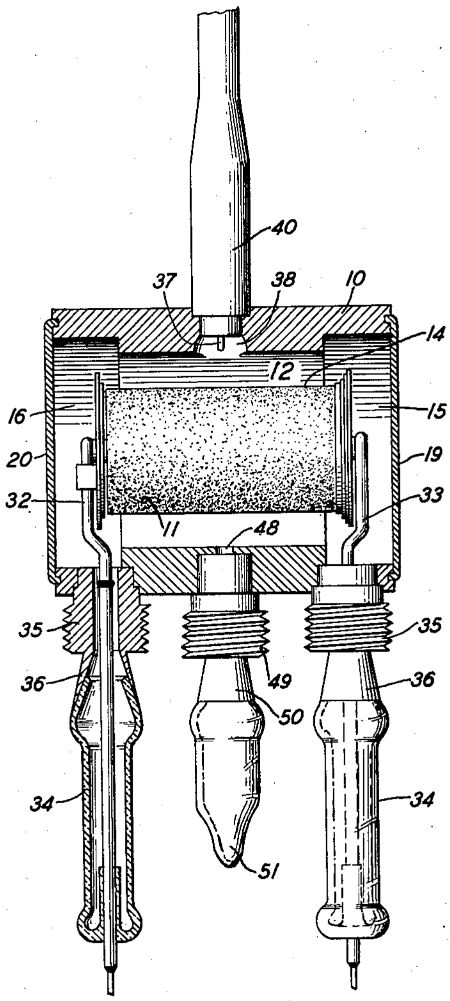
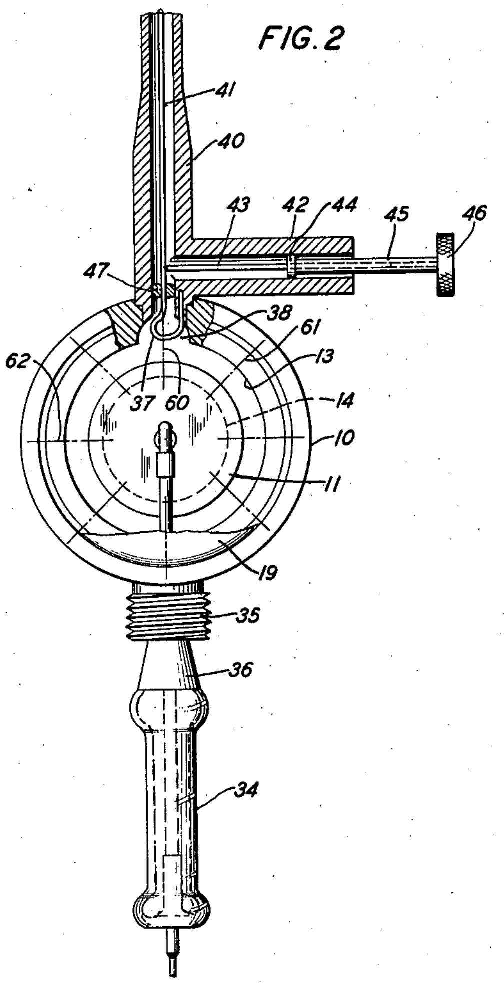


FIG. 2



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MAGNETRON OSCILLATOR

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6 Claims. (Cl. 315—39)

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This invention relates to oscillators and more particularly to those employing a multiple-resonant structure.

The invention is directed to separating the several resonant frequencies of the multiple-resonant system so that oscillations at a single definite frequency readily may be secured without interference from adjacent resonant frequencies.

In accordance with the invention, a coaxial cylindrical type of resonator is employed and is excited in the kind of oscillatory mode characterized by circumferential currents in the cylindrical surfaces. Means are provided for breaking the circumference up into a plurality of antinodal regions separated by nodes, this being done by means of a frequency-selective impedance adjusting device at one point in the circumference. The resonating structure may comprise two spaced substantially smooth parallel cylindrical conductive surfaces in opposing relation, forming a continuous and substantially endless transmission loop or ring, except for the introduction of the impedance adjusting device at one point, which device may be combined with an output connection or load circuit for the oscillator.

In the drawings,

Fig. 1 shows a longitudinal-sectional view of a magnetron oscillator embodying the invention, and

Fig. 2 shows a cross-sectional view of the same.

Referring to the drawings, 10 is an anode structure comprising a perforated cylindrical block of conductive material, 11 is a cathode of cylindrical form concentrically mounted within the anode structure, and 12 is a reaction space between the anode and cathode surfaces.

To facilitate the mounting of the cathode and the making of electrical connections thereto for heating purposes, the anode 10 may be fashioned to provide end spaces 15 and 16 at either end. The spaces 15 and 16 are preferably closed by end plates 19 and 20 which may, if desired, be of suitable feromagnetic material to facilitate the application of a strong steady magnetic field to the reaction space 12 by means of an external magnet or magnets in well-known manner.

The cathode 11 preferably has a coating of thermionically highly emissive material and encloses a heating winding. The cathode assembly may be supported by a pair of heater leads 32 and 33. Each heater lead is in turn supported by a tubular glass seal 34 and a bushing 35. The bushing has a tapered flaring edge 36 to the inner surface of which the glass may readily be sealed.

An output coupling arrangement is provided by

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means of an inductive loop 37 inserted into a radial bore 38 (Fig. 2). The two ends of the loop 37 are connected respectively to the inner and outer conductors of a coaxial output fitting. The outer conductor of the coaxial fitting comprises a tubular member 40 sealed into the hole 38 while the inner conductor 41 may be simply an extension of the conductor forming the loop 37. A seal 47 may be suitably formed as a bead around the inner conductor.

For convenience in pumping out the structure to the desired degree of vacuum, a small hole 48 (Fig. 1) may be formed as by drilling into the anode and a bushing 49, similar to the bushings 35 may be fitted around the hole 48. The bushing 49, preferably includes a flared and tapered portion 50 to which may be sealed a glass tube for use in pumping. The glass tube may be sealed off after evacuation in the usual manner to form a tip 51 as shown in Fig. 1.

The magnetron disclosed is adaptable to being built on any suitable scale according to the frequency at which it is desired to operate. In an embodiment suitable for operation in the neighborhood of 3,000 megacycles (10 centimeters wavelength) the anode block 10 may have an overall length between the end plates 19 and 20 of some 2.6 inches.

The reaction space 12 comprises the space between two cylindrical coaxial conductive surfaces, namely, the inner surface 13 of the block 10 and the outer surface 14 of the cathode 11. Except for the output chamber 38, there are no side chambers or resonating cavities such as are usually found in the anode block of the conventional magnetron, and the cylindrical surfaces are preferably smooth. The coaxial output transmission line 40, 41 is preferably provided with a side branch, the outer conductor 42 of which may be integral with or conductively attached to the outer conductor 40 and the inner conductor 43 of which may be conductively connected to the inner conductor 41. A slidable short-circuiting bridge 44 may be provided between the conductors 42 and 43 in the side branch. The bridge 44 may be adjusted in position by means of a hollow rod 45 and a knob 46. The operation of the system of the invention is in a general way similar to that of the conventional magnetron with a plurality of resonant side chambers, except that in the absence of the side chambers, the standing wave pattern exists exclusively within the reaction space 12 and to some degree in the output chamber 38. The type of standing wave pattern which may advantageously be utilized is one formed as by a pair of waves traveling in opposite directions around the circumference of the reaction space 12, using the surfaces 13 and 14 as the conductors in what is a continuous and substantially an endless parallel cylindrical plate transmission line. Except for the influence of the output chamber 38 as hereinafter described, there is nothing to disturb the radial symmetry of the system and consequently nothing inherent in the structure to define the angular position of the nodes and antinodes of the standing wave pattern around the circumference of the reaction space nor to determine how many nodes and antinodes there shall be.

It is well known that a node may be established at a particular position along a transmission line by locating a suitably designed impedance controlling device such as a side chamber at the position where the node is desired. The output chamber 38 serves in the present invention as such a side chamber and is adjustable in its wave transmission or impedance characteristics by means of the associated branch transmission line 42, 43. By adjusting the position of the bridge 44, a node, indicated diagrammatically by a dot-dash line 60 may be located at or near the entrance to the output chmber as shown in Fig. 2. It is possible to set up such a node 60 to be effective selectively at any desired frequency over a considerable frequency band. To obtain a stable standing wave pattern in the reaction space 12, however, the operating frequency must be such that the circumference of the reaction space 12 may break up into an integral number of subdivisions separated by nodes. The location of the nodes in an illustrative example is shown in Fig. 2, with eight nodes including the node 60 and additional nodes as at 61 and 62. To secure any desired pattern, an adjustment of the bridge 44 is required whereby the node 60 is established opposite the output chamber 38 with reference to an operating frequency which is consistent with the standing wave configuration wanted. Other adjustments of the bridge 44 than that illustrated may be found in which the node 60 appears opposite the opening of the output chamber 38, with a different number of nodes formed around the reaction space 12.

In the conventional magnetron of the type having a plurality of side chambers communicating with a central reaction space, the side chambers operate as individual resonant circuits coupled together through the reaction space. The system as a whole then shows the general operating characteristics of a band-pass filter. Accordingly, multiple resonances appear which are generally as numerous as the side chambers. The multiply resonant frequencies are all included within the transmission band of the structure considered as a filter. In general this means that the resonant frequencies are relatively close together. Trouble often arises due to uncertainty as to which of the several resonant frequencies will be supported in sustained oscillation when the magnetron is operated. Also, it may occur that the magnetron will pass suddenly and unaccountably from one frequency of oscillation to another. The endless transmission line, loop, or resonant ring which forms the resonant system in the present invention, does not have a band-pass filter type of characteristic but instead its resonant frequencies are harmonically related depending upon the number of subdivisions into which the standing wave is divided. Such harmonic frequencies are in general much more widely separated in frequency than the reso-

nances in the band filter structure. The actual resonant frequency may be determined by the setting of the bridge 44 which, as above described gives a frequency-selective control whereby the node 60 is located opposite the output chamber 38 for one particular operating frequency only. Therefore, the operating frequency to be expected may be predetermined and there is substantially no tendency for the system to jump from one operating frequency to another. The system of the invention has the further advantage that, unlike the magnetron with a fixed number of side chambers, permanently incorporated in the anode, the number of nodes may be controlled by means of the bridge 44 and accordingly, the operating frequency may be selected at will from a considerable number of harmonically related resonant frequencies.

Except for the physical configuration of the resonator, the device disclosed is similar to currently preferred types of magnetrons and it operates on substantially the same principle so that it is thought unnecessary to describe the operation in any further detail, the same being already familiar to those skilled in the art.

What is claimed is:

1. An oscillator comprising a pair of opposed substantially smooth coaxial conductors forming a substantially uniform continuous transmission line resonator in the space between said conductors, a side branch transmission line opening out from said resonator and forming a sole principal node-determining irregularity in the said resonator, and a side branch transmission line of adjustable length opening out from said first-mentioned side branch transmission line at a distance from the said resonator of the order of magnitude of a wavelength of a harmonic oscillation in said resonator.

2. An oscillator comprising a pair of opposed substantially smooth coaxial conductors forming a substantially uniform continuous transmission line resonator in the space between said conductors, and a side branch transmission line opening out from said resonator and forming the predominant irregularity in the symmetry of the said resonator, said side branch transmission line presenting a predesigned impedance to the said resonator at a desired harmonic resonant frequency of said resonator, said impedance determining a node in the oscillations of said resonator at the opening of said side branch transmission line.

3. An oscillator comprising a pair of opposed substantially smooth coaxial conductors forming a substantially uniform continuous transmission line resonator in the space between said conductors, and a side branch transmission line opening out from said resonator and forming a sole predominant irregularity in the symmetry of the said resonator, said side branch transmission line having a portion of critical length for determining the impedance presented to the said resonator by the said side branch transmission line, said impedance having a value necessary to produce a node in the oscillations of the said resonator at the opening of said side branch transmission line for a harmonic oscillation of said resonator.

4. A harmonic oscillator comprising a pair of opposed substantially smooth coaxial cylindrical conductors forming a substantially continuous transmission line resonator, said conductors comprising an anode and a cathode, a side branch transmission line opening out from the space

between said coaxial conductors and forming the main node-determining irregularity in the symmetry of the said resonator, said side branch transmission line being tuned to resonate a harmonic oscillation of said resonator.

5. A harmonic oscillator comprising a pair of opposed substantially smooth coaxial cylindrical conductors, additional conductors attached to the outer of said coaxial conductors to form a cavity resonator including the space between said coaxial conductors, said cavity resonator having an aperture in the outer coaxial cylindrical conductor portion thereof, said aperture constituting a sole prominent node-determining irregularity in the symmetry of the said resonator, and said side branch transmission line being tuned to a harmonic oscillation of said resonator.

6. A magnetron for generating harmonic oscillations comprising a pair of opposed substantially smooth coaxial cylindrical conductors forming a substantially uniform continuous transmission line resonator in the space between said conductors, one of said conductors constituting a cathode and the other of said conductors constituting an anode, means for maintaining a steady magnetic field with lines of magnetic force

parallel to the axis of said coaxial conductors, a side branch transmission line opening out from said resonator and forming a sole principal node-determining irregularity in the symmetry of the said resonator, and means in said side branch transmission line for adjusting the length of said side branch transmission line to tune said resonator to produce oscillations in said magnetron at a harmonic resonant frequency of said resonator.

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