

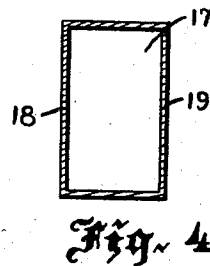
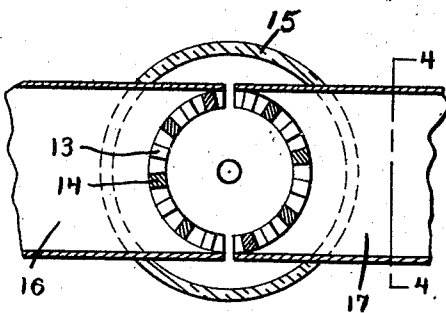
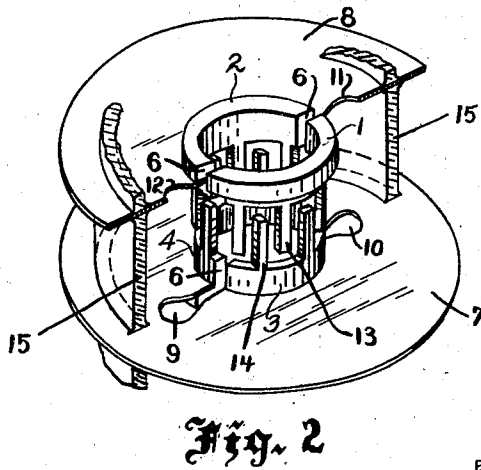
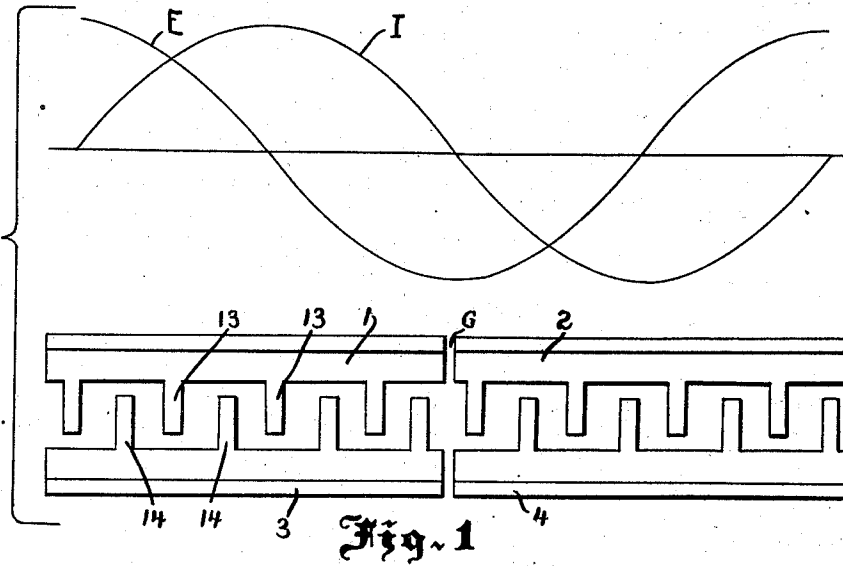
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L. BURNS

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INTERDIGITAL MAGNETRON

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INVENTOR:

Laurence Burns

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INTERDIGITAL MAGNETRON

Laurence Burns, Swampscott, Mass., assignor to
Sylvania Electric Products Inc., Salem, Mass.,
a corporation of Massachusetts

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This invention relates to microwave devices and particularly to microwave generators such as interdigital magnetrons and the like.

Such devices have previously comprised an anode having two oppositely facing sets of conducting fingers or teeth arranged on the surface of a cylinder or the like, the sets being intermeshed but not in contact, with the circuit between the two sets of teeth completed through a resonant cavity.

In such an arrangement there are radial modes of oscillation and circumferential or angular modes. In the latter, the field strength varies around the cylinder formed by the teeth, and the coupling is best when the coupling loop is placed in the plane of the voltage maximum. However, as the coupling is increased, or the anode voltage raised, the voltage maxima tend to shift away from the loop, and may eventually shift 90°, under which condition the device may oscillate strongly with no power output to the coupling loop.

My invention is in preventing this by opening the circuit around the ring at the current nodes, preferably by making a slot or opening in the ring at the nodes, the slot extending far enough into this cavity to insure that the opening in the ring is not short-circuited by the cavity itself. The slot or opening in the ring should be great enough to prevent short-circuiting itself by the capacity between the open ends of the ring, and the opening preferably extends into the cavity sufficiently to insure that a wave going around the circumference of the opening will be delayed just a little more than a wave-length so that the current on one side of the opening in the ring will have a small value in one direction and on the other side a small value in the other direction, to preserve the desired current distribution around the ring. This allows oscillation only for those modes having current nodes at the slotted positions.

Further objects advantages and features of the invention will be apparent from the following specification, taken in conjunction with the accompanying drawing.

Figure 1 is a developed view of the split ring of my invention, with the voltage and current distributions plotted along it.

Figure 2 is a view, partly in section, of the toothed rings with discs attached thereto for connection to the resonant cavity.

Figure 3 is a sectional view in which the split rings are connected to oppositely placed waveguides as resonators; and

Figure 4 is a sectional view of the waveguide along the plane of line 4-4 of Figure 3.

In Figure 1, the current curve I is seen to pass through its node at the gap G in between sections 1 and 2 of the ring 1-2, or sections 3 and

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4 of the ring 3-4. The current through the ring should have the same small, but opposite, value on each side of gap G. The curve E, of voltage between the top and bottom rings, has its maximum at this point.

In Figure 2, the gaps 6 in rings 1-2 and 3-4 extend into the resonator discs 7, 8 as shown at 9, 10, 11, and 12. The teeth 13 on one ring and 14 on the other intermesh but do not touch, although in some cases they may be in contact if desired, as in the copending application of Henry J. McCarthy, filed in the United States Patent Office on or about October 30, 1946, for an interdigital magnetron. The interdigital magnetron itself is well described in the McCarthy application, which is incorporated herein by reference, and in my application I will describe herein only my improvements thereon. A magnetron according to my invention may have a cathode concentric with the ring, an enclosing envelope also concentric therewith, and the usual magnet for producing a field between the anode and the cathode, as shown in said McCarthy application. The enclosing glass tube 15 is herein shown broken, for convenience.

In Figure 3, the concentric resonator discs 7, 8 are replaced by the top and bottom (e. g., 18, 19) of waveguides 16, 17 each of which is connected at its top and bottom to one of the halves 1, 2, 3, 4 of the split rings 1-2 and 3-4. That is half-ring 1 and 3 go to one waveguide 16, half-ring 2 and 4 to the other waveguide 17. There is then no direct connection between the waveguides 16 and 17 inside the tube, but they may be coupled together outside the tube. The glass tube 15 encloses the internal elements of the tube, the wave-guide extending through it. In some cases, one may find it possible to connect the two wave-guides together in the old split-anode magnetron circuit for lower frequencies, thus superposing a lower frequency modulation on the high frequency wave.

In general, the disc type tube of Figure 2 will be easier to manufacture than the wave-guide type of Figure 3, because of the simpler sealing operations.

The circumference of each of the openings 9, 10, 11, 12 is preferably sufficient to cause a slight phase difference between the currents on opposite sides of the gaps 6 in the rings 1-2 and 3-4, so that the currents on opposite sides of the gaps 6 will be small, equal and opposite. This can be accomplished by making the gaps long enough to insure a little more than a wavelength delay to any wave going around or through the gap.

In some cases, it may be desirable to place small baffles over the openings 9, 10, 11, 12 to prevent radiation losses therethrough. Such reflectors or baffles may be supported from one end to prevent shorting the gap.

In some cases, it may be desirable to make the width of the wave guides 16, 17 in Figure 3 greater than the diameter of the tube, or to split the discs 7, 8, taking appropriate termination precautions to prevent loss of energy.

When a tooth is to be shorted as in the McCarthy application, it may at times be desirable to add an additional tooth between two of the other teeth and short the additional tooth. This will be a voltage node, and the teeth on either side of the shorted tooth may be connected to a single ring to insure that the adjacent teeth on opposite sides of the short are of opposite polarities, the shorted tooth being of substantially no polarity, that is at zero potential. Of course, the potential may vary somewhat along the tooth itself. The other teeth may then be alternately connected to opposite rings, except near any shorted tooth.

If such a shorted tooth be used in addition to the slots of the present invention, and if it nonetheless be desired to vary the wavelength of oscillation by moving the ring-supporting discs 7, 8, by a diaphragm arranged as part of the tube envelope or the like in known manner, the shorted teeth will have to be flexible in their contacting arrangement. For example, the shorted tooth may be attached to one ring and its end may fit into and contact a hollow longitudinally split conducting cylinder attached to the other ring. If the teeth are of rectangular cross-section, as shown, the cylinder will also be of rectangular cross-section to fit snugly but slidably around the tooth, bearing against it for contact.

In some cases it may be desirable to have the slots of size other than a value giving a little more than a wavelength delay or phase shift, a slot extending just through the ring, or through the ring and extending just a little into the annular discs attached thereto often being desirable. If the ring is wide enough, the slot may extend only part way into it in exceptional cases. The slot should be sufficient to insure a break in the current distribution curve around the ring if any mode is used other than one which makes the current node or minimum come at that point. The slot in the ring will not greatly affect the current distribution for the desired mode—the current is zero or a minimum at that point anyway. But a mode in which the current will not be a minimum at that point will be hard to establish.

If a coupling loop is used to take power from my magnetron, it will generally be placed in or near a plane through the slots and the longitudinal axis of the toothed cylinder. That is, the loop may be in the plane of the voltage maxima.

Although the slots 9, 10, 11, 12 are shown flared in the drawing they may, of course, have straight sides if desired.

In some cases, an uneven number of teeth may be desirable, in which case one current node may occur between teeth, and in convenient position for slotting, and the other node may occur at a tooth and hence in less convenient position. In such a case a slot at the node in between teeth will generally be sufficient, although a slot extending vertically down the tooth at the other node for a short distance may be helpful. Current may then flow into the tooth, but not across the ring at the top of the tooth.

Additional slots for harmonics may be used if desired.

What I claim is:

1. A cavity resonator magnetron construction comprising two oppositely-facing toothed and split rings, a disc attached to and extending outward from each of said rings, said disc having openings extending radially from the split portions of the rings.

2. An interdigital magnetron construction comprising an anode comprising two rings in register with each other, oppositely placed sets of teeth extending toward each other from said rings, each set coaxial with the other and each set comprising a series of electrically connected spaced teeth mounted longitudinally along the surface of a cylinder, the teeth of the sets being in general spaced from each other, a pair of spaced metallic discs extending from and connected to said rings, each ring and its corresponding disc being slotted radially at some of the approximate current nodes of a mode of oscillation.

3. An interdigital magnetron construction comprising an anode comprising two rings in register with each other, oppositely placed sets of teeth extending toward each other from said rings, each set coaxial with the other and each set comprising a series of electrically connected spaced teeth mounted longitudinally along the surface of a cylinder, the teeth of the sets being in general spaced from each other, a pair of spaced metallic discs extending from and connected to said rings, each ring and its corresponding disc being slotted radially at two diametrically opposite points.

4. An interdigital magnetron construction comprising an anode comprising two rings in register with each other, oppositely placed sets of teeth extending toward each other from said rings, each set coaxial with the other and each set comprising a series of electrically connected spaced teeth mounted longitudinally along the surface of a cylinder, the teeth of the sets being in general spaced from each other, a pair of spaced metallic discs extending from and connected to said rings, each ring and its corresponding disc being slotted radially at one place.

5. An interdigital magnetron construction comprising an anode comprising two rings in register with each other, oppositely placed sets of teeth extending toward each other from said rings, each set coaxial with the other and each set comprising a series of electrically connected spaced teeth mounted longitudinally along the surface of a cylinder, the teeth of the sets being in general spaced from each other, and a pair of metallic pieces extending from and connected to said rings, each ring and its corresponding metal piece being slotted radially at two diametrically opposite points, the slots extending to the edges of the metallic pieces.

LAURENCE BURNS.

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