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E. C. OKRESS

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STRAPLESS RESONATOR SYSTEM

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Fig. 1.

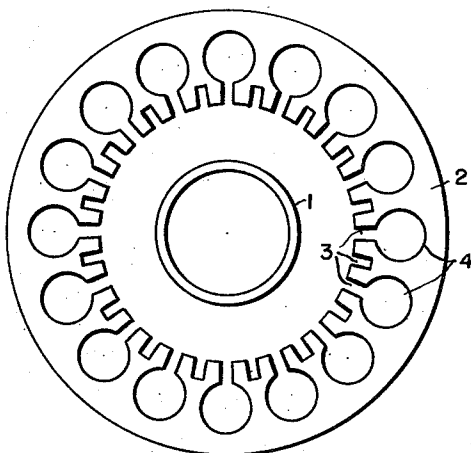
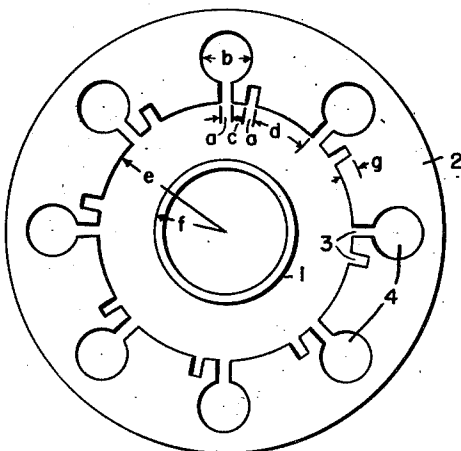


Fig. 2.



WITNESSES:

E. A. M. Maskey
C. F. Remy

INVENTOR

Ernest C. Okress.

BY

F. E. Browder
ATTORNEY

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STRAPLESS RESONATOR SYSTEM

Ernest C. Okress, Montclair, N. J., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

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6 Claims. (Cl. 315—39.65)

My invention relates to magnetron oscillation generators and in particular relates to an anode structure for such generators which is especially adapted to make it possible to operate a tube of given dimensions at higher powers and voltages but with a lower number of modes of oscillation than strapless magnetrons of the prior art.

During the past decade magnetron oscillators having a central cathode surrounded by a cylindrical anode which is subdivided circumferentially by radial slots which form resonating chambers have come to be widely used in the ultra-high-frequency radio art. Two general types of such are common, (a) the symmetric "strapped" form in which the slots and adjoining cavities are alike and evenly spaced and each resonator terminates in a cylindrical chamber commonly referred to as the "interaction space," and (b) the asymmetric "rising sun" form (illustrated in Fig. 1 of the drawings) in which alternate slots and resonators differ in size or geometry or both and both sets terminating in the interaction space referred to. My present invention comprises a modification of the "rising sun" structure.

The "strapped" form of magnetron is so named because the alternate projections or "poles" of its anode are connected together by circumferential straps. The power output of a given magnetron will, of course, increase as the applied anode voltage and magnetic field are increased, but a limit is reached when R. F. arcing occurs between the straps and anode. The "rising sun" type has no straps and so is not subject to this limitation until much higher voltage levels are reached, but finds another limitation in the fact that the inherently larger number of different modes of electrical oscillation tend to make this system less stable and sensitive to loading than the equivalent strapped system.

In one aspect it may be considered that my invention comprises the decrease of this mode instability by omitting every alternate set of large and small resonators as indicated by Fig. 2 of the drawings hereof. The number of modes of oscillation at which the conventional "rising sun" magnetron can oscillate is thus substantially reduced.

One object of my invention is accordingly to provide a new and improved form of magnetron.

Another object is to provide a magnetron capable of stably operating at greater power output than magnetrons of the prior art.

Another object is to provide a magnetron capable of stable operation on greater applied input power than prior art magnetrons.

Another object is to provide a magnetron having fewer modes of oscillation and greater mode stability than asymmetric magnetrons of the prior art.

Still another object is to provide a novel form of anode for travelling-wave magnetrons.

Other objects of my invention will be apparent upon reading the following description taken in connection with the drawings in which:

Figure 1 is a schematic view in cross-section of a conventional magnetron of the "rising sun" type; and

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Fig. 2 is a similar view of a magnetron embodying the principles of my invention.

Referring to the drawings in detail Fig. 1 shows at 1 the wall of a cylindrical electron-emissive cathode which may be of conventional thermionically-emissive type maintained at a sufficiently high operating temperature directly or by a conventional heater (not shown). Surrounding the cathode is an anode 2 of generally cylindrical type, but having its internal face subdivided evenly by radial slots 3, thirty-two in number in the example shown. Alternate slots open into cylindrical resonators 4. As is shown in chapter 3 of the text "Microwave Magnetrons," which is volume 6 of the M. I. T. Radiation Laboratory Series published by McGraw Hill Publishing Company, New York City, such a magnetron has nine possible modes of oscillation, the frequencies of which may be calculated from the dimensions of the resonator system by equations there given.

While I have described the resonator pairs as comprising a slot and cylinder combined with a simple rectangular slot, this particular configuration is not essential as both resonators may be simple rectangular slots, or both may be of the slot-and-cylinder type, or be resonators of other types, the essential characteristic of the "rising sun" anode being that the alternate resonators are of different size regardless of whether or not the geometry is common.

Fig. 2 shows the magnetron of Fig. 1 modified in accordance with my invention; that is to say every second pair of resonators is omitted. As in Fig. 1 the pairs or groups of resonators are similar to each other. Each group consists of two resonators differing from each other, but the resonators comprise two similar series of similar resonators. In Fig. 2, the groups of resonators are circumferentially positioned around the internal cylindrical face of the anode 2. The groups are spaced from each other a distance at least equal to that occupied by one of the groups. That is, the circumferential gap spacing a first type resonator from the preceding resonator of the second type is different from the gap spacing it from the succeeding resonator of the second type.

It is found that with this structure there are only half as many modes of oscillation as is the case with a "rising sun" anode of the dimensions and resonator shape from which the Fig. 2 magnetron was derived by omitting every second group of resonators. This results in greater mode stability than that existing in the "rising sun" type magnetron due to the same causes. A greater mode separation is also found. Calling N the number of groups of resonators in the anode and n being an integer, the $(N-n)$ harmonics which usually cause mode troubles are desirably weaker in the proposed design of Fig. 2. The zero mode component is also desirably weaker in this proposed design than with rising types. On the other hand the $(N/2+n)$ mode component is stronger and may be troublesome and requires particular attention in design. In a magnetron of the Fig. 2 type, operation occurs normally in the N th harmonic whereas in the "rising sun" magnetron it is in half the N th harmonic.

To give one specific example of magnetron dimensions involved, the lettered dimensions in Fig. 2 may be of the following order of magnitude:

$$c=1.2a \text{ to } 1.5a \quad d=2a+3c \quad f=0.59e \text{ to } 0.62e$$

It should be noted, however, that in the proposed type of resonator system illustrated by Fig. 2 in contrast to the conventional rising sun system, the principal or pi-mode wavelength is altered; the upper and lower multiplet wavelengths are altered; the cathode to anode radii ratio is different; the relation between magnitudes of the Hartree harmonics of each mode are altered and are in a more complex spectrum. The admittance Y_L

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of the larger resonator and the admittance Y_s of the smaller resonator correspond to inductive reactance X_L and capacitive reactance X_C respectively. Said admittances and reactances are figured at the resonant frequencies of the large and small resonators respectively.

I claim as my invention:

1. A magnetron comprising a cylindrical cathode and an anode concentric therewith comprising an annulus having resonators each of which embodies an opening through the inner cylindrical face of said annulus, said resonators comprising groups, each consisting of two resonators differing from each other essentially in size, but the respective groups being similar to each other, and said groups being spaced circumferentially from each other around said inner cylindrical face a distance at least equal to that occupied by one of said groups.

2. A magnetron comprising a cylindrical thermionically-emissive cathode and an anode concentric therewith comprising an annulus having resonators, each of which embodies an opening through the inner cylindrical face of said annulus, said resonators comprising groups, each consisting of two resonators differing from each other, but the respective groups being similar to each other, the circumferential gap spacing one resonator type in each group from the preceding resonator of the other type being different from the gap spacing it from the succeeding resonator of that other type.

3. A magnetron comprising a cylindrical thermionically-emissive cathode and an anode concentric therewith comprising an annulus having resonators each of which embodies an opening through the inner cylindrical face of said annulus, said resonators comprising groups, each consisting of two resonators differing from each other, but the respective groups being similar to each other, said resonators comprising two similar series of similar resonators, the resonators of one series being of a type different from those of the other series, and the gap spacing the resonators of the one series from the preceding resonators of the other series being different from that spacing it from the succeeding resonator of the other series.

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4. An anode structure comprising, an annulus having resonators each of which embodies an opening through the inner cylindrical face of said annulus, said resonators comprising groups, each consisting of two resonators differing from each group, but the respective groups being similar to each other, and said groups being spaced circumferentially from each other around said inner cylindrical face a distance at least equal to that occupied by one of said groups.

5. An anode structure comprising, an annulus having resonators, each of which embodies an opening through the inner cylindrical face of said annulus, said resonators comprising groups, each consisting of two resonators differing from each other, but the respective groups being similar to each other, the circumferential gap spacing one resonator type in each group from the preceding resonator of the other type being different from the gap spacing it from the succeeding resonator of that other type.

6. An anode structure comprising, an annulus having resonators each of which embodies an opening through the inner cylindrical face of said annulus, said resonators comprising groups, each consisting of two resonators differing from each other, but the respective groups being similar to each other, said resonators comprising two similar series of similar resonators, the resonators of one series being of a type different from those of the other series, and the gap spacing the resonators of the other series from the preceding resonator of said one series being different from that spacing it from the succeeding resonator of said one series.

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