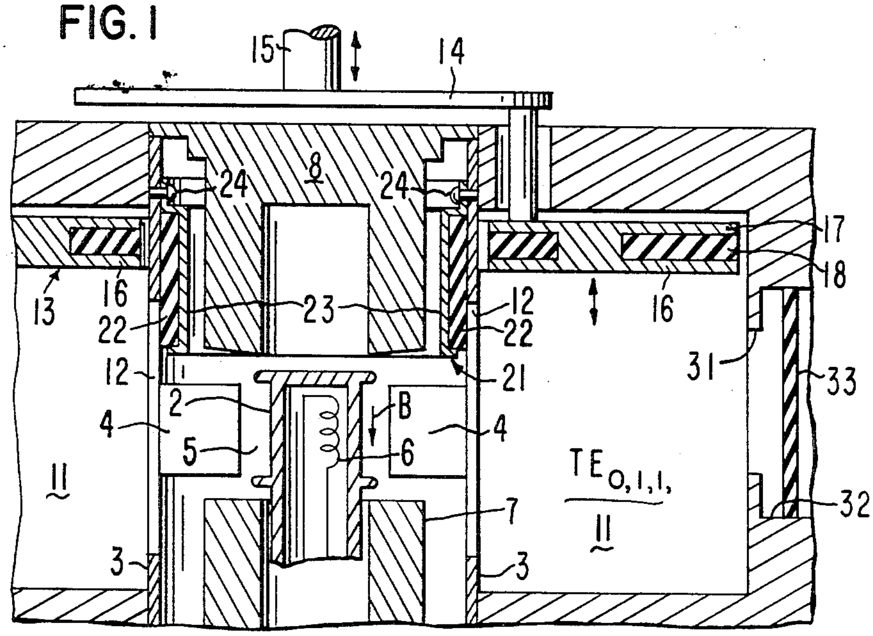
COAXIAL MAGNETRON HAVING A SEGMENTED RING SLOT MODE ABSORBER

Filed Sept. 1, 1967

FIG. 1



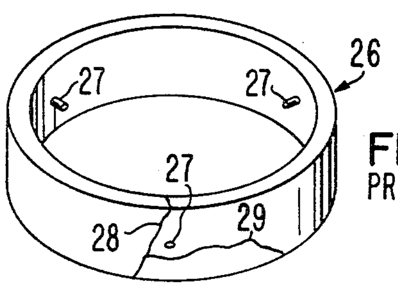


FIG. 2
PRIOR ART

FIG. 5

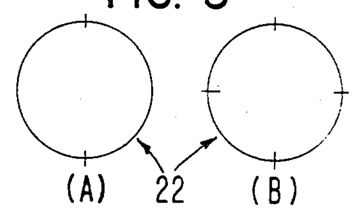


FIG. 3

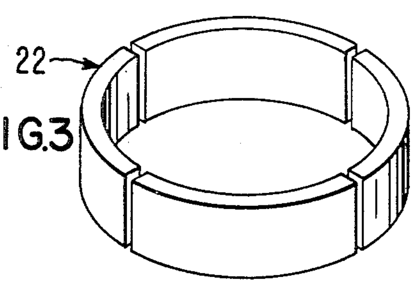


FIG. 4

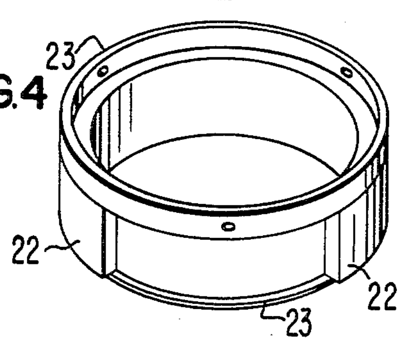
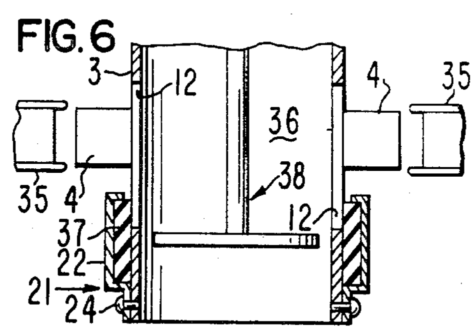


FIG. 6



INVENTOR.
GLENN G. PRYOR

BY Wm. J. Nolan
ATTORNEY

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COAXIAL MAGNETRON HAVING A SEGMENTED RING SLOT MODE ABSORBER

Glenn G. Pryor, Millington, N.J., assignor, by mesne assignments, to Varian Associates, a corporation of California

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U.S. Cl. 315—39.77 6 Claims

ABSTRACT OF THE DISCLOSURE

A slot mode absorber for coaxial magnetron type tubes is disclosed. The coaxial magnetron tube includes concentrically disposed anode and cathode structures to define a magnetron interaction region therebetween. The anode structure includes a cylindrical anode wall having an array of vane resonators projecting from the anode wall toward the cathode structure for electronic interaction with a stream of electrons in the magnetron interaction region to produce an output signal. The circular electric mode resonator is concentrically disposed of the array of vane resonators on the side thereof remote therefrom. An array of longitudinally directed coupling slots communicate through the common wall with the array of vane resonators for locking the π mode of the vane resonators to the resonant frequency of the circular electric mode cavity. A slot mode absorber is disposed over the ends of the coupling slots for damping the resonant frequency of the slot mode. The slot mode absorber includes a ring-shaped lossy ceramic structure formed by a plurality of arcuate ring segments which are held against the ends of the slots by means of a thermally conductive retaining channel member. The channel member is preferably affixed to the anode wall and made of the same material as the anode wall to have the same coefficient of thermal expansion, whereby the lossy mode absorbing structure is continuously held against the ends of the slots during thermal cycling of the anode structure.

Description of the prior art

Heretofore, coaxial magnetron tubes had employed ring shaped slot mode absorbers disposed adjacent the ends of the coupling slots which communicate between the vane array and the circular electric mode cavity. In one such prior art structure exemplified by U.S. Patent 3,169,211, issued Feb. 9, 1965, and assigned to the same assignee as the present invention, the mode absorber ring was pinned to a magnetic pole piece structure adjacent the slotted anode wall. A small cold clearance was provided between the absorbing ring of carbon impregnated alumina ceramic and the anode wall such that as the mode absorber was heated in operation, due to absorption of R.F. energy, it expanded against the anode wall for cooling of the absorber. Such an absorber operated satisfactorily in a tube having a peak power of 1 megawatt with an average power of 1000 watts and a pulse length of 1 microsecond. However, when the performance of this tube was upgraded by increasing the duty cycle from 1 microsecond to 2 microseconds cracking of the absorber was encountered. Upon cracking, the absorber dropped into the region of the anode vanes, rendering the tube inoperable.

In another example of the prior art, as exemplified by U.S. Patent 3,231,781 issued Jan. 25, 1966 and assigned to the same assignee as the present invention, the annular mode absorbing ring was pinned to the anode structure. This mode absorber ring construction was similar to the aforecited ring structure in that overheating of the absorber could cause cracking thereof and portions of the absorber could fall away from the main element to produce shorting of the anode vanes.

In another embodiment of the prior art, the mode absorbing ring was brazed to an annular conductive jacket which in turn was brazed into the tube structure. An example of such a mode absorber structure is described and claimed in U.S. copending application 497,791 filed Oct. 19, 1965 now U.S. Patent 3,412,284, and assigned to the same assignee as the present invention. While this mode absorber construction has the advantage that portions of the absorber will not fall away to produce shorting of the anode vanes, it has the disadvantage of being relatively complicated to fabricate due to the brazing steps required.

Therefore, a need exists for a relatively simple and inexpensive method for mounting the slot mode absorber structure to the anode wall structure in such a manner that the mode absorbing structure will be held against the ends of the slots during thermal cycling of the tube and which will be crack resistant and which will not permit portions of the mode absorber to fall into the region of the anode vanes for shorting same.

Summary of the present invention

The principal object of the present invention is the provision of an improved slot mode absorber structure for coaxial magnetron tubes.

One feature of the present invention is the provision of a slot mode absorber structure for coaxial magnetrons wherein the mode absorber is ring shaped and formed by a plurality of arcuate segments of lossy material, whereby the mode absorber ring structure is free to expand and contract without cracking.

Another feature of the present invention is the same as the preceding feature, wherein the mode absorber structure includes a metallic retaining channel of annular shape for holding the lossy ring segments adjacent the coupling slots to be damped, whereby portions of the lossy ring segments are prevented from falling into the anode structure.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

Brief description of the drawings

FIG. 1 is a fragmentary longitudinal sectional view of a portion of a coaxial magnetron incorporating features of the present invention,

FIG. 2 is a perspective view of a prior art slot mode absorbing ring structure,

FIG. 3 is a perspective view of a slot mode absorbing ring structure incorporating features of the present invention,

FIG. 4 is a perspective view of the slot mode absorbing retaining channel structure incorporating features of the present invention,

FIGS. 5A and 5B are schematic line diagrams depicting alternative arrangements for segmenting the mode absorbing ring structure, and

FIG. 6 is a fragmentary longitudinal sectional view of an inverted magnetron structure incorporating features of the present invention.

Description of the preferred embodiments

Referring now to FIG. 1, there is shown a coaxial magnetron tube **1** incorporating features of the present invention. The tube **1** includes a centrally disposed cylindrical thermionic cathode emitter **2** surrounded by a concentrically disposed cylindrical anode wall **3** having an array of vane resonators **4** projecting inwardly therefrom toward the cathode emitter **2**. The vane tips terminate short of the cathode emitter 2 to define an annular magnetron interaction region 5 in the annular space between the anode vanes 4 and the cathode 2. A heating element 6 heats the cathode emitter 2 to thermionic emission temperature for providing a copious supply of electrons for the magnetron interaction region 5. A pair of axially spaced magnetic pole structures 7 and 8 produce an axially directed magnetic field B in the interaction region 5.

An annular circular electric mode cavity resonator structure 11 surrounds the anode wall 3. An array of axially directed coupling slots 12 communicate through the anode wall structure 3 with the spaces defined by alternate vane resonators for locking the π mode of operation of the system of vane resonators to the resonant frequency of the circular electric mode cavity 11. An annular tuner plate 13 is disposed at one axial end of the circular electric mode resonator 11 for tuning the resonant frequency of the resonator 11. A mechanical spider structure 14 is connected to the annular tuning ring 13 and a tuner shaft 15 is connected to the spider 14 for producing axial translation of the tuning ring 13 for tuning the operating frequency of the tube.

The annular tuning ring 13 includes a pair of annular conductive plates 16 and 17 which sandwich a mode absorbing material 18 such as carbon impregnated alumina for absorbing undesired noncircular electric modes within the cavity 11.

A ring shaped slot mode absorber structure 21 is disposed inside the anode wall 3 adjacent the ends of the coupling slots 12 for absorbing energy of the slot resonant mode within the slots 12. The mode absorber structure 21 includes a ring shaped mode absorbing element 22 formed by a plurality of arcuate segments retained within an annular conductive metallic channel 23 as of copper. (See FIGS. 3 and 4.) The retaining channel 23 is affixed to the anode wall 3 via the intermediary of a plurality of rivets 24. The side edge of the channel 23 which faces the vane resonators 4 does not completely cover the mode absorbing element 22 to facilitate coupling of energy from the slot mode into the mode absorbing element 22. The mode absorbing element 22 overlays the end portions of the slots 12 to provide adequate R.F. coupling between the mode absorbing element 22 and the energy within the slots 12.

The retaining channel 23 is preferably made of the same material as the anode wall 3, such as copper, such that it will have the same coefficient of linear thermal expansion for retaining the mode absorbing element 22 against the anode wall 3 as the tube is cycled in temperature. By assuring that the mode absorbing element 22 is held tightly against the anode wall 3 in the vicinity of the slots 12 arcing is prevented which can sometimes occur if the mode absorbing element 22 is permitted to pull away from the slots to define a gap between the mode absorbing element and the anode wall 3. In addition to providing a retaining structure for the mode absorbing element 22, the channel 23 provides a good thermally conductive path for removing heat from the mode absorbing element 22 to the anode wall 3. Due to the segmented nature of the mode absorbing element 22, assembly of the slot mode absorber 21 is facilitated since these segments are readily inserted within the retaining channel 23 which in turn is readily affixed to the anode wall 3 via rivets 24. As indicated in FIG. 5, the mode absorbing element 22 may be segmented to form two, three, four or more arcuate segments.

Referring now to FIG. 2, there is shown the prior art mode absorbing ring structure 26 which was pinned to the pole piece 8 via pins 27. The mode absorbing ring 26 was made of carbon impregnated ceramic and it had a different coefficient of linear thermal expansion than the iron pole piece 8. As a result, thermal cycling of the tube often produced cracks in the ceramic ring 26 as indicated at 28. Such a crack produces localized hot spots at the gap produced by the crack which further results in cracks 29 running circumferentially of the mode absorbing ring 26. The circumferentially directed cracks 29 cause portions of the mode absorbing ring to crack off and fall into the vane resonators 4, thereby shorting same. By providing the mode absorbing ring structure in the form of a pluralmity of arcuate segments, thermally produced stresses are not transmitted to the ring structure and as a consequence cracks are not formed therein. Moreover, due to the provision of the retaining channel 23 and the segmented nature of the mode absorbing ring element 22 the ring segments may be tightly held to the anode wall during thermal cycling of the tube.

In a typical example of the present invention, the slot mode absorbing ring structure 22 was formed of four arcuate segments having a 0.015 inch wide gap between adjacent segments. The mode absorbing ring structure had an inside diameter of 1.643 inches and a radial thickness of 0.117 inch and an axial length of 0.625 inch. The mode absorbing element 22 overlaid the terminal 0.250 inch length of the coupling slots 12 and was retained within a copper retaining channel 23 formed of sheet metal having a thickness of 0.010 inch. The mode absorbing structure 21 operated in a tube having a peak power of 1 megawatt an average power of 1 kilowatt, and a pulse length of 2 microseconds. Slot mode absorber 21 performed satisfactorily without any tendency for overheating or cracking.

In operation of the tube, magnetron type interaction is obtained between the electric fields at the tips of the vane resonators and the rotating spokes of space charge in the magnetron interaction region to produce microwave power at the frequency determined by the resonance frequency of the circular electric mode resonator 11. Output energy is extracted from the resonator 11 by an iris 31 and fed to a suitable utilization device, not shown, by an output waveguide 32 sealed by a gas-tight wave permeable R.F. window 33. The slot mode absorber 21 loads down the resonant mode of the slots 12 and prevents spurious oscillations in the output signal at the frequency determined by the slot mode of resonance. The output frequency of the microwave power is tuned by tuning the resonant frequency of the circular electric mode cavity 11 via tuner 13.

Referring now to FIG. 6, there is shown an alternative embodiment of the present invention. More specifically, in this embodiment the vane resonators 4 project outwardly from the anode wall 3 toward a surrounding cathode emitter 35. The anode wall 3 surrounds a circular electric mode resonator 36 coupled to the vane resonators 4 via coupling slots 12. A segmented slot mode absorbing ring structure 21 is affixed to the anode wall 3 for absorbing energy from the slot mode. An annular retaining channel 37 holds a plurality of arcuate ring segments of lossy material against the outside surface of the anode wall 3 overlaying the ends of the coupling slots 12. The retaining channel 37 is held to the anode wall 3 via a plurality of rivets 24. A tuner structure 38 is disposed inside the circular electric mode resonator 36 for tuning thereof and, thus, for tuning the operating frequency of the tube.

Since many changes may be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a high frequency tube apparatus, means forming radially spaced concentrically disposed anode and cathode electrode structures to define a magnetron interaction region therebetween said anode structure including a cylindrical anode wall, means forming an array of radially directed vane resonators projection from said

anode wall toward said cathode electrode, said anode structure including a circular electric mode cavity resonator coaxially disposed of said vane resonators, means forming an array of axially elongated coupling slots communicating through said anode wall structure between said array of vane resonators and said circular electric mode resonator for locking the π mode of said array of vane resonators to a resonant frequency of said circular electric mode cavity, means forming a mode absorber structure disposed adjacent the ends of said slots for damping a resonant mode of said coupling slots, the improvement wherein, said mode absorber structure comprises a ring-shaped lossy structure formed by a plurality of arcuate segments of lossy material, and means for holding said lossy arcuate segments adjacent said anode wall overlaying the ends of said slots.

2. The apparatus of claim **1** wherein said means for holding said segments adjacent said anode wall includes, an annular conductive metallic channel having said arcuate lossy segments retained within said channel.

3. The apparatus of claim **2**, including means for affixing said channel to said anode wall with the open side of said channel facing said anode wall.

4. The apparatus of claim **3** wherein said channel is made of a material having substantially the same coefficient of linear thermal expansion as the material of said anode wall.

5. The apparatus of claim **4**, wherein said lossy arcuate segments are made of carbon impregnated ceramic.

6. The apparatus of claim **4** wherein said channel is made of copper and said anode wall is made of copper.

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HERMAN K. SAALBACH, Primary Examiner

SAXFIELD CHATMON, Jr., Assistant Examiner

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315—39.61; 331—91; 333—83