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MAGNETRON

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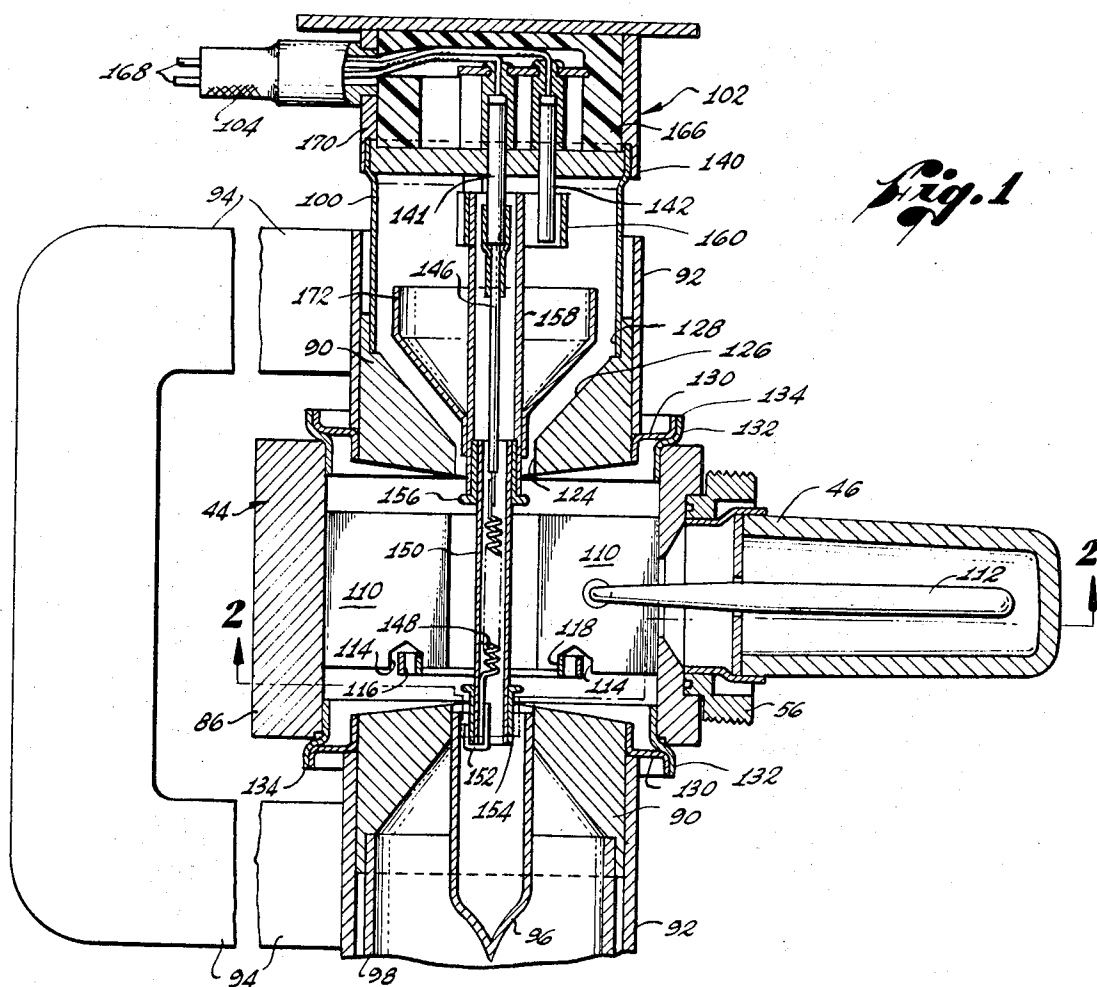


Fig. 1

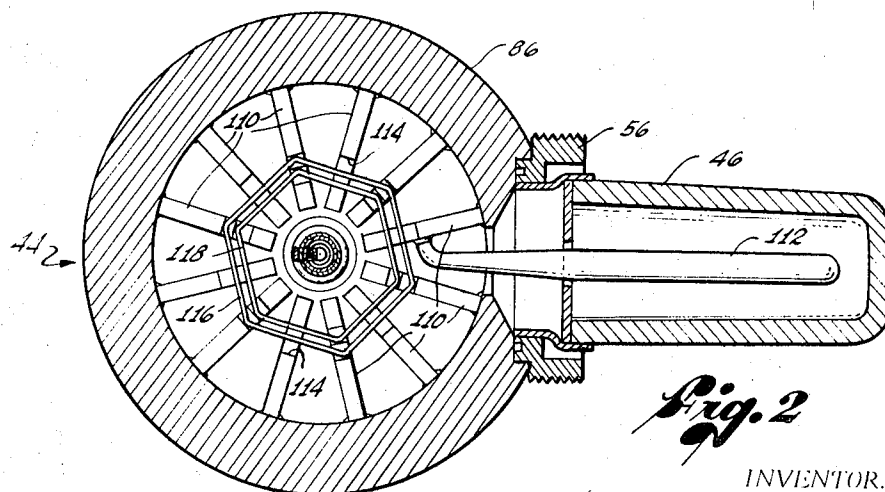


Fig. 2

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3,543,082
MAGNETRON

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5 Claims

ABSTRACT OF THE DISCLOSURE

A magnetron has an anode block with grooved radial vanes, and concentric hexagonal straps disposed with the sides of the inner strap and corners of the outer strap, respectively secured to the inner and outer sides of alternate grooves. The sides of the straps are bendable for mode stabilization purposes. A cathode sleeve in the block is engaged at one end by the smaller end of a stepped tubular element which extends into one of two pole pieces fitted in the ends of the block, the gap thus formed being dimensioned to prevent coupling of energy in the block to an external power supply and to isolate undesired harmonics.

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of my pending application, "Microwave Heating Apparatus," Ser. No. 595,995, filed Nov. 21, 1966.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to devices for generating microwave energy, and more particularly to a novel magnetron structure of the strapped vane type.

Description of the prior art

Heretofore, it has required considerable time, effort and expense to properly make a magnetron with a strapped vane type of tuning cavity. In such a magnetron, an anode block is formed with a cylindrical cavity, and radial vanes are brazed to its inner wall. The vanes are provided with grooves, and care must be taken to secure the vanes in place so that the grooves of adjacent vanes are staggered. Alternate vanes, i.e., those with grooves located the same distance from the inner wall of the cavity, are strapped together by means of a respective circular metal strap. The inner strap is brazed to the inner sides of alternate grooves, and the outer strap is brazed to the outer sides of the remaining grooves.

During brazing, care must be taken to prevent either strap from engaging the bottoms of the grooves. Otherwise adjacent vanes are directly connected, and the structure will not perform the desired mode stabilizing function. Since the grooves are quite narrow and shallow, it is extremely tedious and time consuming to simultaneously hold such a strap in contact with adjacent vanes and above the floors of the grooves. Still further, even when such brazing is properly done, it is still possible to inadvertently bend a part of the strap intermediate brazed portions and bring it into contact with the bottom of the groove it is not supposed to touch. It is not uncommon, therefore, that magnetrons with such strapping arrangements are found to operate improperly, and to require replacement.

Other disadvantages of prior art magnetrons heretofore known are the lack of simple, compact and effective means to satisfactorily and reliably prevent energy gener-

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ated in the tuning cavity from being coupled to the magnetron power supply, and to isolate undesired harmonics.

SUMMARY OF THE INVENTION

My invention embraces a magnetron having a tuning cavity of the strapped vane type wherein all vanes have unstaggered grooves, and wherein the straps and grooves are shaped so the straps can be seated in position and are self-maintained in position during brazing. Further, my invention embraces a magnetron having a hollow pole piece and tubular element surrounded thereby to define a gap of such length and width variations as to form a low impedance coaxial line at the fundamental frequency of the tuning cavity, and to function as successive low-to-high impedance transformers to effectively eliminate undesired effects of predetermined harmonics. Such magnetron structure is one which can be assembled with ease, without the likelihood and need for repair and replacement due to improper assembly occasioned with prior art magnetrons, and which lends itself to volume production compared to prior art magnetrons.

BRIEF DESCRIPTION OF DRAWING

FIG. 1 is a longitudinal sectional view of my magnetron structure; and

FIG. 2 is a sectional view taken along the line 1—1 of FIG. 1, showing the arrangement of my unique mode-stabilizing straps.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown a magnetron 44 which has an output probe 112 extending into a shield 46 that is adapted to be inserted in a waveguide. To permit the magnetron to be releasably secured to such a waveguide, it is provided with a short threaded element 56 to which can be threaded a metal coupler (not shown) that is to be clamped to the waveguide. The magnetron is one having a tuning cavity of the strapped vane type, and having an anode body or block 86 with a plurality of spaced vanes 110 brazed to its inner surface, and with the probe 112 brazed to one vane and extending out of the body and into the shield 46, all in a conventional manner.

Pole pieces 90 extend from the opposite ends of the anode body 86. Slidably placed over the pole pieces 90 are magnetic sleeves 92 which have flat external surfaces. A U-shaped permanent magnet 94 is positioned on the side of the anode body 86 opposite the shield 46, with the flat surfaces at the ends of its legs placed against the confronting flat surfaces of the magnetic sleeves 92.

The magnetron is arranged to be evacuated through a tube 96 that extends through the lower pole pieces 90, and such tube 96 is surrounded by a protective cover or shield 98 which extends into and is secured to the pole piece 90. Electrical connections to the magnetron are made through a tube 100 extending out of the upper pole piece 90. A connector 102 is fitted over the upper end of the tube 100, and a cable 104 extends from the tube for connection to a power supply.

However, I employ unique means for strapping the vanes for mode stabilizing purposes. In this connection, each of the vanes 110 is provided adjacent its inner end with a groove 114, the sides of which are straight and parallel, and the bottom of which is V-shaped. Unlike conventional strapped vane magnetron cavities, wherein adjacent grooves are radially staggered, the grooves 114 in my improved structure are not staggered. As best seen in FIG. 2, the inner sides of all the grooves 114 are spaced the same radial distance from the inner wall of the body 86. Similarly, the outer sides of all the grooves are spaced the same distance from the inner wall of the body.

Thus, all vanes **110** are made of the same dimensions, with grooves located in the same positions in all such elements. Accordingly, the vanes can be easily assembled by an operator without taking the time heretofore required to make certain that adjacent vanes have their grooves staggered.

Such ease of assembly of the vanes is made possible by my unique strapping arrangement. Twelve vanes are shown in the particular example, and alternate ones of these vanes are connected by respective outer and inner hexagonal straps **116**, **118**. The corner portions of the outer strap **116** are brazed to the outer sides of alternate grooves, and the mid-points of the sides of the inner strap **118** are brazed to the inner sides of the remaining grooves. Inspection of FIG. 2 will show that the corner portions of the inner strap are located inwardly of respective grooves, and do not touch the adjacent inner wall of such grooves. Also, the mid-portions of the sides of the outer strap **116** pass through alternate grooves without touching any portion thereof.

In addition, the shapes of the grooves **114** and straps **116**, **118** facilitate assembly of the straps. The inner strap **118** preferably is dimensioned so that when it is slipped into the grooves, the mid-portions of its sides are in frictional engagement with the inner sides of the grooves to which such mid-portions are to be brazed. The strap is thus restricted against angular displacement prior to brazing. Also, since the bottoms of the grooves slope away from the sides thereof, the bottom edges of the mid-portions of the sides of the strap **118** come to rest against the outer end of the V, i.e., where the sides and bottoms of the grooves are joined.

The corners of angles of the outer strap **116** are similarly located in position against the outer sides of the grooves in which they are inserted. In assembly, the outer strap **116** is positioned with its corners aligned with those of the inner strap **118**, which automatically orients the strap **116** properly for connection to alternate vanes. As with the other strap, the shape of the groove limits inner movement of the strap **116**, and hence serves to locate it properly for brazing. Also, the strap **116** preferably is dimensioned so that slight force has to be exerted to force it inwardly, whereby its corners frictionally engage the outer sides of the grooves in which they are located. Such corner portions are then brazed and secured in place.

As previously indicated, the straps **116**, **118** perform the usual mode stabilizing function. In this connection, my strap arrangement is one that is readily adjustable after assembly to provide such corrections as are necessary for the desired mode stabilization and resonance frequency. To this end, all that is necessary is to deform one or more portions of the straps intermediate the points at which they are brazed. Thus, one or more corner portions of the inner strap **118** and/or one or more of the mid-portions of the sides of the strap **116** may be forced inwardly or outwardly to change the capacitance of the straps as needed. Since the straps are ribbon-like metal elements, they remain such deformation.

For ease of manufacture and assembly, the pole pieces **90** are made identical. As best seen in FIG. 1, each of the pole pieces is formed as a cylindrical element having a central opening that has a small cylindrical portion **124**, a frusto-conical portion **126**, and a recessed, enlarged diameter portion **128**.

The pole pieces **90** are mounted in the anode block **86** with their rounded end faces extending into the ends of the block. In the arrangement shown, the pole pieces are secured at the ends of the block by means of flanged rings **130**, **132** that are brazed, respectively, to the pole piece **90** and the block. In the particular arrangement shown, the rings **130** nest in the rings **132**, and are welded together as indicated at **134**, e.g., as by heliarc welding.

The tube **100** is supported in one of the pole pieces **90**, as by inserting it in the enlarged diameter portions **128** of the opening therein, and brazing it to the pole piece. An end cap **140** is inserted in the outer end of the tube **100** and bonded thereto, and connector pins **141-144** (see FIG. 1) extend through and are bonded to the cap. In the arrangement shown, the pin **141** extends through the center of the cap **140** and the pins **142-144** are spaced pins equidistant from the center pin **141**.

Within the interior of the tube **100**, the center pin **141** is connected to the heater lead **146** for a heater element **148** located in a sleeve cathode **150** that passes through the center of the vanes **110**. The heater **148** is connected at **152** to an end shield **154** that is fitted around the cathode **150** at one end thereof.

A similar end shield **156** is fitted around the opposite end of the cathode **150**, and a tube **158** is secured at one end to the shield **156**. As shown, the tube **158** surrounds the heater lead **146** and the inner end of the connector **141**, the outer end of the tube **158** being spaced from the inner face of the cap **140**. Frictionally fitted around the outer end of the tube **158** is a clip element **160** which, as best seen in FIG. 1, has outwardly extending legs which pass around and frictionally engage the connector pins **142-144**. Thus, the connector pins **142-144** are connected together electrically.

Through the connector **102** and the cable **104**, the heater **148** (via the pin **141**) and the cathode **150** (via the pins **142-144**) are adapted for connection to suitable heater and cathode potentials. To this end, the connector **102** is formed with an insulating body **166**, through which leads **168** extend from the cable **104** for connection to respective pins **141**, **142**. In the arrangement shown, the ends of the leads **168** are supported in socket connectors frictionally fitted over the outer ends of the pins **141**, **142**. The body **166** is surrounded by a shield **170** which is frictionally fitted over the outer end of the tube **100**.

The improved magnetron of my invention includes a novel choke structure for isolating the power supply from the microwave energy developed in the anode block **86**. To this end, I provide a tubular element **172** which has a surface configuration that generally conforms to the portions **124**, **126**, **128** of the opening in the pole piece **90**. The element **172** has its smaller end fitted over the tube **158** and secured thereto adjacent its inner end, as by spot welding. The length of the element **172** is such that the length of the gap surrounding the element **172**, measured from the outer end of the element **172** to the inner end of the pole piece **90**, is a quarter-wavelength of the fundamental frequency of the energy generated within the anode block **86**.

At such fundamental frequency, which for microwave cooking purposes preferably is in the region of 2,400 MHz., the confronting surface portions of all elements defining the gap, i.e., the portions of the elements **172** and the end shield **156** together with the confronting surface portions of the pole piece **90** and tube **100**, function as a low impedance coaxial line at such fundamental frequency. Since such line terminates at the outer end of the element **172**, the space within the tube **100** beyond the outer end of the element **172** constitutes an effective high impedance to the microwave energy. Accordingly, this construction form an effective choke to prevent the microwave energy from being coupled through the pin connectors to the power supply.

In addition, the choke construction of my invention is adapted to minimize the effects of troublesome harmonics. In this connection, it will be observed that the coaxial line above-mentioned is a stepped affair. The gap is the smallest in the region of the portion **124** of the opening in the pole piece **90**, is somewhat wider in the frusto-conical region thereof, and is widest along the enlarged diameter portion of the element **172**. Such step-wise variations in the width of the gap, together with the

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differing lengths of the cylindrical and frusto-conical portions thereof, provide effective coaxial lines which are successive low-to-high impedance transformers. The dimensions preferably are selected to effectively isolate the most troublesome harmonics, e.g., the second and fourth harmonics.

After the magnetron is assembled, it is evacuated via the tube 96. The tube 96 is brazed at its inner end within the small diameter portion of the pole piece 90 in which it is inserted. After assembly of the magnetron, the tube 96 is connected to a vacuum pump for evacuating the entire structure in a conventional manner, following which the tube 96 is pinched off and closed at its outer end as indicated in FIG. 1.

In addition to the advantages of my magnetron structure as above described, I achieve a marked improvement over prior art structures in the concentration of magnetic lines of force at the ends of the vanes 110. Since the inner ends of the pole pieces 90 are rounded, whereby their center portions are closest to the inner ends of the vanes 110, and since the pole pieces are inwardly tapered as described and have the greatest portion of their masses located immediately adjacent the ends of the vanes, they are effective to concentrate the flux from the magnet in the center portion of the anode block 86.

I claim:

1. The combination, in a magnetron of:
an anode block;

a plurality of spaced radial vanes in said block, each vane at one end having a groove with parallel sides, said grooves being located in the same positions in said vanes;

and a pair of concentric metal straps of predetermined widths disposed in said grooves, each strap being performed with equidistant corner portions equal in number to half the number of vanes,

the outer strap being dimensioned to be inserted in the the grooves so the corner portions along the widths thereof fit snugly against the outer sides of alternate grooves, the side portions of said outer strap passing intermediate and in non-touching relation with any portions of the remaining grooves,

the inner strap being dimensioned to be inserted in the grooves so that its side portions along the widths thereof midway between adjacent corner portions thereof fit snugly against the inner sides of said remaining grooves, the corner portions of said inner strap passing intermediate and in non-touching relation with any portions of said alternate grooves,

the corner portions of said inner strap and the side portions of said outer strap being adjustably radially deformable within their grooves to vary their capacitance with the confronting portions of the other strap,

and the corner portions of said outer strap and sides of said inner strap being permanently and conductively secured to the sides of the grooves engaged thereby.

2. The combination of claim 1, wherein the bottoms of the grooves are V-shaped, wherein the lower edges of the corner portions of said outer strap are seated on the outer top portions of the V-shaped bottoms of said alter-

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nate grooves, and wherein the lower edges of the side portions of said inner strap are seated on the inner top portions of said V-shaped bottoms of said remaining grooves.

3. A magnetron comprising:

a cylindrical anode block having strapped radial vanes therein;

an external probe extending into the space between two of the vanes;

a pair of pole pieces secured in the ends of said block, one of said pole pieces having a stepped opening therethrough, the smallest portion of said opening being at the end of said one pole piece adjacent said block;

a cylindrical element secured to the other end of said one pole piece;

a cathode sleeve extending through the center of said block and intermediate the ends of said vanes;

a tubular extension for said sleeve extending through said cylindrical element;

a stepped tubular element in said one pole piece, said tubular element surrounding said extension and having its smaller end secured to said extension in said smallest portion of said pole piece opening, the confronting surface portions of said stepped tubular element and said one pole piece forming a gap of varying dimensions to isolate the fundamental and predetermined harmonics of microwave energy generated within said block from the outer end of said cylindrical element;

means at the outer end of said cylindrical element for connecting said heater and cathode to respective energizing potentials;

and an exhaust tube extending out of the other pole piece.

4. A magnetron as defined in claim 3, wherein the opening in said one pole piece has a frusto-conical portion extending between relatively small and large cylindrical portions, and wherein said stepped tubular element is shaped with a frusto-conical portion intermediate relatively small and large cylindrical portions.

5. A magnetron as defined in claim 4, including a pair of magnetic sleeves slidably mounted on said pole pieces, each of said sleeves having a flat external face; and a U-shaped permanent magnet having its ends engaging said flat faces.

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