

Aug. 26, 1958

P. W. CRAPUCHETTES

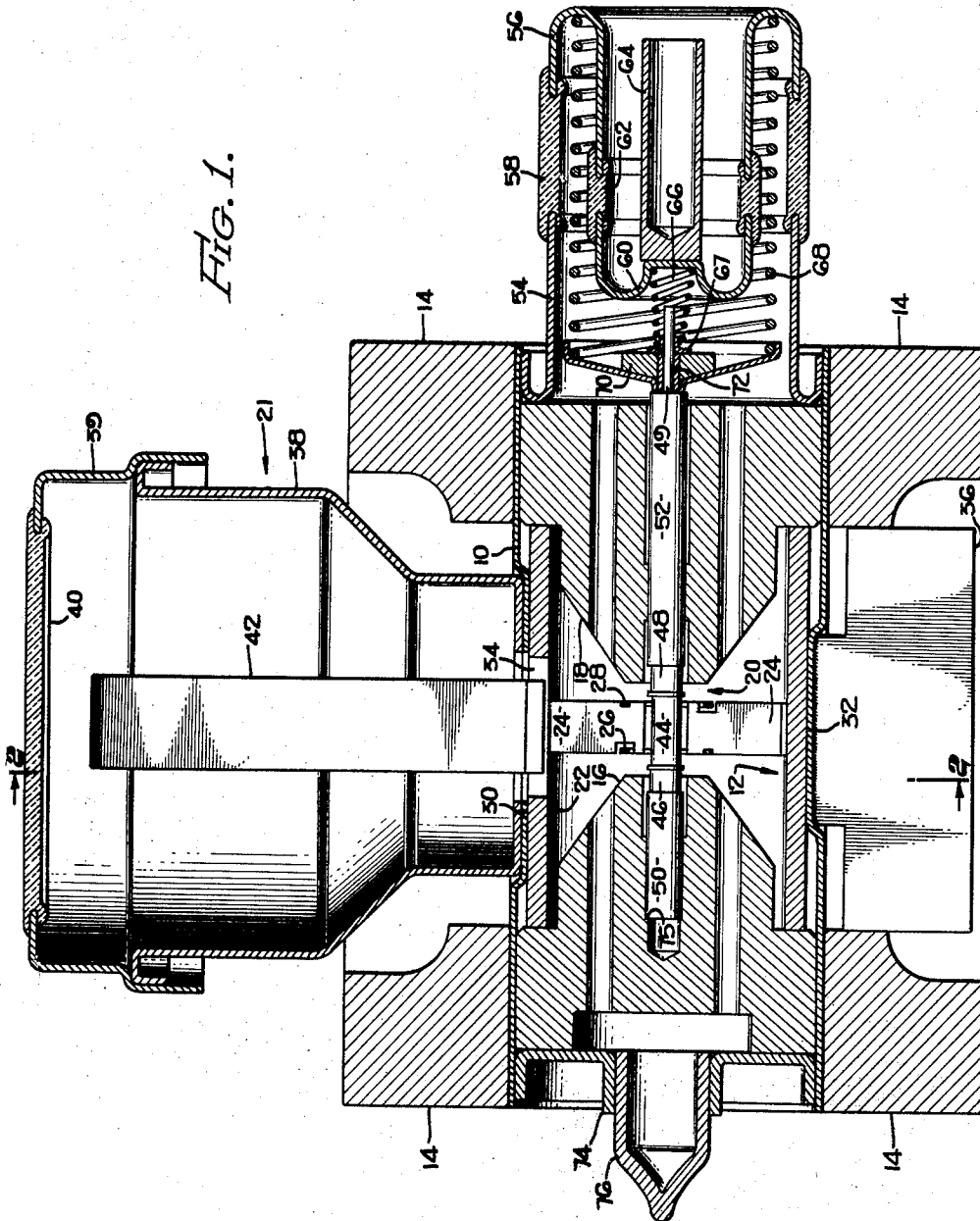
2,849,633

MAGNETRON

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2 Sheets-Sheet 1

FIG. 1.



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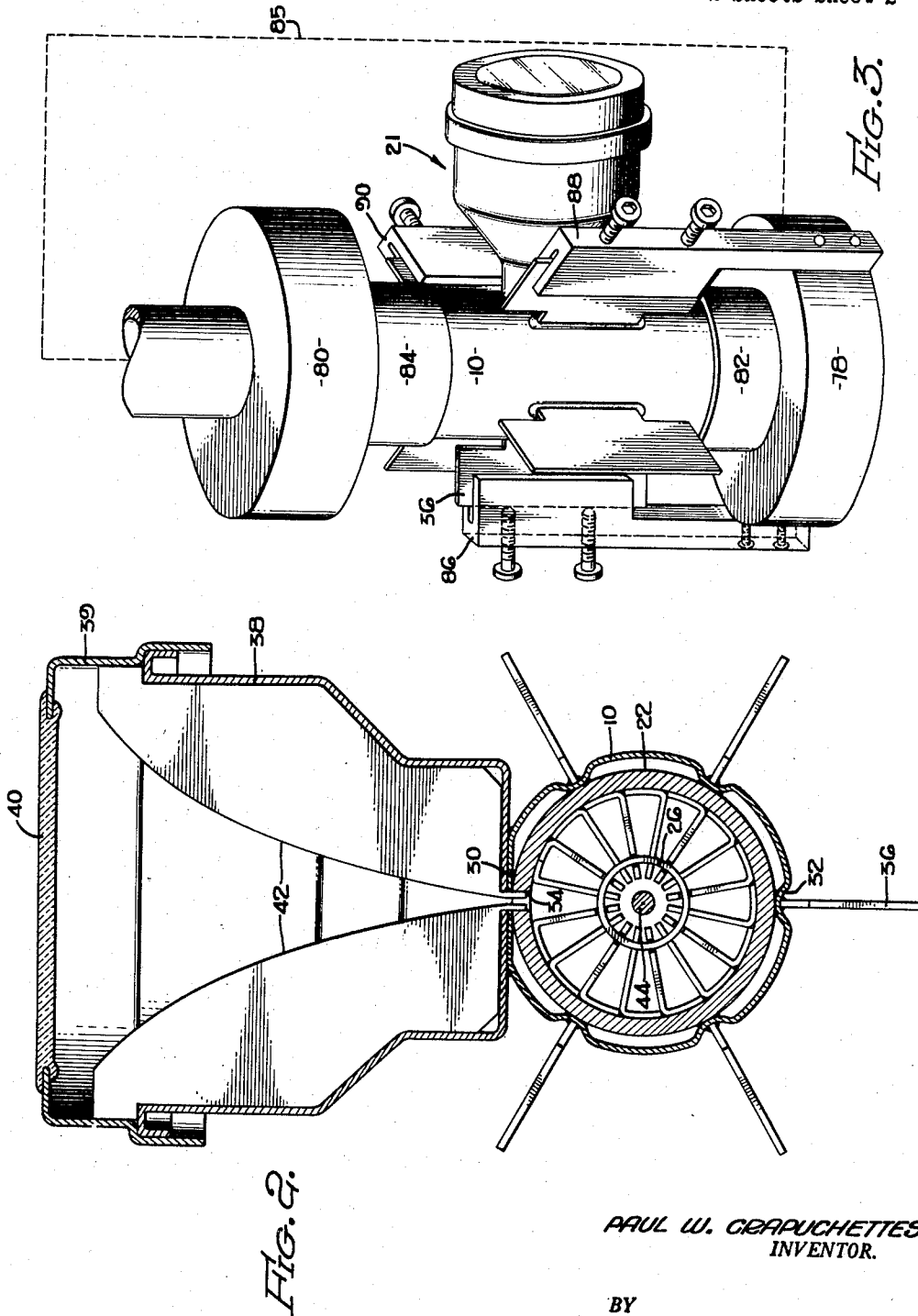
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MAGNETRON

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9 Claims. (Cl. 313—45)

This invention relates to magnetrons and more particularly, to magnetrons which include a housing structure having a plurality of spaced projections therein for supporting the associated magnetron anode at a plurality of spaced points about the anode periphery.

In the magnetrons of the prior art, the anode, which comprises an annular member of conducting material having a plurality of longitudinally arranged resonant cavities therein, is conventionally mounted by inserting the anode within an associated housing member having a cylindrical hole bored therethrough, the inside diameter of the hole being slightly larger than the outside diameter of the anode. After the anode has been properly positioned longitudinally within the housing member, the two are brazed together to provide a unitary structure wherein the housing member is fused to the original anode over substantially all of its cylindrical periphery. Magnetrons illustrating this general construction are illustrated in copending U. S. patent applications Serial Numbers 373,761, for "Frequency Stable Magnetron," and 373,762, for "Magnetron Anode-Cathode Structure," both filed August 12, 1953, by Paul W. Crapuchettes.

Although magnetrons in which the anode has been mounted in the above-described manner have been found to perform satisfactorily in most instances, there are several distinct disadvantages inherent in this prior art structure and in the method of making it. Firstly, the brazing process whereby the anode is affixed along its entire periphery to the interior of the housing member has been found to produce air pockets or gas traps between the anode and the housing. These traps frequently remain isolated from the vacuum chamber of the magnetron until the magnetron has been completely assembled, out-gassed and sealed, whereupon gas molecules leak from the traps into the relatively hard vacuum that has been established, thereby creating a gassy tube.

A second disadvantage of the prior art magnetron housing assembly is that it is difficult to subsequently center the anode properly about the associated magnetron cathode, this centering operation usually being performed after the magnetron has been assembled by deforming the housing member to which the anode has been affixed. Still other disadvantages of the above-mentioned prior art process are that it is relatively expensive and time-consuming, and rupturing of the housing member occasionally occurs when the anode is brazed along its entire periphery.

The present invention obviates the above and other disadvantages inherent in the magnetrons of the prior art and provides magnetrons which are relatively free from gassing and in which centering of the associated anode and cathode is easily performed. According to the basic concept of the invention, magnetrons are provided in which the anode is mounted within a tubular housing member at a plurality of spaced points, the anode being spaced from the housing member by a finite distance in the regions between these points to provide an assembly

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which is easily fabricated and in which gas traps are essentially eliminated.

More particularly, the magnetrons of the present invention include a tubular housing member having a central region and two end regions, the central region of the housing member having a plurality of evenly spaced grooves or indentations in the external periphery thereof, or stated differently, a corresponding plurality of evenly spaced projections protruding from the interior wall of the housing member. The diameter of the reference circle defined by these projections within the housing member is preferably slightly smaller than the diameter of the magnetron anode so that the anode may be press-fitted against the projections in the central region of the housing member and thereafter be affixed permanently thereto as by brazing the anode to the housing member at the points of contact therebetween.

According to the invention the anode is preferably affixed to the housing member as by brazing the two together at each of the contacting projections except one, this one area of contact being machined in a suitable manner to provide an iris or output aperture for coupling the resonant system of the magnetron to an electrical output circuit such as a waveguide, for example. Cooling of the magnetron anode may then be provided by affixing a plurality of cooling fins to the center of the housing member, the fins preferably being positioned in the bottom of the indentations previously formed in the housing member.

It is therefore an object of the invention to provide magnetrons wherein the anode is mounted within its associated magnetron housing member at a plurality of spaced points, thereby facilitating the subsequent centering of the anode about its associated cathode.

Another object of the invention is to provide magnetrons which are relatively immune from gassing owing to the fact that the connection between the anode and the associated magnetron housing member consists of a plurality of spaced connections of relatively small cross-sectional area, thereby substantially eliminating gas traps.

Still another object of the invention is to provide magnetrons in which the anode includes an annular member which is fixedly suspended in the associated housing member by a plurality of spaced projections which protrude from the interior wall of the housing member.

A further object of the invention is to provide magnetrons in which the anode is mounted within a tubular housing member having a plurality of spaced grooves in the external periphery of its central region, the anode being connected to the projections thereby formed in the interior of the housing member whereby gas traps are substantially eliminated and the anode subsequently may be easily centered about its associated cathode.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which one embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

Fig. 1 is a sectional view of a magnetron, according to the invention, illustrating the manner in which the anode assembly is mounted within its associated housing member;

Fig. 2 is a partial sectional view of the magnetron of Fig. 1 taken perpendicular to the plane defined by section line 2—2 in Fig. 1; and

Fig. 3 is a diagrammatic view of one form of centering apparatus which has been found suitable for centering

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the anode and cathode assemblies of magnetrons constructed according to the invention.

Referring now to the drawings, wherein like reference characters are employed to designate like or corresponding parts throughout the several views, there is shown in Fig. 1 a sectional view of a magnetron which includes the novel housing structure of the invention. As shown in Fig. 1 the magnetron includes five basic components, namely: a tubular housing member 10, according to the invention; a multicavity anode assembly, generally designated 12; a magnetic circuit including a magnet 14, and a pair of pole pieces designated 16 and 18, respectively, for generating a magnetic field of predetermined magnitude and gradient along the longitudinal axis of the anode assembly; a cathode assembly, generally designated 20, connected to the right hand end of housing member 10, as viewed in Fig. 1 and adapted to cooperate with the anode assembly for emitting electrons which, under the influence of the magnetic field, are operable to convert D.-C. electrical energy to high-frequency radio energy; and an output structure, generally designated 21, which is connected to the external periphery of housing member 10 and is employed for coupling the resonant system of the magnetron to an output circuit, not shown.

Anode assembly 12 may be constructed to have any of numerous cavity conformations known to the art. As shown in Fig. 1, for example, wherein a vane type anode structure is employed, the anode assembly includes an anode ring or annular member 22 consisting of a suitable material such as copper-clad molybdenum, for example, and a plurality of vanes 24, which are brazed to the center of ring 22 and extend radially inward, only two of the vanes being visible in Fig. 1. In addition, the anode assembly may also include a pair of strapping rings 26 and 28, as shown in Fig. 1, which interconnect the inner ends of alternate vanes to effect separation of the oscillatory modes of the magnetron in the manner well known to the art.

The magnetron anode assembly is mounted substantially in the center of tubular housing member 10, the housing member, according to the invention, having a plurality of evenly spaced grooves or indentations depressed in the external periphery thereof whereby a corresponding plurality of projections are formed in the interior wall of the housing member, the anode assembly being held by and affixed to these projections. In the sectional view of Fig. 1 only two of these projections are visible, the projections being designated 30 and 32, respectively. A magnetron iris or output aperture 34 is machined through housing member 10 at projection 30 and through the adjacent portion of anode ring 22 for coupling the resonant system of the magnetron to output structure 21, while the remainder of the projections, as exemplified by projection 32, are connected to the anode assembly as by brazing, for example. In addition a cooling fin, such as fin 36, is positioned in the bottom of each of the grooves formed in the external periphery of the housing member, with the exception of groove 30, and is affixed to the housing member by brazing, for example, to provide a cooling system for dissipating heat which is generated when the magnetron is placed in operation.

It will be noted from Fig. 1 that groove 30 is slightly longer than groove 32, the reason being that in the particular embodiment of the invention illustrated the housing member is embossed adjacent the output aperture in order to provide a flat surface for butt-brazing output wave guide structure 21 to the housing member. It will be readily recognized, however, that groove 30 could be shaped to be identical in form with groove 32, if desired, in which instance the connecting portion of output structure 21 would be flanged outwardly and would be affixed to the cylindrical periphery of the housing member.

With reference now to Fig. 2, there is shown a partial sectional view of the magnetron of Fig. 1 taken along line 2—2 illustrating the manner in which the anode assembly

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is affixed to the projections which extend within housing member 10. For purposes of illustration, the housing member is shown to have six evenly spaced grooves about its periphery, these grooves forming a corresponding plurality of projections within the housing member. It will be readily recognized, of course, that a larger or smaller number of grooves may be employed in the construction of magnetrons in accordance with the fundamental concept of the invention.

In practice, housing member 10 is preferably fabricated so that the reference circle defined by the tips of the projections has a diameter slightly smaller than the outside diameter of anode ring 22 thereby enabling the anode assembly to be press-fitted into the housing member and thereafter permanently affixed to the projections. The housing member may be composed of any suitable material such as 326 Monel, for example, and as shown in Fig. 2, is brazed to anode ring 22 at five of the regions of contact between the two elements. The remaining projection corresponds to projection 30 in Fig. 1, and as will be recalled, is apertured for coupling the resonant system of the magnetron to output structure 21. In addition, Fig. 2 illustrates how projection 30 may be formed by embossing the housing member to provide not only a projection in contact with the anode assembly, but a flat surface for mounting the associated output structure.

The output structure of the magnetron, as shown in both Fig. 1 and Fig. 2, includes a horn-shaped member 38 affixed to housing member 10 as by brazing, an output window 40 which is composed of glass or a similar material transparent to high-frequency waves and which is hermetically sealed to a Kovar sleeve 39 at the upper end of the horn-shaped member, and a pair of ramps 42 positioned within the horn-shaped member and extending into output aperture 34 in the housing member. As illustrated in Fig. 2, ramps 42 are positioned close together within output aperture 34 and diverge outwardly as they approach window 40, the ramps being operable as an impedance transformer for matching the impedance of the resonant system of the magnetron to the impedance of an output waveguide, not shown.

It will be recognized by those skilled in the art that although the output structure is apparently coupled to only one magnetron cavity, the fact that alternate vanes are strapped together results in the output structure being actually closely coupled to all of the cavities which together form the oscillatory or resonant system of the magnetron. It will also be recognized that other forms of output circuits, such as a loop-coupler for example, may be employed with the basic magnetron structure of the invention.

Referring again to Fig. 2 there is also shown in more detail the cooling fin arrangement whereby heat energy developed within the magnetron is readily dissipated. As set forth hereinabove, a cooling fin, such as fin 36, is connected to the external periphery of housing member 10 adjacent each region of engagement between the anode assembly and the housing member. In practice it has been found that the placement of the cooling fins in the bottom of the grooves in the housing member, substantially as shown, functions to maintain the operating temperature of the magnetron anode assembly at a relatively low value.

Consider now the advantages inherent in the utilization of the novel housing structure of the invention. In addition to the obvious fact that the structure is relatively simple and inexpensive to construct, it will be readily recognized from Fig. 2 that the mounting of the anode assembly at a plurality of spaced points effectively eliminates completely the occurrence of gas traps which are frequently formed in the magnetrons of the prior art wherein the anode assembly is welded or brazed along its entire periphery to the housing structure. In addition, suspension of the anode assembly at a plurality of spaced points provides a rigid unitary structure which

nevertheless permits the tubular housing member to be easily deformed with the use of a suitable jig, thereby facilitating the centering of the anode assembly about its associated cathode during the final testing of the magnetron.

Referring once more to Fig. 1, cathode assembly 20 is illustrative of one form of pulse magnetron cathode structure which may be employed in the magnetron of the invention, it being understood, of course, that magnetrons constructed according to the basic concept of the invention may also be employed for continuous wave operation. As shown in Fig. 1, the cathode assembly includes a tubular oxide-coated cathode 44, a pair of end hats, designated 46 and 48, respectively, which are positioned over a portion of the cathode to restrict the region of electron emission to the interaction space between the anode vanes and cathode, and an associated cathode support and lead-in assembly for mechanically mounting the cathode and for electrically energizing a heater element 49, only the right hand end of which is shown, the filament being positioned inside the tubular cathode 44.

Cathode 44 may be composed of an oxide-coated nickel sleeve, for example, while end hats 46 and 48 are preferably constructed of a relatively non-emissive material such as molybdenum coated with aluminum oxide. As shown in Fig. 1, the cathode and its associated end hats are mounted in a pair of insulative sleeves 50 and 52, these sleeves in turn being mounted within pole pieces 16 and 18, respectively, for maintaining cathode 44 in a fixed position relative to anode assembly 12.

The lead-in assembly for the cathode and its associated filament comprises two Kovar grommets 54 and 56 which are sealed to and mechanically interconnected by a first glass sleeve 58, and a Kovar cup 60 which is mechanically coupled to grommet 56 by a second glass sleeve 62. In operation the filament of the heater is energized by applying the filament voltage across grommet 56 and a terminal stud 64 which is connected to cup 60, the electrical connection between cup 60 and one end of the filament being made through a spring 66 which contacts a grommet 67 affixed to the end of the filament. The other end of the filament is connected to the inner wall of the nickel sleeve which constitutes the cathode, the connection being made in the region of end hat 46. The filament circuit is completed through a second spring 68 which electrically interconnects grommet 56 and the right hand end of the cathode sleeve which, as illustrated in Fig. 1, is flared to provide a bell-like region for receiving the left hand end of spring 68. The two springs 66 and 68 also function to maintain the axial position of cathode 44 by forcing sleeve 50 against an internal shoulder 73 in pole piece 16. It will be noted that the cathode assembly further includes an insulative washer 70 and an insulative sleeve 72 for insulating filament 49 from the cathode within that portion of the cathode assembly surrounded by the outer insulative sleeve 52.

The axial position of the cathode terminal assembly is predetermined by the dimensions of pole piece 18 which abuts anode ring 22 on its left hand end, as viewed in Fig. 1, and grommet 54 on its right hand end, grommet 54 being brazed to the end of housing member 10. Pole piece 16, on the other hand, is maintained in abutment with the other end of the anode assembly by an annular closure member 74, which is affixed, as by brazing, to the left hand end of housing member 10 as viewed in Fig. 1. Affixed to closure member 74 at its aperture is a relatively short length of tubing 76 which is utilized for evacuating the magnetron, the tubing thereafter being pinch-sealed at its end substantially as shown.

Pole pieces 16 and 18 may be composed of any suitable ferromagnetic material, such as 410 stainless steel, for example, and are operable in conjunction with magnet 14, which is preferably constructed of Alnico V, for generating the magnetic field essential to operation of

the magnetron. In the embodiment of the invention shown in Fig. 1, the permanent magnet includes a pair of E-shaped magnets each having a circular hole in its middle arm for fitting over the ends of housing member 10 adjacent pole pieces 16 and 18. Thus, as viewed in Fig. 1, only one half of each of the magnets is visible, one of the magnets being fitted over housing member 10 adjacent pole piece 16, while the other magnet is fitted over the housing member adjacent pole piece 18, the two magnets being joined together in the vertical plane which bisects housing member 10 and output structure 21.

It will be recalled that one of the principal advantages inherent in the magnetron structure of the invention is that the anode assembly may be easily centered about its cathode after the magnetron has been assembled and evacuated. Referring now to Fig. 3, there is shown one form of apparatus which has been found suitable for performing the centering operation, the apparatus including a pair of electromagnets 78 and 80 having a pair of respectively associated collars 82 and 84 attached thereto, the electromagnets being mechanically interconnected and axially moveable relative to each other by a suitable structure as indicated schematically by the dotted line 85. The centering apparatus also includes three evenly spaced jigs 86, 88 and 90, respectively, which are mechanically connected at their lower ends to magnet 78, each jig including a slotted upper end and two adjusting screws which are moveable horizontally within the associated slot.

Assume now that the apparatus of Fig. 3 is to be employed for centering the magnetron anode about its associated cathode which, it may be recalled, is rigidly held within the magnetron housing member by its associated mounting assembly. The magnetron is first placed in the centering apparatus so that its cathode and filament terminals and the adjacent portion of the housing member are held by collar 82, the collar being provided with suitable clamping means, not shown, for rigidly holding the magnetron. During this operation the magnetron is oriented so that one fin is inserted in each of the slots in jigs 86, 88 and 90. The upper electromagnet and its collar 84 are then moved down over the upper end of the housing member after which the electromagnets are energized and electrical connection is made to the cathode and filament terminals with suitable electrical connectors, not shown. In addition, an output waveguide, not shown, is connected to output structure 21 for coupling the magnetron to a suitable load.

After the magnetron has been properly positioned in the centering apparatus and the necessary electrical connections have been made, the magnetron is energized and its electrical characteristics are observed through the utilization of suitable measuring instruments. If the electrical characteristics are different from those desired owing to the fact that the anode is not suitably positioned relative to the cathode, selected screws in the vertical jigs are either tightened or loosened in a conjugate manner to selectively deform the housing member at its central region, thereby moving the magnetron anode assembly relative to the cathode until the proper position has been achieved.

In practice it has been found that although the novel magnetron structure of the invention permits the above-described centering operation to be performed with the utmost facility, the centering of the magnetron anode and cathode is permanent and relatively immune from shock. At the completion of the centering operation, the magnetron is removed from the centering apparatus and its own permanent magnet assembly is attached thereto after which final electrical tests may be made upon the entire device in the manner well known in the art.

What is claimed as new is:

1. In a magnetron, the combination comprising: an anode assembly including an annular anode member hav-

ing a substantially cylindrical periphery; a tubular housing member having a central region and two end regions, said housing member having a plurality of evenly spaced grooves depressed in its external periphery at its central region whereby a corresponding plurality of projections are formed in the internal wall of said housing member, each of said grooves and its corresponding projection being substantially parallel to the longitudinal axis of said tubular housing member, the reference circle defined by the tips of said projections having a diameter substantially equal to the diameter of said annular member, said annular member being positioned within said housing member adjacent said central region and being held therein by said projections; and a plurality of cooling fins fixedly attached to said central region of said housing member and extending radially outward, the plane of each of said fins being substantially parallel to the longitudinal axis of said tubular housing member.

2. The combination defined in claim 1 wherein the number of cooling fins is one less than the number of grooves in said central region of said housing member, said fins being respectively connected to said housing member at the bottoms of all of said grooves except one whereby heat generated within said anode assembly is readily dissipated in the surrounding atmosphere.

3. In a magnetron, the combination comprising: an anode assembly including an annular anode member having a substantially cylindrical periphery; and a tubular housing member having a central region and two end regions, said housing member having a plurality of evenly spaced grooves depressed in its external periphery at its central region whereby a corresponding plurality of projections are formed in the internal wall of said housing member, each of said grooves and its corresponding projection being substantially parallel to the longitudinal axis of said tubular housing member, the reference circle defined by the tips of said projections having a diameter substantially equal to the diameter of said annular member, said annular member being positioned within said housing member adjacent said central region and being apertured at the region of contact between said annular member of one of said projections whereby high frequency radio energy generated within said anode assembly may be coupled without said housing member.

4. In a magnetron, the combination comprising: a cylindrical anode assembly forming a plurality of cavity resonators extending radially inward toward the axis thereof; an evacuated envelope comprising a metallic tube, said tube having a central region and two relatively smooth cylindrical end regions, the central region of said tube having a plurality of evenly spaced grooves depressed therein to form a corresponding plurality of projections within the central region of said tube, said anode assembly being press-fitted inside the central region of said tube against said projections; a cathode; and means for mounting said cathode within said metallic tube and substantially concentric with said cylindrical anode assembly, said metallic tube being formed of relatively thin sheet metal to permit said anode assembly to be centered precisely with respect to said cathode by selective deformation of the grooved region of said metallic tube.

5. The combination defined in claim 3 which further comprises an output waveguide, said output waveguide including a pair of ramps each having one end positioned within the aperture in said housing member, said ramps diverging outwardly without said housing member.

6. In a magnetron, the combination comprising: an anode assembly including an annular anode member having a substantially cylindrical periphery; a tubular housing member having a central region and two end regions, said housing member having a plurality of evenly spaced grooves depressed in its external periphery at its cen-

tral region, each of said grooves forming a corresponding projection in the internal wall of said housing member and being substantially parallel to the longitudinal axis of said tubular housing member, the reference circle defined by the tips of said projections having a diameter substantially equal to the diameter of said annular member, said annular member being positioned within said housing member adjacent said central region and being held therein by said projections; a pair of end means hermetically sealing the opposite ends of said tubular housing member whereby the interior of said housing member may be evacuated, at least one of said end means including an insulated terminal; a cathode positioned within said tubular housing member concentric with said annular anode member, and means for electrically connecting said cathode to said insulated terminal.

7. In a magnetron, the combination comprising: a tubular housing member having a plurality of longitudinal grooves in its external periphery, said grooves being radially spaced equidistant from each other to form a corresponding plurality of projections in the internal wall of said housing member; a cylindrical anode assembly forming a plurality of cavity resonators extending radially inward, said anode assembly being positioned within said housing member and affixed at its periphery to said projections; and end means affixed at opposite ends of said tubular housing member and forming therewith a vacuum-tight enclosure.

8. In a magnetron the combination comprising: a tubular housing member having a plurality of longitudinal grooves in its external periphery, said grooves being radially spaced equidistant from each other to form a corresponding plurality of projections in the interior wall of said housing member; and a cylindrical anode assembly having a plurality of longitudinally arranged cavity resonators therein, said anode assembly being positioned within said housing member and being brazed to all but one of said projections, said housing member and said anode assembly being apertured in the region of contact between said one projection and said anode assembly whereby one of said cavity resonators within said anode assembly is coupled without said housing member.

9. A magnetron comprising: a tubular housing member having a central region and first and second end regions, said housing member having a plurality of evenly spaced longitudinal projections protruding from its interior wall at its central region; an anode assembly including an annular supporting member positioned within said housing member and fixedly supported by said projections, and a plurality of vanes mounted inside said supporting member integrally therewith, the size and position of said vanes forming together with said supporting member a plurality of resonators; first and second cylindrical magnetic pole pieces positioned within said first and second end regions, respectively, of said housing member and in spaced relationship with respect to said vanes, said pole pieces having an outside diameter slightly smaller than the inside diameter of said housing member; and closure means connected to the ends of said housing member for fixedly maintaining the axial position of said pole pieces relative to said vanes.

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