

Jan. 29, 1963

B. D. KUMPFER
MAGNETRON DEVICE

3,076,122

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2 Sheets-Sheet 1

Fig. 1

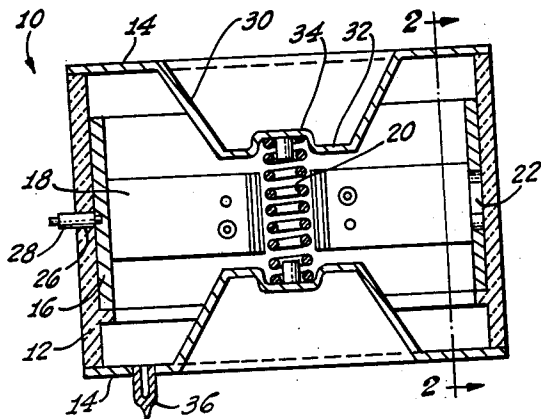


Fig. 2

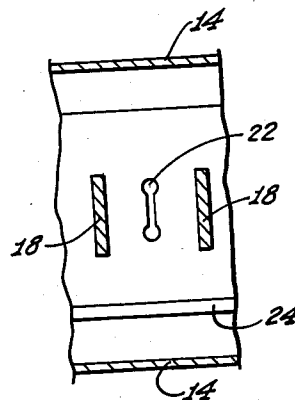
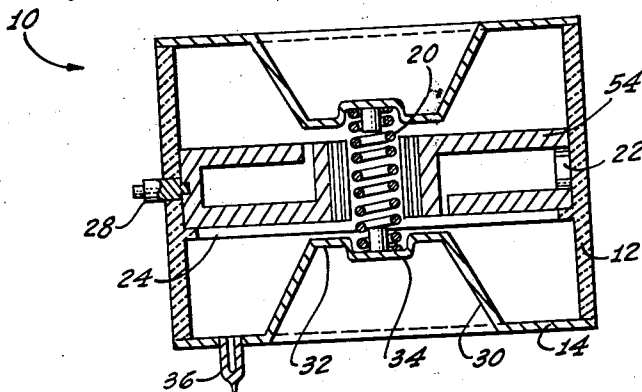


Fig. 5



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Fig. 3

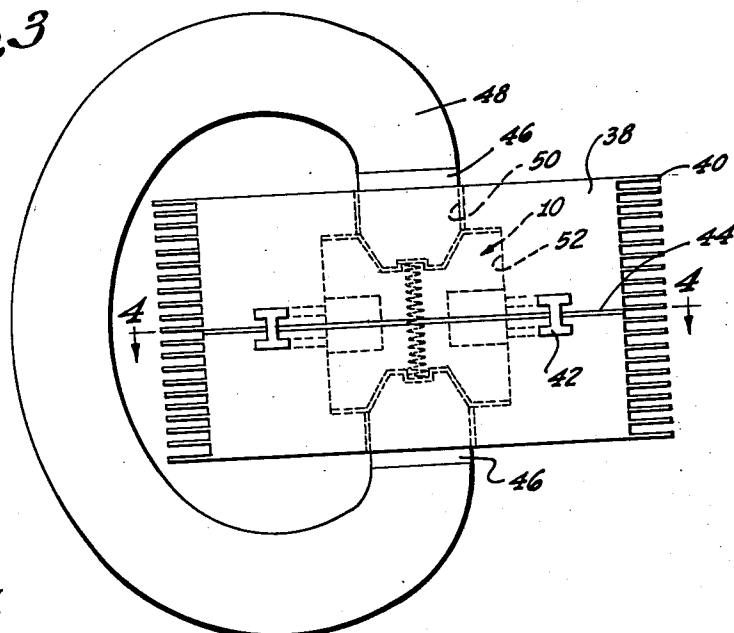


Fig. 4

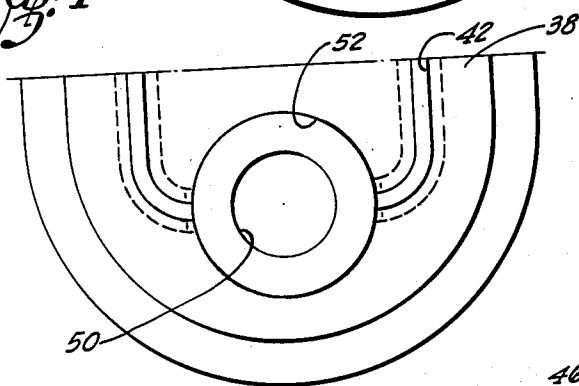
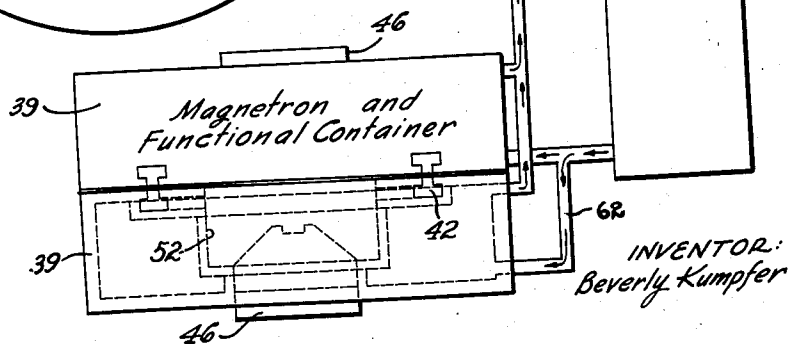


Fig. 6



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3,076,122

MAGNETRON DEVICE

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27 Claims. (Cl. 315—39.53)

This invention relates to a magnetron device, and more particularly to a microwave frequency magnetron having a unique structure for communicating microwave energy from its resonant circuit and a cooperating structure for removing heat and transmitting microwave energy generated by the magnetron during its operation.

In the prior art it has been customary to extract output energy from the anode of a multiresonator magnetron by means of a transmission network such as a coaxial line or wave guide structure which is included within the vacuum enclosure of the magnetron. In the instance of the coaxial line, one end of the center conductor thereof is generally a coupling loop which is disposed within one of the cavity resonators of the magnetron, where the end of the loop is grounded to the back wall of the cavity, while the other end thereof extends a preselected distance externally through an opening through the back wall. The outer conductor of the coaxial line, on the other hand, is terminated at one end at the outer wall of the anode block concentric with the aforesaid opening. The center and outer conductors are separated from one another along their entire length, which is a part of the vacuum envelope of the magnetron, and are terminated by an insulating member hermetically sealed therebetween.

On the other hand, the wave guide output coupling assembly generally comprises a suitable quarter wave transformer or an associated pair of exponential ramps disposed within and affixed to a section of wave guide which is hermetically affixed externally at one end to the anode block adjacent a coupling iris formed in the back wall of one of the cavity resonators of the magnetron. The other end of the wave guide assembly, which is part of the vacuum enclosure of the magnetron, is terminated by hermetically sealing thereto an output window of a preselected configuration substantially transparent to microwave energy.

Although the technique for employing coaxial lines or wave guide structures have been found to perform reasonably well in prior art magnetrons, especially those designed for military use, there still are several serious disadvantages attendant their use for commercial use, where factors of cost and simplicity of construction are of primary importance. Firstly, the mechanical configurations of the transmission networks which employ either a coaxial line or a wave guide structure are usually complicated from a structural point of view requiring intricate parts having close dimensional tolerances in order to form such structural configurations and therefore are costly to fabricate. Secondly, the number of structural components increases as the configuration of the transmission network becomes more complex, and generally this requires an increased number of vacuum seals to fabricate the structure thereby increasing the number of places where leaks may develop in the vacuum envelope. Finally, the complexity of the transmission network structure requires a rather elaborate associated external coupling device to insure good impedance matching between the magnetron and the external load, and therefore makes it difficult to alter the configuration of the output circuit when required. In addition, if the impedance match is not good, RF losses are generated which reduce the overall efficiency of the output coupling structure.

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In addition to the aforementioned technique, the prior art has also employed a technique of directly coupling one of the cavity resonators of the magnetron to an output transmission line through the use of a dielectric window wherein the window is disposed within the metallic enclosure wall of the magnetron adjacent the back wall of the cavity resonator by means of a hermetic seal. This type of output window has gained general acceptance because of its simplicity and strength. However, there still is a major disadvantage attendant its use under continuous wave operation at microwave frequencies where the window is relatively small. As energy is extracted from the magnetron during its operation, the concentration of electric fields in such a very small dielectric window generates excessive heat which tends to soften the window which in turn may cause the window to be punctured by the pressure difference between the vacuum within the magnetron and atmospheric pressure. The excessive heat which accumulates in the dielectric window arises primarily from the fact that the window is not readily accessible for the application of an outside cooling means, and in addition, the heat conducting properties of the magnetron envelope and the window are incompatible to thereby permit the heat to be carried from the window to the magnetron envelope efficiently.

In accordance with the present invention it has been found that the foregoing and other disadvantages of the prior art magnetrons may be overcome by extracting energy directly through a vacuum tight enclosure structure which provides both excellent microwave energy transmission and heat conductive properties. More particularly, in accordance with the present invention, the extraction of energy from the magnetron is accomplished through the use of a vacuum tight dielectric enclosure structure concentrically surrounding the cylindrical anode block of the magnetron which has at least one coupling aperture or iris in the back wall thereof adjacent the enclosure structure wall for communicating energy there-through. In addition, it is a further feature of the invention to provide an associated cooling structure encompassing the magnetron in heat dissipating relationship with substantially the entire exterior surface thereof to dissipate the heat generated by the magnetron during its operation.

It is, therefore, an object of the invention to provide a combination apparatus in which microwave energy is generated and extracted efficiently therefrom, and the heat accompanying said generated energy is readily and efficiently dissipated.

Another object of the invention is to provide a magnetron including a novel magnetron envelope through which microwave energy is communicated from the magnetron efficiently and the heat accompanying the generation of microwave energy during the magnetron's operation may be efficiently dissipated by a cooling fluid flowing through an associated functional container.

A further object of the invention is to provide a magnetron oscillator from which the energy generated therein is extracted therefrom directly through an enclosure wall of said oscillator without the facility of a communicating opening within said wall.

Still another object of the invention is to provide a functional container or case for encompassing a magnetron oscillator whereby microwave energy is received by said container or case from said magnetron through the enclosure wall of said oscillator, to thereby communicate said energy to an external load.

Still a further object of the invention is to provide a functional container or case for encompassing a magnetron oscillator whereby substantially all microwave energy leakage from said magnetron is eliminated in the space surrounding said container or case.

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 several embodiments of the invention are illustrated by way of example. It is to be expressly understood, however, that the drawings are intended for the purpose of illustration and description only, and are not intended to limit the scope of the invention.

FIGURE 1 is a side elevation view, partly in cross section, of a vane type multicavity magnetron, in accordance with the invention, illustrating the space relationship and configuration of the elements thereof;

FIGURE 2 is a fragmentary view of the magnetron of FIGURE 1 taken along line 2—2, illustrating the location of a coupling iris which is employed in the embodiment of FIGURE 1;

FIGURE 3 is a side elevation of a functional case encompassing a magnetron of the type shown in FIGURE 1 and an associated permanent magnet, illustrating the space relationship of the various components in accordance with the present invention;

FIGURE 4 is a plan view of the functional case shown in FIGURE 3, taken along line 4—4;

FIGURE 5 is a side elevation of an interdigital cavity resonator magnetron, partly in section, illustrating another form of resonant circuit which may be employed in accordance with the present invention; and

FIGURE 6 illustrates a method for employing a vapor condenser with the functional container of the present invention for dissipating heat generated by the magnetron within the container.

Referring now to the drawings, wherein the same reference characters designate like or corresponding parts throughout the several views, there is shown in FIGURE 1 a side view of a vane type multi-cavity magnetron 10 embodying a housing member 12 and a pair of associated depressed enclosure members 14 constructed in accordance with the teachings of the invention, providing a vacuum envelope for the magnetron and an energy transmitting window therefor. As shown in FIGURE 1, the magnetron includes a conventional cylindrical anode block 16, a plurality of regularly spaced vane segments 18 extending radially inward from the inside wall of the anode block and forming therewith a plurality of cavity resonators, a cathode 20, positioned concentrically with respect to the anode, and a coupling iris 22 through anode block 16 which functions as the back wall of the cavity resonators.

Considering now the specific elements of the magnetron of the invention, multicavity magnetron 10 is preferably cylindrical in form, and in the specific embodiment of FIGURE 1 is shown to include a housing member 12 in the form of a cylinder having a wall of uniform thickness. The interior wall of the housing member preferably has a narrow ridge 24 near one end thereof which functions as a supporting and positioning means for anode block 16 during the fabrication process of the magnetron although it will be appreciated from the ensuing description that it is not a limiting structural element. In addition, there is an aperture 26 through the housing member wall and perpendicular thereto through which an energizing electrode 28 is hermetically sealed for applying a potential to the anode circuit of the magnetron. It should be noted at this point that it is essential for the housing member to be made of a material which is transparent to electromagnetic energy and simultaneously electrically non-conductive with good heat dissipation characteristics, as for example, 98 percent pure beryllium oxide ceramic.

Continuing, disposed at opposite ends of the housing member are a pair of electrically conductive depressed

enclosure members 14 which are circular in form and have a diameter which corresponds to that of the housing member. The center of these members, as shown in FIGURE 1, have a depressed surface 30 in the form of a truncated cone and an associated circular surface 32 having a small circular indentation 34 in the center thereof. As shown in FIGURE 1, one of the depressed end members has a vacuum tight exhaust tubulation 36 for exhausting said magnetron during the manufacturing process thereof.

As further shown in FIGURE 1, the end members 14 are hermetically connected to opposite ends of said housing member with the pair of small circular indentations 34 in axial alignment with said cathode, the indentations of the depressed members thereby functioning as a means of mechanically positioning and supporting cathode 20 axially within the tube and providing electrical connections for imposing a potential thereto. In addition surface 32 and indentation 34 combine to form a pair of end hats at each end of the interaction space in the well known manner and thus function to constrain the electrons within the interaction space. Furthermore, the truncated conical surface of the depressed members functions as a means for receiving and positioning a pair of magnetic pole pieces, not shown in FIGURE 1, to provide a source of magnetic flux for the magnetron as will be described in greater detail hereinbelow. It will be noted that the anode structure is disposed concentrically with the housing member and is affixed thereto, as by brazing to a metallized surface of the ceramic, for example, so that vanes 18 are equidistant from the truncated ends of the enclosure member 14. In addition, coupling aperture 22 is disposed adjacent the cylindrical wall of member 12 to facilitate efficient transmission of energy sequentially through the iris and the solid housing member wall.

Referring now to FIGURE 2 there is shown a fragmentary view of the magnetron in FIGURE 1 taken along line 2—2, illustrating the relative space relationship of vanes 18 and coupling iris 22 and showing typical configurations therefor. The aperture configuration may be of any suitable form, of course, and is not limited to the dumbbell shaped configuration shown in FIGURE 2.

Consider now the advantages which are provided by the novel construction of the magnetron of the invention shown in FIGURE 1. Owing to the inherent properties of beryllium oxide from which the housing member is made, such as its excellent microwave energy transmission properties, it will permit the communication of microwave energy directly through its cylindrical wall adjacent the coupling iris with substantially no RF loss, thereby eliminating the need for the conventional associated output coupling window. Thus, the use of a simple cylindrical structure which does not require the forming of an aperture in the side wall of the housing member and the inclusion therein of an output window transparent to microwave energy or the use of an associated coaxial or waveguide output device substantially reduces the complexity of the tube as well as its cost for manufacture. In addition, the elimination of these output devices reduces the total number of locations in the overall vacuum envelope whereat leaks may occur, and thereby reduces the possibility of the magnetron becoming gassy. Finally, the use of the housing member, anode circuit, and depressed end members, all of which are simple and economic to manufacture in the forms disclosed, enables one to produce a magnetron which should provide an impetus to the manufacture and sale of low cost commercial magnetrons in general.

Referring now to FIGURE 3 there is shown a functional case 38 for mounting magnetron 10 in heat dissipating and energy coupling relationship therewith. As shown in the drawing, case 38 is a solid material divided into first and second sections separated by a dielectric member 44, each of the case sections including a plurality

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of fins 40 affixed thereto and surrounding a substantial portion of the case's perimeter for dissipating heat transferred from the magnetron, and a pair of routed passages 42 which form waveguides that provide means for transmitting microwave energy from the magnetron to an external load. In addition, each of the sections further includes an opening 52 in axial alignment with the magnetron, which openings combine to form a space for mounting the magnetron and for receiving a pair of magnetic pole piece elements 46 at opposite ends of the magnetron. The elements of the combination shown in FIGURE 3 are held in position with the aid of a permanent magnet 48 and other suitable means not shown, the magnet being operable in the conventional manner to provide the magnetic flux needed for magnetron operation.

In FIGURE 4 there is shown further details of the case 38 illustrating the paths of the waveguide forming passages 42 in accordance with the invention, it being expressly understood that the number and configuration of the passages as shown in FIGURE 4 is not intended as a limitation of the invention. For example, the number of passages employed is limited only by the number of coupling irises that appear in the anode circuit, and the configuration of the functional case itself.

As shown in FIGURE 4 the diameter of the pole piece receiving apertures designated 50 is slightly larger than the diameter of pole piece 46, while the diameter of the magnetron-receiving aperture 52 is slightly larger than the diameter of magnetron 10. The slight difference in diameters is to facilitate the insertion and removal of the pole piece elements and the magnetron; however, in the instance of the magnetron the difference in diameters is not sufficient to impair the heat transferring or energy coupling capabilities of the magnetron and case in combination.

Consider now the advantages which are provided by the novel combination of magnetron 10 and functional case 38 of the invention. Firstly, the case is made of a material, such as aluminum, having high heat dissipating properties and is in close contact with substantially the entire large external surface of housing member 12 which has very high thermal conducting properties. In addition, the fins which are affixed to the external surface of case 38 greatly enhance the heat dissipating capabilities of the case, especially when a fluid, such as cool air for example, is passed over the surface of the fins. Thus, the ability of the magnetron to dissipate heat generated thereby during its operation is greater than that of similar known prior art devices.

Secondly, as discussed hereinabove, housing member 12 has inherently good energy transmission properties directly through its cylindrical wall and eliminates the need for providing a conventional associated output window or conventional transmission network assemblies. In order to extract energy, therefore, one end of the waveguide forming passages originating at the opening designated 52 in FIGURE 4 is disposed adjacent the housing member in the region where the internal coupling irises are located. Finally, the functional case offers the additional advantage of substantially eliminating all microwave energy leakage from the magnetron in the space surrounding the case. The necessity of this advantage becomes more significant and is better appreciated if it is understood that the magnetron might be employed in a domestic application, such as in a microwave heater or cooker. In such applications the Federal Communications Commission has prescribed the maximum permissive radiation level which may exist in the environment of the magnetron while it is in operation. Thus, the leakage prevention capability of the functional container is extremely important when the magnetron is destined to be employed in a domestic application which is subject to Federal regulations.

In operation cathode 20 is activated to provide a source of electrons by connecting a potential difference

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between the first and second sections of case 38, and since each section of the case is in electrical contact with one of depressed end enclosure members 14 the potential is thus applied to the opposite ends of said cathode. In addition there is a high potential difference applied between the anode circuit through the use of a voltage electrode 28 and a ground connection whereby the anode is made positive with respect to the cathode. Once the potentials have been applied to magnetron 10, as described hereinabove, the generation of microwave energy is substantially the same as that of conventional magnetrons known in the prior art, and therefore no further discussion in this regard is deemed necessary.

Continuing with the operation of the combination of the invention, the microwave energy generated in the anode circuit is coupled therefrom through the use of at least one coupling iris located in the metallic back wall of said anode. After the microwave energy passes successively through the iris and the cylindrical wall of the ceramic housing member, it couples to the waveguides built into the functional case where it is then transmitted to an external load.

As the microwave energy passes through the cylindrical wall of said housing member very little heat is generated therein owing to the low RF loss factor of the housing material. Moreover, since the output window is an integral part of the entire cylindrical wall there is provided a large surface area over which the little heat which is generated through the coupling process may be dissipated. In addition, the functional case is in eminent heat conducting contact with said housing member and thereby provides further capacity and means for dissipating the larger amounts of heat generated within the anode structure.

It is expressly understood, of course, that the invention may be practiced by using an anode circuit having a form different from that shown in FIGURE 1. With reference to FIGURE 5, for example, there is shown a view of magnetron 10 similar to that shown in FIGURE 1, illustrating an alternative embodiment of the invention exemplifying how the teachings of the invention may be utilized with an anode circuit in the form of an interdigital structure. As shown in FIGURE 5 there is disposed concentrically within housing member 12 and affixed thereto a resonant anode circuit 54 having an interdigital form which is supported by ridge 24 during the fabrication process of the magnetron. The coupling iris may have the same or similar configuration as the iris shown in FIGURE 2, and is also in the same cooperative coupling relationship with the housing member wall as that shown in FIGURE 1. The operation of the magnetron shown in FIGURE 5 is substantially the same as the magnetron shown in FIGURE 1, and therefore no further discussion of its operation is necessary at this point.

It should be further understood that the cooling advantages derived through the use of the functional case shown in FIGURE 3 may be further enhanced by using a functional case adapted to employ a liquid coolant as the cooling fluid in place of air. With reference to FIGURE 6, for example, there is shown a diagrammatic view of a functional container 39, similar to that shown in FIGURE 3 except that it is a hollow container which has been adapted to employ a liquid and a vapor condenser 56 which functions to convert vapor to liquid during a cooling process. The condenser comprises a heat exchanger 58, a vapor passage tube 60 for carrying vapor generated within the container to the heat exchanger where it is reconverted to fluid and returned to the container through a return passage tube 62. The embodiment of the invention shown in FIGURE 6 thus offers the added advantage of permitting the use of a liquid in those applications where the use of a gaseous coolant may be undesirable. In this embodiment it should be noted that the liquid coolant may be in direct

contact with the magnetron's external surface, and the necessity for having container 39 in close physical contact with the magnetron may be eliminated.

In operation the fluid is circulated through the container shown in FIGURE 6 and may remove enough heat from the container to vaporize the liquid circulating therein. As the fluid becomes vaporized the vapor rises in a vapor tube 60, as shown in FIGURE 6 by the flow arrows where it passes into the condenser. The condenser in turn converts the vapor to a liquid which is returned to the functional container through a liquid tube 62.

While the magnetron and functional container and case of the present invention have been described with reference to several structural configurations for the magnetron and several modes of operation for the functional container and case, it will be understood that various modifications could be made in these devices without departing from the spirit and scope of the invention. Accordingly, it is to be expressly understood that the foregoing description shall be interpreted only as illustrative of the invention, and that the appended claims be accorded as broad an interpretation as is consistent with the basic concept herein taught.

What is claimed as new is:

1. In a magnetron oscillator for generating microwave energy, the combination comprising: a cylindrical cathode structure having an axis; an anode circuit including an anode block surrounding said cathode, and a plurality of regularly spaced vanes extending inwardly toward said cathode from said block forming a plurality of cavity resonators and an interaction space adjacent to and concentric with said cathode, said anode including means for coupling microwave energy from said magnetron; a vacuum envelope, said envelope including an electrically non-conducting housing member having a cylindrical wall transparent to microwave energy and having first and second ends, means for mounting said anode concentrically within said housing member, and a pair of electrically conductive depressed enclosure members hermetically enclosing said ends of said housing member and forming means for supporting said cathode concentrically with respect to said anode, said enclosure members forming a pair of end hats adjacent opposite ends of said interaction space.

2. In a magnetron oscillator for generating microwave energy, the combination comprising: a cylindrical cathode structure having an axis; an anode including an anode block surrounding said cathode, a plurality of regularly spaced vanes extending inwardly toward said cathode from said block forming a plurality of cavity resonators, and an interaction space adjacent to and concentric with said cathode said anode including coupling means for transmitting microwave energy from said magnetron; a vacuum envelope, said envelope including an electrically non-conductive ceramic housing member having a cylindrical wall transparent to microwave energy and having first and second ends, means for mounting said anode concentrically within said housing member, an energizing electrode hermetically sealed within said housing member wall for electrically energizing said anode, and a pair of electrically conductive end members hermetically enclosing said ends of said housing member said end members forming means for supporting said cathode axially within said interaction space, said end members forming a pair of end hats adjacent opposite ends of said interaction space.

3. In a magnetron oscillator for generating microwave energy, the combination comprising: a cylindrical cathode structure having an axis; an anode including an anode block surrounding said cathode, and a plurality of regularly spaced vanes extending inwardly toward said cathode from said block forming a plurality of cavity resonators and an interaction space adjacent to and concentric with said cathode; a vacuum envelope, said envelope

including a ceramic housing member transparent to microwave energy and having first and second ends, means for supporting said anode concentrically within said housing member, and a pair of electrically conductive depressed enclosure members hermetically enclosing said ends of said housing member and forming means for supporting said cathode axially within said interaction space, the depressions in said enclosure members forming a pair of end hats adjacent opposite ends of said interaction space.

4. In a magnetron oscillator for generating microwave energy, the combination comprising a cylindrical cathode structure having an axis; a vacuum envelope concentric with said axis, said envelope including a ceramic housing member transparent to microwave energy and having first and second ends; an anode disposed concentrically within said envelope having at least one coupling iris for communicating microwave energy from the magnetron; said cathode being supported within said member concentric with said anode forming an interaction space therewith; a pair of electrically conductive depressed enclosure members hermetically enclosing said ends of said housing member providing means for supplying input power to said cathode and for supporting said cathode axially within said interaction space, the depressions in said enclosure members forming means at opposite ends of said interaction space for constraining electrons emitted by said cathode within said interaction space.

5. The magnetron defined in claim 4 in which the material from which said housing member is formed has relatively high thermal dissipation properties.

6. The magnetron defined in claim 5 in which said housing member is composed essentially of beryllium oxide.

7. The combination comprising: a magnetron oscillator for generating microwave energy, said magnetron including a cylindrical cathode structure having an axis, an anode including an anode block surrounding said cathode and forming a plurality of cavity resonators and an interaction space adjacent to and concentric with said cathode, a vacuum envelope, said envelope including a ceramic housing member transparent to microwave energy and having first and second ends, means for mounting said anode within said housing member, a pair of enclosure members hermetically enclosing said ends of said housing member for supporting said cathode axially within said envelope, and means for supplying input power to said cathode; and an electrically conductive functional case for enclosing said magnetron to provide shielding means for substantially eliminating leakage of microwave energy from said case, said case including at least one passage forming output coupling means for transmitting microwave energy generated within said magnetron to an external load.

8. The combination defined in claim 7 wherein said case further includes means for receiving a cooling fluid for removing heat generated by said magnetron.

9. The combination comprising: a magnetron oscillator for generating microwave energy, said magnetron including a vacuum envelope, said envelope including an electrically non-conductive housing member having a cylindrical wall transparent to microwave energy and having first and second ends, an anode member mounted within said enclosure concentric with said cathode, said anode member defining at least one cavity resonator, a pair of enclosure members hermetically enclosing said ends of said housing member, a cathode mounted between said enclosure members axially within said envelope; and a functional case for encompassing said magnetron to provide substantial insulation of said magnetron from microwave energy leakage, said case including output coupling means for communicating microwave energy to an external load, and means for removing and dissipating heat generated by said magnetron.

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10. The combination comprising: a magnetron oscillator for generating microwave energy, said magnetron including a vacuum envelope, said envelope including a cylindrical housing member transparent to microwave energy and having first and second ends, a cathode positioned axially within said member, an anode member defining at least one cavity resonator surrounding said cathode and mounted within said housing member, and a pair of enclosure members hermetically enclosing said ends of said housing member and forming means for supporting and energizing said cathode; and a functional container having an interior space for encompassing said magnetron to provide substantial insulation of said magnetron from microwave energy leakage, said container including means for receiving a cooling liquid to dissipate heat generated by said magnetron and transferred to said container from said magnetron, said container including means forming at least one microwave energy communicating passage which extends therethrough from a point adjacent said magnetron housing member for extracting microwave energy from said magnetron.

11. The combination defined in claim 10 wherein said communicating passage is in the form of a ridged wave guide.

12. The combination comprising: a magnetron oscillator for generating microwave energy, said magnetron including a substantially cylindrical housing member transparent to microwave energy and having first and second ends, a cathode positioned axially within said member, an anode member mounted within said housing member concentric with said cathode, said anode member defining at least one cavity resonator, a pair of enclosure members hermetically enclosing said ends of said housing member and forming means for supporting said cathode axially; and a functional case having an interior space for receiving said magnetron to provide substantial insulation of said magnetron from microwave energy leakage, said case including means for removing and dissipating heat generated by said magnetron and having at least one microwave energy communicating passage which extends therethrough from said interior space adjacent said magnetron for extracting microwave energy from said magnetron.

13. The combination defined in claim 12 wherein said communicating passage is in the form of a ridged wave guide.

14. The combination comprising: a magnetron oscillator for generating microwave energy, said magnetron including a vacuum envelope, said envelope including a housing member having a cylindrical wall transparent to microwave energy and having first and second ends, a cathode mounted axially within said enclosure, an anode member defining at least one cavity resonator, a pair of depressed enclosure members hermetically enclosing said ends of said housing member forming means for supporting said cathode axially and means for supplying input power to said cathode; and a functional container having an interior space for encompassing said magnetron to provide substantial insulation of said magnetron from microwave energy leakage, said container including means for removing and dissipating heat generated by said magnetron, said means having a plurality of ducts for receiving a cooling liquid to dissipate said heat transferred to said container by said magnetron, an associated condenser means for changing vapor to liquid, and an output coupling line having at least one microwave energy communicating passage which extends therethrough perpendicular to said cathode from said interior space adjacent said magnetron.

15. The combination defined in claim 14 wherein said communicating passage is in the form of a ridged wave guide.

16. A magnetron oscillator for generating microwave energy, the combination comprising: a cylindrical envelope having a wall transparent to microwave energy, and

first and second ends, an anode mounted internally concentrically, said anode including a metallic member affixed to said envelope, a plurality of vanes extending radially inward from said member forming a plurality of cavity resonators and an interaction space concentric with said envelope, and output coupling means for communicating microwave energy from said anode, a pair of electrically conductive enclosure end members hermetically enclosing said ends of said envelope, and a cylindrical cathode mounted between said end members concentric with said interaction space, said end members forming means at opposite ends of said interaction space for constraining electrons emitted by said cathode within said interaction space.

17. The combination comprising: a magnetron oscillator for generating microwave energy, said magnetron includes a cylindrical envelope having a wall transparent to microwave energy, and first and second ends, an anode mounted internally concentrically within said envelope, said anode including a metallic member affixed to said envelope, a plurality of vanes extending radially inwardly from said member from a plurality of cavity resonators and an interaction space concentric with said envelope, and output coupling means for communicating microwave energy from said anode, a pair of electrically conductive enclosure end members hermetically enclosing said ends of said envelope, a cylindrical cathode mounted between said end members concentric with said interaction space, a magnetron envelope for enclosing said magnetron providing shielding means to substantially eliminate leakage of microwave energy from said magnetron envelope, means for dissipating heat generated by said magnetron, through the use of an associated cooling fluid, and means through which microwave energy is communicated away from said magnetron.

18. The magnetron defined in claim 17 in which said cylindrical envelope is further defined as electrically non-conductive beryllium oxide having a high coefficient of thermal conductivity.

19. A magnetron oscillator for generating microwave energy, the combination comprising: a cylindrical envelope having a wall transparent to microwave energy, and first and second ends, said cylindrical envelope being formed of beryllium oxide on the order of 98 percent purity, an anode mounted internally concentrically, said anode including a metallic member affixed to said envelope, a plurality of vanes extending radially inward from said member forming a plurality of cavity resonators and an interaction space concentric with said envelope, an output coupling means for communicating microwave energy from said anode, a pair of electrically conductive enclosure end members hermetically enclosing said ends of said envelope, and a cylindrical cathode mounted between said end members concentric with said interaction space.

20. An inexpensive magnetron comprising a conductive anode structure including at least one resonant cavity and having a generally cylindrical outer wall, a cylindrical insulating sleeve having its inner surface in extended contact with the cylindrical outer wall of said anode, a cathode, and means including two concave circular sheet metal end pieces in peripheral vacuum sealing engagement with the respective ends of said sleeve for supporting said cathode within said anode structure.

21. An inexpensive magnetron structure comprising: a vacuum sealed envelope assembly, said vacuum sealed envelope assembly consisting solely of an insulating sleeve, an anode assembly including at least one cavity resonator and an outer conductive sleeve engaging the inner surface of said insulating sleeve, first and second stampings in vacuum sealing engagement with the ends of said insulating sleeve, and a cathode assembly supported directly on said two stampings to extend through said anode assembly; and

- means for applying a magnetic field to the space between said anode and said cathode in a direction parallel to said cathode.
22. An inexpensive vacuum sealed envelope assembly for a magnetron comprising:
- an electrically non-conductive housing member having a cylindrical wall transparent to microwave energy;
 - an anode assembly including at least one cavity resonator and an outer cylindrical sleeve engaging the inner cylindrical wall of said housing member;
 - first and second stampings in vacuum sealing engagement with the ends of said housing member to complete the vacuum envelope; and
 - a cathode assembly supported directly between said two stampings to extend through said anode assembly.
23. An inexpensive vacuum sealed envelope assembly for a magnetron oscillator tube consisting solely of a vacuum envelope including:
- a cylindrical ceramic housing member transparent to microwave energy having first and second ends;
 - an anode assembly having an outer conductive cylindrical wall engaging the inner surface of said ceramic housing;
 - a pair of depressed stamping elements hermetically enclosing said ends of said ceramic member to complete the vacuum sealed envelope; and
 - a cathode supported directly between said two stamping elements to extend through said anode assembly.
24. In an inexpensive magnetron:
- an anode assembly including at least one cavity resonator having generally a cylindrical outer wall;
 - a cathode mounted within said anode;
 - a generally cylindrical sleeve of material, which is transparent to microwaves and of high heat conductivity, for enclosing said anode and said cathode, the inner surface of said sleeve being in extended intimate contact with the outer cylindrical wall of said anode assembly;
 - means, including a pair of electrically conductive depressed stampings hermetically enclosing the ends of said cylindrical sleeve, for forming a vacuum envelope and for supporting said cathode; and
 - means, including a magnetic pole piece at each end of said sleeve interfitting with the depressions in said stampings, for applying a magnetic field to the space between said anode and said cathode.
25. In an inexpensive magnetron:
- an anode assembly including at least one cavity resonator having an outer wall;
 - a cathode extending through said anode;
 - a vacuum-tight envelope for housing said cathode and anode structure, including a hollow cylindrical body of material which is transparent to microwaves and of high heat conductivity having first and second ends; and
 - a pair of electrically conductive depressed stampings enclosing said ends of said hollow body and forming means for interfitting a magnetic pole piece at each end of said hollow body, for applying a mag-

- netic field to the space between said anode and said cathode, the inner surface of said hollow cylindrical body being in extended intimate contact with the outer wall of said anode.
26. In an inexpensive magnetron:
- a vacuum-tight envelope including a hollow cylindrical body of material which is transparent to microwave energy and of high heat conductivity, and a pair of depressed end members hermetically enclosing the ends of said body;
 - a cylindrical anode including at least one cavity resonator having an outer wall and means for transmitting microwave energy from said anode;
 - a cathode mounted within said anode and supported therein by said end members, said end members also providing electrical input power terminals for said cathode; and
 - means, including a pair of magnetic pole pieces positioned outside the vacuum envelope by said end members, for applying a magnetic field to the space between said anode and said cathode, the inner surface of said body being in intimate contact with the outer cylindrical wall of said anode for dissipating heat generated at said anode through the wall of said vacuum-tight envelope.
27. In an inexpensive magnetron structure:
- a cylindrical anode including at least one cavity resonator having generally a cylindrical outer wall and means for transmitting microwave energy from said magnetron;
 - a cathode mounted within said anode;
 - a generally cylindrical sleeve of material, which is transparent to microwaves and of high heat conductivity, for enclosing said anode and said cathode, said sleeve having first and second ends;
 - means, including a pair of electrically conductive depressed end members hermetically enclosing said ends of said cylindrical sleeve forming a vacuum envelope therewith, for supporting said cathode and providing electrical connection therefor; and
 - means, including a magnetic pole piece at each end of said sleeve interfitting with the depressions in said end members for applying a magnetic field to the space between said anode and said cathode, said depressed end members forming a pair of end hats adjacent opposite ends of said interaction space; the inner surface of said sleeve being in extended intimate contact with the outer cylindrical wall of said anode to dissipate heat generated at said anode in contact with the inner surface of said sleeve.

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