July 8, 1958 P. P. DERBY 2,842,713

ELECTRON DISCHARGE DEVICE

Filed July 3, 1953 2 Sheets-Sheet 1

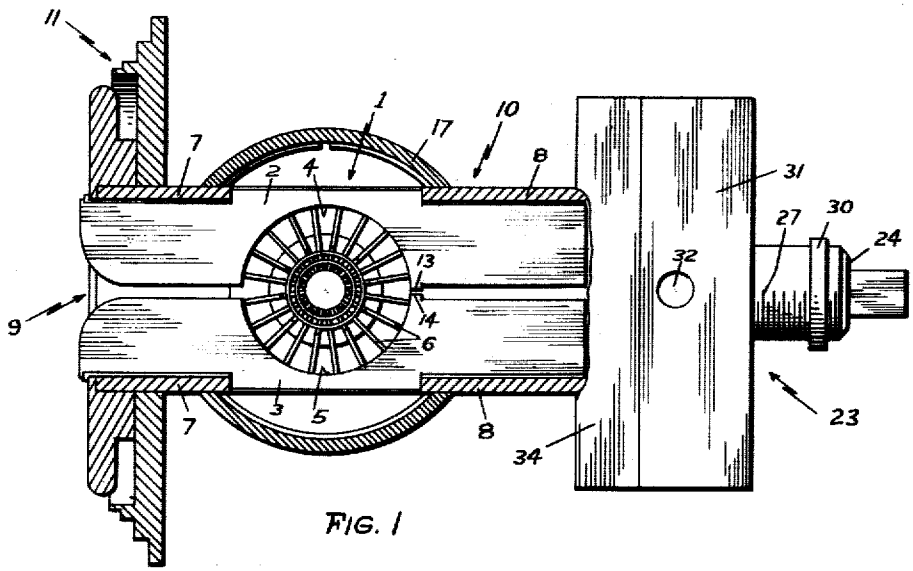


FIG. 1

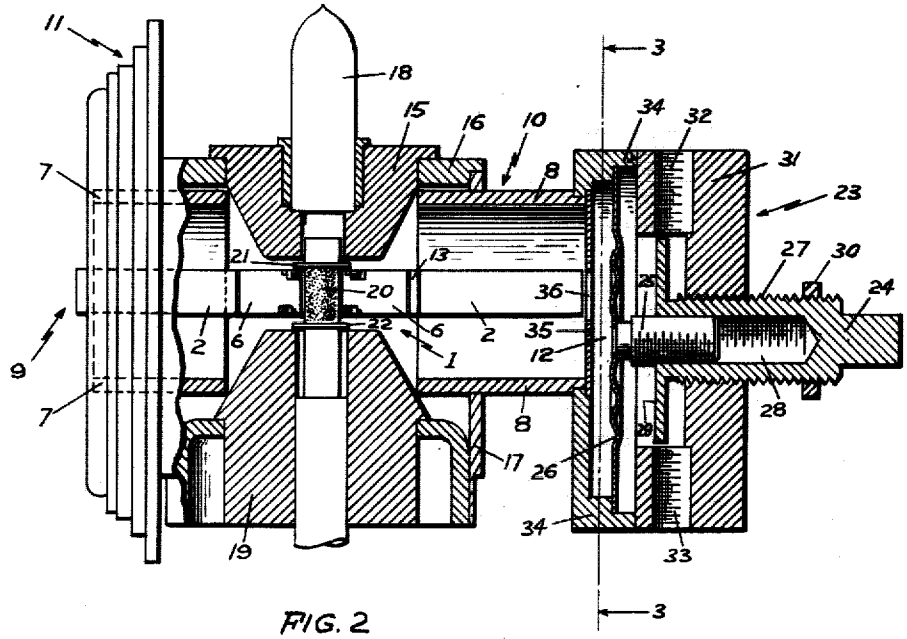


FIG. 2

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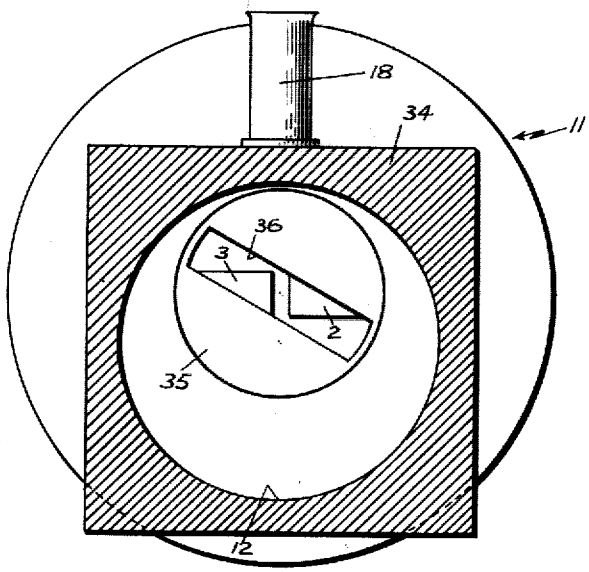


FIG. 3

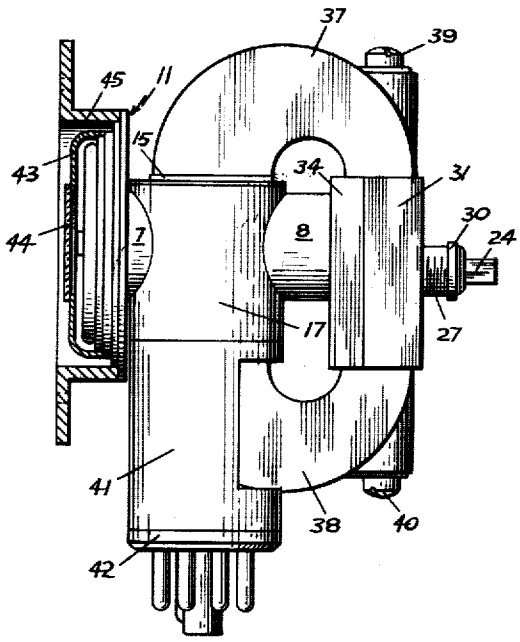


FIG. 4

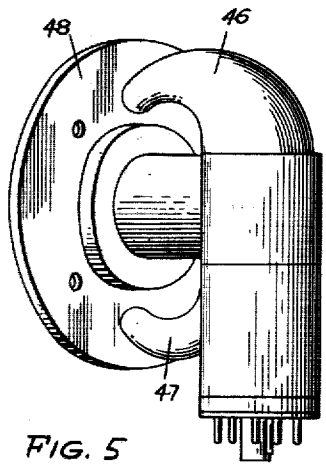


FIG. 5

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United States Patent Office 2,842,713 Patented July 8, 1958

2,842,713

ELECTRON DISCHARGE DEVICE

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Application July 3, 1953, Serial No. 365,816

4 Claims. (Cl. 315—39)

This invention relates to an electron discharge device and more particularly to the structure and packaging arrangement for a microwave oscillator of the magnetron type.

In the commercial manufacture of magnetrons it is desirable to design and assemble a package in which the weight and size of the magnetron are minimized, yet which is mechanically rugged, efficient and easy to mount. When the design involves the use of a waveguide output system and an external cavity tuning arrangement, these features are more difficult to attain due to the increased complexity of parts required in such a magnetron assembly.

This invention involves the use of a novel magnetron assembly in which the desirable features described above are combined. In the particular embodiment illustrated herein the anode structure consists of a pair of flat rectangular conductors capable of being produced in solid or laminar form. Each of the conductors has a semi-circular opening centrally located thereon so that when these conductors are slightly separated and paired, the semi-circular portions thereof form a cylindrical wall on which the magnetron vane structure may be mounted. The balance of these rectangular conductors are mounted and spaced from each other within a pair of sleeves to form opposed H-shaped waveguide transmission lines. These waveguide transmission lines couple the anode vanes to both an output assembly and a tunable cavity, and they also act as supporting members between the anode structure and the output and tuning assemblies. However, in a package of this type, it is practically impossible to couple efficiently the fields between the waveguide transmission line to those in the cylindrical tuning cavity without the use of a coupling iris. A slotted disk positioned between the transmission line and the cavity has been used in this novel assembly to overcome this difficulty.

To minimize the weight of the magnets used in the magnetron package, the cavity tuning assembly is housed in a case made of ferromagnetic material. Thus, the magnets used in the tube may be mounted on the top and bottom surfaces of this case so the case will act as a return path for the magnetic circuit. As a result, the size of the magnets is reduced and the weight of the tube is decreased.

Another advantage to this packaging arrangement lies in using a face of the housing as a mounting plate through which the tuning shaft extends. Therefore, when the tube is panel mounted, the tuning shaft will protrude through the panel to permit the use of a simple control knob to actuate the tuning assembly. A further feature is that in an assembly of this type the center of gravity of the magnetron lies close to the mounting support which permits the tube to withstand considerable vibration and shock without suffering detrimental effects.

This invention and the features therof will be understood more clearly and fully from the following detailed

description of two embodiments of the invention with reference to the accompanying drawings wherein:

Fig. 1 is a top view of a magnetron oscillator made in accordance with this invention with a broken-away section showing the anode and output assemblies;

Fig. 2 is a front view of Fig. 1 with a broken-away section showing the anode and mechanical tuning assemblies;

Fig. 3 is a cross-sectional view of Fig. 2 taken along line 3—3;

Fig. 4 is a view of the complete magnetron package; and

Fig. 5 is a view of a fixed frequency magnetron packaged in accordance with this invention.

Referring now to Figs. 1 and 2, an anode assembly made in accordance with this invention is shown. In this embodiment of the invention, the anode assembly **1** consists of a pair of flat substantially rectangular-shaped conductors **2** and **3**, each of which includes a circular sector-shaped or semi-circular opening **4** and **5** centrally located thereon. These conductors may be made of oxygen-free copper, for example, and are capable of being produced in a laminar form as well as in the solid one-piece construction shown. It should be noted, however, that the shape and size of the conductors **2** and **3** and the openings **4** and **5** may be varied and are only limited in that when the conductors are paired they should form a cylindrical anode wall and oppositely disposed transmission lines. Therefore, when the anode conductors **2** and **3** are paired, as shown in Fig. 1, the semi-circular openings **4** and **5** form a cylindrical wall on which a series of strapped magnetron vanes **6** may be mounted. The sides of the conductors **2** and **3** are curved slightly so the balance of the rectangular conductors **2** and **3** may be easily mounted along the end sections thereof within a pair of cylindrical metal sleeves **7** and **8** to form a pair of oppositely disposed waveguide transmission lines **9** and **10**. These lines are used to couple the vanes **6** to an output system **11** and a tuning cavity **12**, as shown in Fig. 2. The complete waveguide output assembly may be seen in Fig. 4 and includes the output system **11** referred to above.

The tuning cavity **12** is a simple cylindrical resonator operating in the TM-010 mode, for example. To insure stable operation of the magnetron, it is necessary to adjust in frequency the relationships between the resonances in the tuning cavity **12** and the anode assembly **1**. The proper adjustment may be obtained by introducing a shunt impedance in the transmission line **10** at the junction between this line and the anode assembly **1**. This impedance is realized geometrically in the form of a capacitance effected by the protuberances **13** and **14**, shown in Fig. 1, on the anode conductors **2** and **3**. Likewise, the conductors **2** and **3** are tapered at the ends adjoining the output system **11** to improve the loading and coupling characteristics of the tube.

Fig. 2 also shows a ferromagnetic pole piece **15** which is supported on the upper surface **16** of a cylindrical chamber **17**. The pole piece **15** extends into the chamber and is positioned adjacent to the upper edges of the anode vanes **6**. The pole piece is also provided with a tube **18** whereby the magnetron may be evacuated. The tube **18** may be copper, for example, and can be pinched off, as shown in Figs. 2 and 3, to hermetically seal the tube after it has been packaged. A second pole piece **19** is supported in the lower section of the chamber **17** and should be positioned adjacent to the lower edges of the vanes. The sleeves **7** and **8** are joined to the chamber **17** through two opposed openings located in the longitudinal wall of the chamber.

It should be noted that inner ends of the vanes **6** define

a space centrally located in the anode assembly **1** wherein a cathode **20** may be mounted. The cathode is supported within a hole in the pole piece **19**, and is provided with a pair of end shields **21** and **22** positioned between the pole pieces **15** and **19** and the vanes **6**. The end shields prevent the axial escape of electrons from the interaction space between the cathode **20** and the vanes. The tuning assembly **23** shown in Fig. 2 consists of a shaft **24** having a differential threading arrangement whereby a coaxial member **25** threaded within the shaft and connected to a diaphragm **26** may be moved to vary the position of the diaphragm. Therefore, the shaft **24** is provided with an outer set of threads **27** which have a substantially greater pitch than those located in an inner threaded aperture **28**. Thus, when the shaft is rotated toward the cavity **12** a certain distance, the member **22** and the diaphragm **26** will move away from the cavity a distance which is substantially less than that traversed by the shaft. A flanged section **29** located on the internal end of the shaft, and a ring **30**, threaded onto an external section of the shaft, act as stops which prevent excessive inward or outward movement of the diaphragm **26**.

The tuning assembly **23** is housed in a case **31**, as shown in Figs. 1 and 2, made of ferromagnetic material. This case is provided with a pair of threaded openings **32** and **33** whereby the magnets, as described below, may be connected. Thus, the case acts as a return path for the magnetic circuit thereby decreasing the size of the magnets used in the magnetron. The tuning assembly **23** is completed by joining the case **31** to the outer edge of the cavity panel **34**. This panel contains a series of circular recesses which form the tuning cavity **12** and provide surfaces for mounting the diaphragm **26**, the sleeve **8** and a coupling iris **35**. The panel **34** should be assembled so that the axis of the circular cavity **12** intersects and is perpendicular to the axis of the anode assembly **1**.

The unique packaging arrangement described above is provided with the coupling iris **35**, shown in Figs. 2 and 3, without which it would be practically impossible to efficiently couple the fields in the waveguide transmission line **10** to those in the cavity **12**. It may be seen in Fig. 3 that the conductors **2** and **3** enter the area adjacent to the cavity **12** so that the lengths of these conductors, which form a part of the waveguide transmission line, are parallel to the axis of the cavity **12**. With an arrangement of this type, the high frequency fields in the transmission line are perpendicular to those in the cavity **12**. This condition does not permit coupling between the line and the cavity. However, coupling can be facilitated by using the iris **35** to rotate the fields in the transmission line to make a better match to the fields in the cavity. The iris **35** may be a thin disk of metal having a diametrical slot **36** therein. For example, highly-conductive oxygen-free copper has been used successfully to form the iris. By appropriately positioning the angle of the slot with relation to the fields in the transmission line and the cavity, the fields in the line may be twisted or rotated to more nearly match those in the cavity. It should be noted then an iris would not be necessary if the transmission line entered the cavity so that the parallel section of the conductors **2** and **3** of the H-guide were perpendicular, rather than parallel, to a diameter of the cavity. However, such an arrangement would not permit the compact packaging arrangement described herein, since the axis of the cavity would not intersect the axis of the anode assembly.

Referring now to Fig. 4, a complete magnetron assembly made in accordance with this invention is shown. Two magnets **37** and **38** of opposite polarity are connected with a pair of threaded bolts **39** and **40** to the upper and lower surfaces of the case **31** and the panel **34**, and are positioned adjacent to the pole pieces **15** and **19** shown in Fig. 2. The lower magnet **38** enters a cylindrical can **41** through an opening provided in the longitudinal wall thereof. The can **41** provides a housing for the leads

and internal connections made to the cathode and the anode assemblies, and is joined to the chamber **17** at one end and to the tube pin assembly **42** at the other end. It should be noted that additional structural support is provided for the magnetron by the sleeves **7** and **8**. The output system **11** is enclosed with a metal cover **43** having a window **44** connected thereto whereby electrical energy may be extracted from the output system **11**. A circular output flange **45** may be joined to the output system to complete the magnetron package.

Referring now to Fig. 5, a fixed frequency magnetron oscillator is shown as a second embodiment of the packaging technique previously illustrated. Since a tuning assembly is not needed, the magnets shown in Fig. 4 may be reversed as shown in Fig. 5. Thus, the magnets **46** and **47** are joined to an output flange **48** made of ferromagnetic material so that the flange, instead of the tuning case, serves as a tube support, a mounting surface and as a return path for the magnetic circuit.

It should be understood that this invention is not limited to the particular details described above, as many equivalents will suggest themselves to those skilled in the art. For example, when a fixed frequency magnetron is packaged, the conductors **2** and **3**, shown in Fig. 1, can be revised to include only an output transmission line which adjoins the output assembly as shown in Fig. 5. Likewise, the transmission lines need not be diametrically opposed, as shown in Figs. 1 and 2, and the shape of these conductors need not be limited to the substantially rectangular form illustrated therein. Also the case for the tuning assembly can be fabricated from either ferromagnetic or magnetic material which is capable of producing additional magnetomotive force. Therefore, it is desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. An electron discharge device comprising a pair of elongated anode conductors each having a semi-circular notch located along an edge and intermediate the ends thereof, said conductors being spaced from each other with their axes parallel and their notches aligned to define a substantially cylindrical aperture intermediate the ends of said conductors and a pair of oppositely disposed cylindrical metallic sleeves positioned respectively on each of the end sections of the conductors with the anode conductors centrally disposed therein so as to form an H-guide, a plurality of anode vanes spaced on the wall of said aperture and extending radially inward therefrom and an electron source positioned in the space defined by the inner ends of said vanes.

2. An electron discharge device comprising a pair of elongated anode conductors each having a semi-circular notch locatde along an edge and intermediate the ends thereof, said conductors being enclosed on the end sections thereof with a pair of sleeves and spaced from each other with their axes parallel and their notches aligned to define a cylindrical aperture intermediate the ends of a pair of oppositely disposed waveguide transmission lines, a plurality of anode vanes spaced on the wall of said aperture and extending radially inwardly therefrom and an electron source positioned in the space defined by the inner ends of said vanes, said aperture being connected by one of said transmission lines to an output system, said aperture being connected by the other of said transmission lines to a cylindrical cavity resonator and coupled thereto by an iris, a mechanical tuning assembly adjoining said resonator for controlling the frequency of said oscillations, a ferromagnetic case housing said tuning assembly and forming with a pair of magnets connected to it a magnetic circuit.

3. An electron discharge device comprising a pair of elongated anode conductors each having a semi-circular notch located along an edge and intermediate the ends thereof, said conductors being spaced from each other

with their axes parallel and their notches aligned to define a substantially cylindrical aperture intermediate the ends of said conductors and a pair of oppositely disposed cylindrical metallic sleeves positioned respectively on each of the end sections of the conductors with the anode conductors centrally disposed therein to form an H-guide, a plurality of anode vanes spaced on the wall of said aperture and extending radially inward therefrom, an electron source positioned in the space defined by the inner ends of said vanes, a tunable cavity resonator, and means including an iris coupling element for operatively connecting said cavity resonator with said H-guide.

4. An electron discharge device comprising a pair of elongated anode conductors each having a semi-circular notch located along an edge and intermediate the ends thereof, said conductors being spaced from each other with their axes parallel and their notches aligned to define a substantially cylindrical aperture intermediate the ends of said conductors and a pair of oppositely disposed cylindrical metallic sleeves positioned respectively on

each of the end sections of the conductors with the anode conductors centrally disposed therein to form an H-guide, a plurality of anode vanes spaced on the wall of said aperture and extending radially inward therefrom, an electron source positioned in the space defined by the inner ends of said vanes, a tunable cavity resonator, and means including a disc-shaped iris coupling element for operatively connecting said cavity resonator with said H-guide, said iris having a diametrical slot therein aligned with regard to said H-guide to couple the high frequency fields in said H-guide, to the fields in said resonator.

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