

April 12, 1949.

N. WAX

2,466,922

ELECTRON DISCHARGE DEVICE

Filed Feb. 12, 1946

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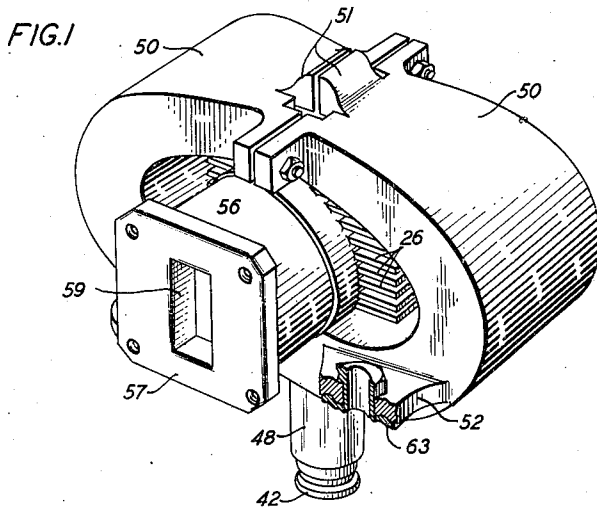
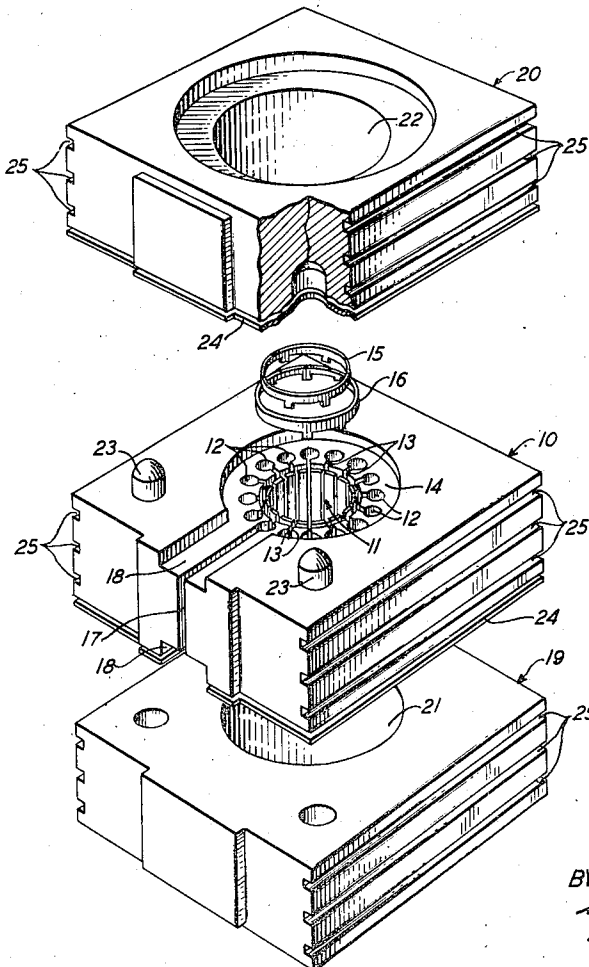


FIG. 6



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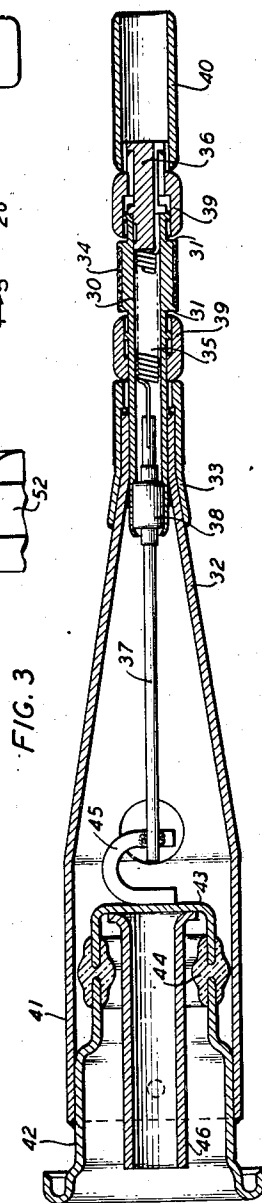
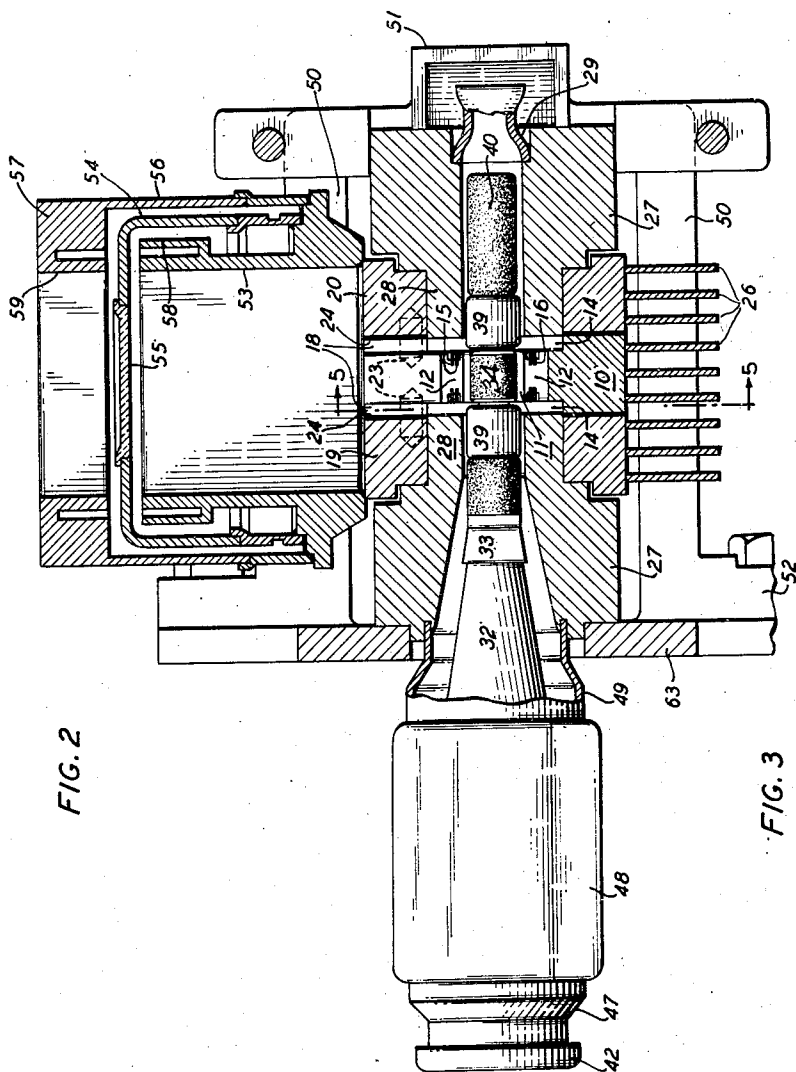
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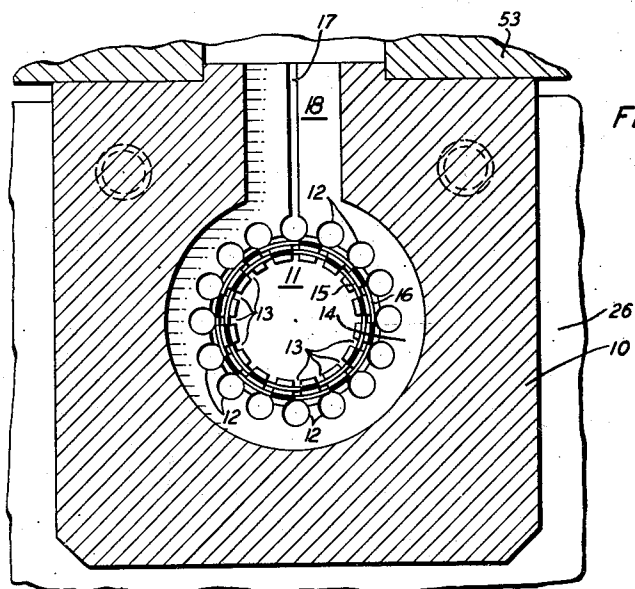
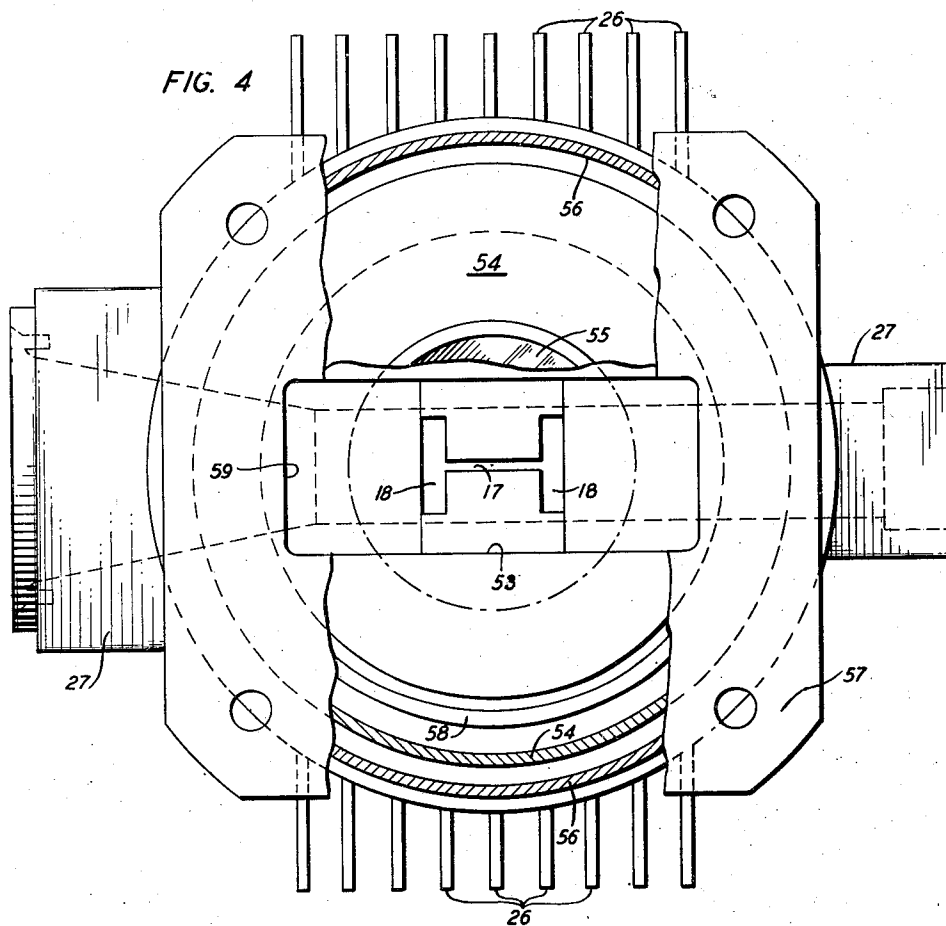
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ELECTRON DISCHARGE DEVICE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,466,922

ELECTRON DISCHARGE DEVICE

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11 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and more particularly to magnetrons of the internal cavity resonator type.

Such magnetrons comprise, generally, a cathode mounted within an anode having a plurality of segments and provided with slots or bores constituting cavity resonators. In one construction, the anode comprises a metallic block having an axial opening extending therethrough and in which the cathode is positioned, and a plurality of bores parallel to one another and to the cathode, defining cavity resonators and having communication with the anode-cathode space through radial slots in the block. Power may be taken from the device by way of a wave guide coupled to one or more of the resonators.

The characteristics of a wave guide are dependent upon its transverse dimensions. For example, the cut-off frequency of the guide is dependent primarily upon the major effective transverse dimension of the guide and the guide impedance varies with the transverse dimensions. For practical reasons, among which is the size of the magnet requisite to produce the necessary magnetic field intensity in the anode-cathode space, it is desirable that the cathode be relatively short. The cavity resonator length is determined by the cathode length and, thus, the guide dimensions may be limited by the cathode length and the cut-off frequency may be limited similarly. Further, inasmuch as the guide impedance is dependent upon the dimensions noted, difficulty has been experienced heretofore not only in constructing a magnetron with a wave guide output to meet prescribed characteristics, but also in manufacturing such devices in quantity with uniformity of characteristics.

One object of this invention is to improve electron discharge devices, such as magnetrons, having internal cavity resonators to which a wave guide is coupled.

More specifically, objects of this invention are to facilitate the realization of a relatively low cut-off frequency for a wave guide of restricted dimensions, such as the output wave guide for a magnetron, to expedite the construction of such an output guide which will have prescribed characteristics, and to enable the attainment of uniformity of product in quantity manufacture of magnetrons having such guides.

In accordance with one feature of this invention, in a magnetron of the general construction described heretofore, the output wave guide is of rectangulated H-section and is formed by slots, which are readily machinable to close tolerances

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and accurately reproducible. A guide of such construction is of the lumped impedance type, has a large effective transverse length and, in a magnetron, may be utilized to transform the load impedance, as presented to the oscillatory system of the magnetron, to a preassigned value.

In accordance with a more specific feature of the invention, the H-section guide is formed by a rectangular slot in the anode block, extending from one of the cavity resonators with its medial plane passing through the longitudinal axis of this resonator, and by a pair of parallel rectangular slots normal to the first slot, in opposite faces of the anode block and each in communication with a respective end of the resonator. The parallel slots are bounded at one major side by metallic blocks or plates affixed to the opposite faces aforementioned of the anode block.

The H-section guide may open at its outer end into a second wave guide section sealed to the anode assembly and provided with a vitreous window highly transparent to electromagnetic waves.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing, in which:

Fig. 1 is a perspective view of an electron discharge device embodying features of this invention;

Fig. 2 is a side view, mainly in section, of the electron discharge device shown in Fig. 1;

Fig. 3 is an enlarged sectional view of the unitary cathode assembly included in the device;

Fig. 4 is an enlarged end view, partly broken away, of the device shown in Fig. 1, with the magnets and cathode assembly removed, illustrating clearly the configuration of the wave guide section;

Fig. 5 is a fragmentary sectional view, taken along line 5—5 of Fig. 2, showing details of the anode and associated wave guide section; and

Fig. 6 is an exploded perspective view illustrating particularly the elements defining the wave guide section.

Referring now to the drawing, the electron discharge device therein disclosed is a magnetron of the multiresonant cavity type and comprises a substantially square anode block 10, for example of copper, having an axial circular cylindrical bore 11 extending therethrough and provided with a plurality of other and equally spaced, circular, cylindrical bores 12 parallel to one another and to the bore 11. The bores 12 have communica-

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tion with the bore 11 by way of radial slots 13, which thus provide a multisegment anode, and are dimensioned to define cavity resonators resonant at the intended operating frequency of the magnetron or at the mid-frequency of the intended operating band. The block 10 is provided with counterbores or recesses 14 in opposite faces, coaxial with the axial bore 11 so that, as will appear presently, the several resonant cavities are coupled to one another at opposite ends.

One group of alternate anode segments are connected electrically at opposite ends by annular, metallic bands 15 and the remaining segments are connected by similar bands 16. The alternate connections are seen most clearly in Fig. 5, wherein the connection between band and segment is indicated by the heavy shading of the respective band. These bands 15 and 16, commonly designated as mode locking straps, serve to confine oscillation of the device to a single mode.

The block 10 is provided also with a narrow slot 17 which extends from one of the bores or cavities 12 and is provided also, in its opposite faces, with similar slots or rectangular recesses 18 extending from the counterbores or recesses 14. Overlying the slots or recesses 18 and sealed to the block 10 are similar substantially square metal blocks 19 and 20, for example of copper, provided with counterbored, circular cylindrical apertures 21 and 22, respectively, of the same diameter as and coaxial with the recesses 14. The blocks 19 and 20 are positioned upon the block 10 by dowel pins 23 and are sealed hermetically thereto as by brazing, the brazing material being indicated at 24 in Figs. 2 and 6.

The three blocks 10, 19 and 20 constitute a unitary assembly having therein a passageway of H-section, as seen clearly in Fig. 4, comprising the slot 17 and slots or recesses 18. The latter, as is clear from Fig. 2, communicate with the recesses 14 at the ends of the resonant cavities 12 and the slot 17, as noted heretofore, communicates with one of the cavities 12. The function and characteristics of the H-section passageway will be discussed hereinafter. The three blocks are provided with parallel slots 25 in three sides in which metallic heat radiating fins 26 are affixed.

Affixed to each of the blocks 19 and 20, as by brazing, is a centrally apertured magnetic pole-piece 27, each pole-piece having a circular cylindrical portion 28 fitted in the bore 22 in the respective block. Sealed to one of the pole-pieces 27, as shown in Fig. 2, is a metallic exhaust tubature 29 through which the interior of the device may be evacuated. The other pole-piece mounts a unitary cathode assembly.

This assembly, as shown clearly in Figs. 2 and 3, comprises a circular cylindrical cathode sleeve member 30 provided with annular flanges 31 and joined at one end to a frusto-conical metallic support 32 having on one end thereof a metallic sleeve 33. The portion of the cathode sleeve member 30 between the flanges 31 is coated with thermionic material 34. Encompassed by the sleeve member 30 is helical, insulated heater element 35, one end of which is connected to a pin or extension 36 affixed to the sleeve member 30 and the other end of which is connected to a leading-in conductor 37 which extends through an insulating bushing 38 within the cathode member 30. Mounted upon the cathode sleeve member 30 and extending into immediate proximity to the flanges 31 are circular cylindrical magnetic collars 39. Mounted upon the pin 36 and extending from

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the adjacent collar 39 is a metallic cylinder 40. As illustrated in Fig. 2, the magnetic collars 39 extend coaxially within the apertures in the pole-pieces 27 and are of slightly smaller diameter than these recesses.

The support 32 has a cylindrical portion 41 which is fitted upon and sealed to a flanged metallic cylindrical member 42 to one end of which a metallic cap 43 is sealed by a vitreous cylindrical section 44. The cap 43 is connected to the conductor 37 by a tie wire or connector 45 and has affixed thereto a cylindrical metallic socket 46 coaxial with the member 42. The members 42 and 46 constitute a coaxial type jack for receiving an appropriate plug to establish connection between the cathode 34 and heater element 35.

The flanged member 42 is sealed hermetically to a metallic cylinder 47 sealed in turn to one end of a vitreous cylinder 48, the other end of which is sealed similarly to a metallic cylinder 49. The latter is sealed, as by brazing, to the adjacent pole-piece 27 so that the cathode assembly is mounted coaxially with the anode assembly and the electron emissive coating 34 is positioned coaxially within the bore 11 in the block 10.

Initially, in the operation of the device, the heater element 35 is energized to heat the coating 34 to emitting temperature. During operation of the device, the cathode is subjected to intense electron bombardment which results in heating of the cathode. However, the cathode assembly shown and described provides dissipation of the cathode heat so that the cathode is maintained at a safe temperature and also the glass-to-metal seals between the cylinder 48 and the cylinders 47 and 49 are protected. These desiderata are realized in part by proper correlation of the materials and dimensions of the elements constituting the cathode assembly to provide thermal gradients away from the electron emissive coating 34, thereby to dissipate the excess heat. In a particular construction, the cathode member 30 may be of nickel or molybdenum, the sleeve 33 and radiator 40 may be of copper and have their outer surfaces coated with zirconium, the support 32 may be of copper or a nickel copper alloy, the pin or extension 36, cap 43 and cylinders 47 and 49 may be of a nickel-cobalt-iron alloy and the flanged member 42 may be of stainless steel.

The magnetic collars 39, in addition to reducing the gap between the pole-pieces 27 and the anode-cathode region, being substantially non-emissive when subjected to electron bombardment, serve to confine electron emission to the area of the cathode having thereon the coating 34. Further, these collars 39 have their inner end, i. e., the end toward the anode-cathode region, rounded to provide a substantially uniform field over the major portion of the gap adjacent these ends. It is to be noted also that the inner diameter of each cap 39 over the major portion of the length thereof is somewhat greater than the diameter of the portions of the cathode member 30 which these caps encompass. Consequently, migration of the emissive material 34 to exposed portions of the cathode assembly beyond the flanges 31 is minimized and emission from these portions thus is substantially prevented.

The magnetic field requisite for operation of the device is provided by a pair of horseshoe magnets 50, the ends of which are shaped to fit the pole-pieces 27. Two juxtaposed magnet ends are formed with hollow portions 51 constituting

a protective cover for the exhaust tube 29. Also, as illustrated in Figs. 1 and 2, the magnets are provided with mounting lugs 52 for attachment to a non-magnetic mounting plate or bracket 63.

As noted heretofore, the slots 17 and 18 define an H-section passageway. This constitutes a lumped impedance type of wave guide, the slot 17 providing the capacitance and the slots 18 providing the inductance, through which power is taken from the device and which serves to transform the load impedance, as presented to the oscillatory system, to a prescribed value. The guide is made such that its effective length is substantially equal to one-quarter wavelength of the operating frequency of the device or of the mid-frequency if the device is intended for operation over a preassigned band.

The cut-off frequency of a wave guide is dependent largely upon its effective major transverse dimension. In a magnetron, such as of the type disclosed, the cathode length is limited, for practical purposes, by the magnet weight; that is, increases in cathode length necessitate use of larger magnets to provide a magnetic field of the requisite intensity in the anode-cathode region. An H-section guide of the construction shown and described enables and facilitates the attainment of a low cut-off frequency despite the limited permissible cathode length dictated by magnet weight requirements. That is to say, the H-section provides a relatively large effective transverse length for the guide. In a particular illustrative construction, specifically a magnetron intended for operation at 3.2 centimeters, the cross-sectional dimensions of the slot 17 may be 0.25 inch and 0.025 inch and those of the slots 18 may be 0.254 inch and 0.065 inch.

Furthermore, it will be noted that the H slot boundary surfaces are readily and accurately machinable to close tolerances whereby a guide of accurate dimensions and prescribed characteristics is readily attained. The formation of the complete guide automatically upon joinder of the blocks 19 and 20 to the block 10 not only expedites the assembly of the device but also, because of the manner in which the guide is formed, enables manufacture of the device in quantity with uniformity of product.

The H-section guide opens into a cylindrical, metallic guide 53 of rectangular inner section hermetically sealed, as by brazing, to the blocks 10, 19 and 20, the section 53 having a cup-shaped cover 54, for example of a nickel-cobalt-iron alloy sealed thereto. The cover 54 is provided at the center of its base with a circular aperture which is closed by a window 55. The window 55 is sealed hermetically to the cap 54 and is of a glass highly transparent to electromagnetic waves so that reflections thereat are minimized.

The cap 54 is encompassed by a cylindrical guide coupler 56 secured at one end to the guide 53 and terminating at its other end in a coupling flange 57. The guide 53 and flange 57 are provided with cylindrical portions 58 and 59, respectively, to define choke joints for minimizing power losses at the junction between the internal guide and an external guide, not shown, coupled to the flange 57.

Although a specific embodiment of the invention has been shown and described, it will be understood that it is but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A magnetron comprising an anode block having therein a pair of bores in communication with each other and extending between opposite faces of said block, one of said bores defining a cavity resonator, a cathode within the other of said bores, said block having a pair of parallel grooves in said opposite faces thereof and extending from the ends of said one bore, and a pair of plate members affixed to said faces and each overlying a respective one of said grooves thereby defining a pair of slots, said block having therein a slot extending from said one bore, connecting said grooves and defining an H-section wave guide with said pair of slots.

2. A magnetron comprising an anode block having an opening extending between opposite faces thereof and countersunk recesses at the ends of said opening, said block having also therein a plurality of bores positioned about said opening, in communication therewith and opening into said recesses, said bores defining cavity resonators, a cathode within said opening, said block having also a pair of parallel grooves in said opposite faces and each extending from the respective one of said recesses and a slot extending from one of said bores and connecting said pair of grooves, and an end plate overlying each of said faces and forming a slot with the groove therein, said first slot and the slots formed by said grooves and end plates constituting an H-section wave guide.

3. A magnetron comprising an anode block having an opening extending therethrough, a bore extending therethrough and in lateral communication with said opening and a recess in one face thereof extending from one end of said bore, said bore defining a cavity resonator, a cathode in said opening, and an end plate overlying said recess and forming a slot therewith, said anode block having therein also a slot substantially parallel to said bore, in communication with said bore and recess and defining a wave guide with said first slot.

4. A magnetron comprising an anode member having an opening extending from one face thereof and a cavity resonator defining bore in communication with said opening and also extending from said face, a cathode within said opening, said anode member having also therein a slot extending from said bore and intersecting said face, and a second member overlying said face, one of said members having therein a recess in communication with said bore, intersecting said slot and defining a wave guide with said slot.

5. A magnetron comprising an anode member having an opening extending from one face thereof and substantially normal thereto and having also a cavity resonator defining opening parallel to said first opening, in lateral communication with said first opening and extending from said one face, a cathode within said first opening, and a second member overlying said face, one of said members having a recess of substantially rectangular cross-section therein, communicating with the adjacent end of said resonator defining opening and extending substantially normal to said resonator defining opening, and said anode member having therein a slot of substantially rectangular section extending from said resonator defining opening, intersecting said recess at substantially right angles and defining a wave guide with said recess.

6. An electron discharge device comprising an electrode member having an opening extending

between opposite faces thereof and having also a second opening extending between said faces, in communication with said first opening and defining a cavity resonator, a second electrode member within said first member, said first member having a slot extending from said resonator and between said faces, and means cooperating with said first member, overlying said opposite faces and defining with said slot an H-section wave guide coupled to said resonator.

7. An electron discharge device comprising an electrode body having an opening extending between opposite faces thereof and having also a plurality of cavity resonator defining openings extending between said faces and in communication with said first opening, said body having also a slot extending between said faces and communicating with one of said resonator defining openings, an electrode within said first opening, and means overlying said opposite faces, cooperating with said electrode body and defining with said slot an H-section wave guide coupled to said one resonator defining opening.

8. An electron discharge device comprising a block constituting an electrode member and having therein an opening extending from one face thereof and a second opening also extending from said one face and in communication with said first opening, said second opening defining a cavity resonator, an electrode in said first opening, and means cooperating with said block and defining a first slot extending from the end of said second opening toward said face, said block having therein a slot in communication with said second opening, intersecting said first slot and defining a wave guide section therewith.

9. An electron discharge device comprising a conductive block constituting an electrode member and having a bore extending between opposite faces thereof, said block having also a plurality of cavity resonator defining openings extending between said faces, disposed about and in communication with said bore and substantially parallel thereto, and having recesses in said faces into which said openings open, a pair of conductive blocks each overlying a respective face of

said first block, said first block and each of said pair of blocks having cooperating portions defining a rectangular section slot extending from the respective recess, the two slots being substantially parallel, said first block having therein a third slot communicating with one of said resonator defining openings, extending between said two slots and defining an H-section wave guide therewith, and an electrode member in said bore.

10. A conductive block having an opening extending between opposite faces thereof and defining a cavity resonator, said block having also a slot therein extending from said resonator and between said faces, and a pair of members overlying said faces and each joined to a respective face, said members and said block having cooperating portions forming parallel slots at the ends of said opening which together with said first slot define an H-section wave guide coupled to said resonator.

11. A conductive block having a plurality of parallel bores in circular formation extending between two opposite faces thereof, means defining recesses in said faces into which said bores open, said bores defining cavity resonators, said block having therein a passageway of rectangular cross-section opening into one of said bores and having its major transverse dimension parallel to said bores, and means defining with portions of said faces a pair of slots each extending into a respective one of said recesses and intersecting said passageway, said slots being parallel and defining an H-section wave guide with said passageway.

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