Jan. 21, 1958 D. A. WILBUR 2,820,923

MAGNETRON

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Fig. 1.

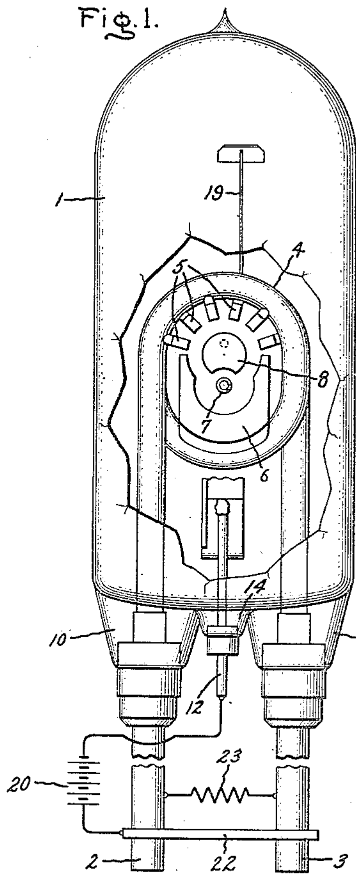


Fig. 2.

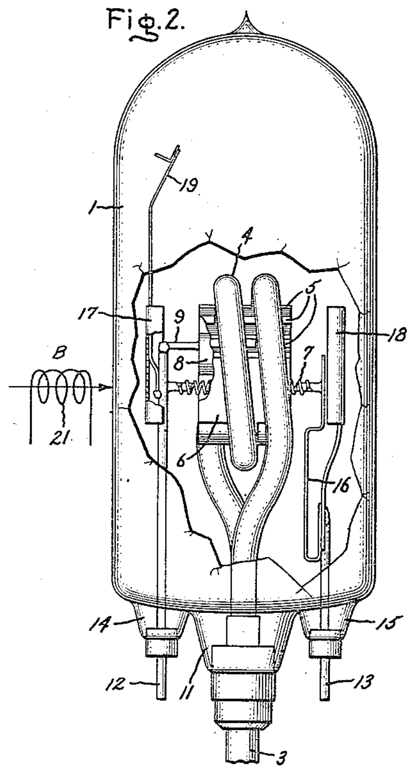


Fig. 3.

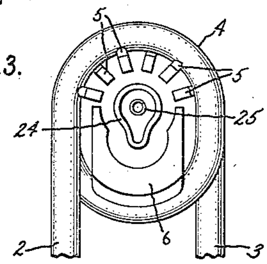
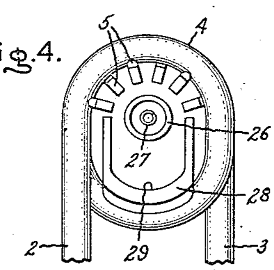


Fig. 4.



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2,820,923

MAGNETRON

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13 Claims. (Cl. 315—39.3)

This invention relates to discharge devices of the magnetron type.

In its usual form a magnetron discharge device comprises an elongated cathode surrounded by an anode assembly comprising a plurality of anode segments or vanes which define a cylindrical space charge chamber between their inner surfaces coaxial with the cathode. When axial magnetic and radial electric fields are established within the space charge chamber an average angular velocity about the cathode is imparted to the space charge composed of electrons emitted from the cathode. In such conventional magnetrons the anode segments are interconnected to form resonant circuits therebetween so that the fringing alternating electric fields between the segments extract some of the kinetic energy from the portions of the rotating space charge in phase with the fringing fields, the in-phase electrons finally being collected on the anode assembly. The reference to in-phase electrons refers to those electrons having a velocity component in the direction of the alternating field so that they must give up energy to the field. The space charge is thus re-entrant, since the same portion of the space charge, by reason of its rotation about the cathode, may pass under the anode segments more than once until all of the available energy imparted by the direct current source establishing the radial electric field has been extracted. Such re-entrant space charge magnetrons have been able to produce large amounts of power at relatively high efficiencies, and have accordingly found widespread use as high frequency oscillators.

In the course of normal operation the rotating space charge is bunched in groups of in-phase electrons which travel towards the anode and out-of-phase electrons which travel back towards the cathode. Since these bunches are also re-entrant, they must remain in synchronism if the advantages of the re-entrant space charge are to be retained. This raises problems in the fabrication of magnetron anode assemblies for higher operating frequencies where the resonant circuit dimensions must be necessarily smaller and the anode segments decreased in width and increased in number. While the manufacturing problem can be greatly simplified in multi-vane anode assemblies by employing a neutral anode segment to replace several of the resonant segments for operation under conditions corresponding to a large number of segments with but one or a few pairs of active anode segments, some loss of synchronism of the space charge bunches with the high frequency fields due to the space charge passage under a relatively long neutral segment is encountered, even though the space charge bunches themselves are maintained. It is accordingly desirable to provide means for utilizing a re-entrant space charge in order that the space charge energy may be fully utilized without the problem of maintaining re-entrant electron bunches in synchronism with the alternating electric fields.

It is therefore an object of my invention to provide a magnetron discharge device having a re-entrant space

charge in which the space charge bunching is not re-entrant.

It is another object of my invention to provide an improved discharge device of the magnetron type having means for debunching the electron stream at a point along its travel without materially affecting its kinetic energy.

It is yet another object of my invention to provide a magnetron discharge device in which cathode back-heating is controlled.

According to my invention the rotating or re-entrant space charge of a magnetron is demodulated at a point or region along its path without materially decreasing the space charge density or energy. This is accomplished by providing a portion of the space charge path with a relatively small ratio of cathode radius to anode radius as compared with the conventionally chosen corresponding ratio of the portion of the space charge path including the output anode segments. After each excursion around the cathode in the space charge chamber the effect of the modulation of he space charge by the high frequency fields of the resonant circuits coupled to the anode segments is removed so that the spacing between the last anode segment on one side of the debunching region and the first anode segment on the other side of the debunching region is not critical. In this way the advantages of a re-entrant space charge are obtained without the restrictions imposed when the space charge bunching is also re-entrant. The effectiveness of the magnetron as an oscillator is thus enhanced since loss of synchronism of the re-entrant space charge cannot adversely affect the oscillation, and the magnetron is also adapted for amplifier operation since electronic back-coupling from an output anode section to an input anode section is readily avoided by positioning the debunching means between them.

The features of my invention desired to be protected herein are pointed out in the appended claims. The invention itself, together with further objects and advantages may best be understood by reference to the following description taken in connection with the accompanying drawings in which:

Fig. 1 represents a view partly in section of a magnetron discharge device embodying the principles of my invention;

Fig. 2 represents a side view of the device of Fig. 1;

Fig. 3 is a view of a magnetron electrode structure illustrating a modification of my invention; and

Fig. 4 is a view of a magnetron electrode structure illustrating another modification of my invention.

In accordance with my invention, the instability of the space charge bunching in a traveling wave magnetron oscillator where the space charge must rotate about a cathode portion of small radius relative to the anode radius is usefully employed. This instability is believed to be caused by the collapse of the space charge spoke since its base, which needs travel a much lesser distance than its top, tends to lead the top and eventually cause the spoke to topple. This condition is particularly noticeable in oscillators of the type where the number of anode segments is large and the cathode radius to anode radius ratio is small. In such structures the alternating electric fields do not penetrate the space charge chamber to any large extent as they do, for example, in a two-segment split anode magnetron. Therefore, unless the alternating field has a particularly high intensity, only the top part of the space charge spoke can be maintained in synchronism by the fringing alternating field. An active or normal portion of the space charge chamber path is accordingly defined between anode and the cathode surfaces of optimum relative radii for high power output. Another substantial portion of the space charge path is between a cathode portion and facing anode surface having a small cathode-to-anode radius ratio to establish the so-called diode cutoff or upper current cutoff limit at a low value. Accordingly, the electron bunches or spokes produced by modulation of the space charge by the anode segments along the normal portion of the space charge path, are substantially debunched as they pass around the small radius portion of the cathode. The anode segment or segments along the debunching region are primarily useful in maintaining the radial electric field and need not be coupled to the output circuit. Consequently, when the space charge thus demodulated reenters the active portion of the space charge chamber, there are no resultant bunches or spokes to be maintained in synchronism with the alternating fields. Accordingly, space charge synchronism need be maintained only along the anode segments in the output portion of the magnetron, and the remainder of the path, including the debunching region, is not critical in length.

Referring now to Figs. 1 and 2, there is shown a magnetron comprising hermetically sealed envelope **1** enclosing a part of a resonant circuit such as a transmission line formed by parallel conductors **2** and **3** extending through the envelope **1** and a one and one-half turn spiral coil **4** which terminates the conductors. Within the spiral coil are provided a plurality of active anode segments **5** of uniform width together with an additional neutral anode member or segment **6** of greater width. Each of the segments is conductively supported from a different point on the inner periphery of the spiral coil as by welding thereto. As may be seen by the drawing, the six anode electrodes or segments **5** are positioned in a generally semi-cylindrical configuration by virtue of their attachment to the spiral and the wide electrode **6** completes the side wall of the space charge chamber. The segments are conventionally spaced to provide small interaction gaps between them.

Disposed within the space charge chamber defined between the anode segments is a cathode assembly which is arranged in two parts in the embodiment shown to simplify heating of the emitting surface. In the drawing the emitting section of the cathode is shown as comprising a close wound spiral tungsten coil **7** which may be coated with a suitable thermionic emissive material of the type well-known in the art, and spaced from it is a cathode member **8** which may be suitably formed from a solid conductor whose axis is parallel to that of the cathode helix and the space charge chamber. The portion of the cathode block facing the anode segments **5** preferably has a constant radius of curvature on the same center as the radius of curvature of the facing surfaces of the anode segment array. The cathode emitting helix **7** has a relatively small radius compared to the radius of the cathode member **8** and is positioned adjacent the cathode member **8** between it and the neutral anode segment **6**, the radius of curvature of the facing portions of the anode segment **6** being centered on the cathode helix axis. The portions of the neutral segment **6** near the array of active anode segments **5** are preferably shaped to provide a gradual transition in radius to that of the segments **5**. One end of the cathode helix is connected to the cathode member through a support member **9** welded between the cathode member **8** and the support means for the cathode helix **7**, which also maintains the cathode member **8** at the same potential as the helix **7** with respect to voltages applied to the anode segments connected to the loop **4**. It is to be understood that the emitting portion **7** of the cathode assembly need not be a helical coil, but may be, for example, a cylindrical sleeve.

As shown in Fig. 1, the ratio of the radius of the helix **7** to that of the facing portions of the neutral anode segment **6** is much smaller than the ratio of the radius of the cathode member **8** to that of the facing active anode segments **5**. The latter ratio is chosen for a relatively high upper-current cutoff point for effective operation of the conventional portion of the magnetron whereas the former ratio is chosen to provide a low upper-current cutoff. In this particular embodiment, the disparity of the ratios is obtained by the disparity in the radii of curvature of the cathode portions **7** and **8**. Accordingly, while the upper-current cutoff point is governed in part by the relative radii of curvature of the facing portions of the cathode and anode for a portion of the angular travel of the space charge, the cutoff point may be considered as changing with the cathode radius of curvature where all anode portions surrounding the cathode assembly have the same or nearly the same spacing from the facing cathode portions.

Conductive connections are made to the spiral coil through the envelope **1** by means of any suitable glass-to-metal hermetic seals, such as the seals **10** and **11** surrounding the lines **2** and **3** and permitting them to pass through the envelope wall. Similarly, conductive connections may be made to the cathode helix by the leads **12** and **13** which pass through the envelope wall at similar glass-to-metal seals **14** and **15**. The cathode coil may be rigidly attached to lead **12** at one end and at the other end to a spring tension member **16**, rigidly secured to the lead **13**. It will be understood that the spring member **16** holds the cathode helix **7** taut and fixed in its position relative to the spiral **4** and anode segments **6**.

For the purpose of precluding excessive destructive bombardment of the envelope **1** and the lead in seals by electrons escaping from the space charge chamber, anode end shields **17** and **18** are provided and welded to the filament supports **12** and **13** respectively. A suitable getter may be provided on a getter support **19** welded to the lead **12** or shield **17**. The getter is flashed according to any conventional manner during the evacuation process.

The anode electrodes **5** are connected to different points on the spiral **4** for the desired coupling to the tuned output circuit. Adjacent electrodes **5** are connected to different turns of the upper part of the coil **4** so that each set of three alternate segments is progressively spaced along the upper portion of one of the turns of the coil assembly. In this manner, if one lengthwise half of the coil becomes electrically positive and the other negative at any instant during the high frequency oscillation of the tank circuit comprising the transmission line, then adjacent anode segments will have opposite high frequency polarities, corresponding to the usual π mode of operation. Since the width and spacing of the six segments **5** corresponds to that of six segments of a twelve segment or twelve gap magnetron, the frequency corresponding to twelve gap action is obtained. This means of connecting the active anode segments to the resonant circuit offers advantages in ease of fabrication and is described and claimed in my Patent 2,521,556, issued September 5, 1950, and assigned to the assignee of the present invention.

The neutral anode segment **6**, also called a neutrode, is advantageously employed in order to further simplify construction of the magnetron by permitting the omission of a number of active anode segments, which in this case is six. The segment **6** is accordingly connected to the midpoint of the coil **4**, which is the lower loop as oriented in the drawing, and hence is at a high frequency neutral point. This neutral electrode has no induced nor imposed high frequency potential variations since it is connected to a point on the transmission line which has a zero high frequency voltage during oscillation. Its function is to help establish the radial electric field necessary for the maintenance of the rotating space charge about the cathode, and its use affords a higher frequency operation characteristic of multi-anode constructions with a fewer number of anodes. The neutral electrode feature is described and claimed in my Patent 2,462,698, issued February 22, 1949, and assigned to the assignee of the present application.

In operation a source of relatively high unidirectional voltage, indicated schematically in Fig. 1 as a battery **20**, is connected between the cathode assembly and the anode assembly, the cathode being negative with respect to the anode segments, so that a radial electric field is established in the space charge chamber. A magnetic field in the space charge chamber parallel to the cathode axis is also provided, the means for providing the magnetic field being shown schematically in Fig. 2 as a solenoid **21**, although, of course, permanent magnet means may be substituted. When the cathode helix is suitably heated so that electrons are emitted to provide a space charge, a generally rotating motion of the space charge around the cathode is established at an average angular velocity.

In the embodiment shown in Figs. 1 and 2 the emitting cathode **7** is spaced from the cathode member **8** but the spacing is sufficiently close so that the emitted electrons rotate about the assembly as a whole, rather than between the cathode members themselves. The interaction between the rotating space charge and the anode segments **5** excites the circuit to which the segments are connected at its resonant frequency. As shown in Fig. 1, a slidable tuning member **22** is positioned along the length of the external portion of the transmission line to short circuit the lines **2** and **3** together at the position corresponding to the desired frequency. The energy translated from the direct current voltage source into ultra-high frequency energy is suitably coupled to a desired load, the load being schematically shown in Fig. 1 as a resistor **23** connected across the transmission line conductors **2** and **3**.

In the usual mode of operation the instantaneous high frequency voltages of the adjacent segments of the segments of the array **5** are of opposite phase, and those electrons of the space charge which are in phase with the fringing electric field between the segments lose energy to the fields and thus reinforce the oscillations. At the same time, upon loss of some of their energy, these electrons regain energy from the static electric field by moving towards the anode segments, eventually being collected by the anode as the energy is extracted in successive steps at successive gaps. The in-phase portions thus tend to assume a greater diameter and are believed to take the form of space charge spokes while the out-of-phase portions of the space charge are accelerated by the alternating fields of the anode segments and in part returned to the cathode. In order to maintain excitation of the oscillatory circuit the spokes must remain substantially in synchronism with the alternating fields as they advance under successive gaps. This normally calls for utmost precision in the fabrication and assembly of the electrodes, especially since the array is not linear but must provide for re-entrant space charge spokes. While a number of active segments **5** are replaced by the neutrode **6**, thus simplifying the magnetron construction, there is some tendency for the space charge spokes to exceed the synchronous velocity as they pass under the long neutral segment. Such space charge spokes reentering the active section of the magnetron out of synchronism limit the power output and may even prevent operation altogether.

In accordance with my invention, the space charge spokes which represent the regions of bunched in-phase electrons of the rotating space charge are dispersed when these portions of the space charge pass around the relatively small radius portion of the cathode assembly under the neutrode segment **6**. Since this electrode is longer than any one of the several active anode segments it replaces, it facilitates arrangement of a relatively long space charge path or large angle of rotation about the small radius cathode helix for increasing the effectiveness of the debunching function. As shown in the illustrated embodiment there is approximately 180° of space charge rotation about the cathode helix. The absence of the alternating fields in the neutrode region tends to make the debunching effect more pronounced. Accordingly, the electron stream is substantially demodulated after passing through the portion having the small cathode radius to anode radius ratio. Upon re-entering the active section under the segments **5** the space charge is again readily modulated by the fringing electric fields, and the newly formed spokes or bunches of in-phase electrons are maintained in synchronism until the space charge again enters the debunching region.

Since maintenance of synchronism of the modulated re-entrant space charge with the electric fields set up between the active anode segments is of no concern, the fabrication of the magnetron is greatly simplified. Thus, the length of the space charge path between the last segment encountered by the rotating space charge and the first segment where it re-enters the active region is not critical. Only the array of active anode segments **5** must be designed and spaced to meet the critical requirements of high frequency magnetron operation. This also permits further structural simplification through the use of longer neutrodes, i. e., neutrodes subtending a greater angle with respect to the cathode so that they may replace a greater number of active anode segments. While it is not necessary that the anode segment nearest the small radius of curvature portion of the cathode be a neutrode, the neutrode type of construction lends itself readily to such a debunching arrangement since the neutrode is not part of the active anode segment array in which the bunching must be maintained to utilize the anode segments for output purposes.

It will be appreciated that the separation of the emitting portion **7** and the non-emitting portion **8** of the cathode assembly is not necessary to provide the debunching action described. However, it does simplify construction in so far as it permits use of more or less standard emitting helixes or sleeves without the increase in heating current which would be necessary to heat the entire cathode assembly. In addition, since the cathode emitting portion **7** is substantially isolated from the active anode segments **5**, it is not subject to back heating by electrons accelerated by the anode segments. The cathode operating temperature can thus be readily controlled for conservation of the emitting surface.

Referring now to Fig. 3 an electrode assembly is illustrated in which the cathode is shown as a single member rather than as an assembly of cathode emitting and non-emitting members as is Figs. 1 and 2. In the arrangement of Fig. 3 the tuned circuit conductors **2** and **3** are terminated by a loop **4** as previously described and having an array of anode segments **5** properly connected to maintain the usual π mode excitation of the output circuit. As in Figs. 1 and 2 a neutrode **6** defines a substantial portion of the space charge chamber, the electrons passing under the neutrode for approximately half the angular rotation about the cathode.

As distinguished from the embodiment illustrated by Figs. 1 and 2, the cathode **24** is a single member having one portion with a large radius of curvature together with a smaller portion having a small radius of curvature, the centers of the two portions being displaced from each other in order that the small radius of curvature portion may extend beyond the larger radius. The radii of curvature of the anode portions are centered on the centers of the curvature of the facing cathode portions and do not vary substantially. Such a unitary cathode assembly can range in shape according to the separation of the centers of the two portions from a generally egg-shaped or oval cross section to a configuration in which a small cylinder is tangent to a larger one.

In the specific arrangement shown, the small radius of curvature portion of the cathode bulges out from the larger cylinder, the small radius being maintained for approximately 180° in order that a substantial portion of the electron angular rotation may be about this small portion. A heater **25** extending through the cathode permits heating of the entire cathode surface and the cathode coating for the desired thermionic electron emission is applied over the entire outer surface of the cathode to provide a high density space charge. Of course, if desired, only portions of the cathode need be provided with an emitting coating, as, for example, in the cathode of Figs. 1 and 2. The debunching operation corresponds to that previously described.

Another magnetron electrode assembly incorporating my invention is illustrated in Fig. 4, where tuned circuit conductors 2 and 3 are again terminated by a loop 4 as previously described. An array of anode segments 5 is properly connected to maintain the usual π mode excitation of the output circuit. However, a single cylindrical cathode 26 having a circular cross section and suitably provided with an internal heater 27 is employed, the position and radius of the cathode being entirely conventional with respect to the anode output segments 5. Thus as shown in the drawing, the faces of the anode segments facing the cathode are arranged in a circular arc centered on the cathode axis. The relative radii of the cathode and the facing anode surfaces are designed for conventional operation, the upper current cutoff point being suitably high in this region.

In the debunching region anode segment 28, corresponding in function and circuit connection to the neutrode 6 previously described, has a substantial portion 29, corresponding in this case to over 60° of the space charge travel about the cathode, having a relatively large radius from the cathode axis. Accordingly, the ratio of the radius of the cathode 26 to the radius of the neutrode surface 29 is so small as compared to the corresponding ratio in the output portion of the magnetron device that a much lower upper-current cutoff point is obtained. Debunching of the space charge spokes traveling under the neutrode surface is obtained in the same manner as previously described except that the critical ratio is obtained by increasing the effective radius of curvature of the neutrode rather than by decreasing the cathode radius.

While the large radius of the curvature portion of the neutrode surface facing the cathode may be conveniently arranged with its center of curvature on the cathode axis, some deviation can be tolerated for the sake of ease of construction. For example, the portion 29 may be a plane surface all of which is a substantial distance from the cathode. In such a case its radius of curvature, strictly speaking would be infinite, but it is the average or equivalent radius of curvature over a substantial rotational angle that provides the desired low upper-current cutoff point. The principle involved is the same as that previously described in that for a substantial portion for the angular travel of the space charge the portions of the space charge near the anode must travel a much greater distance than the portions near the cathode with resulting instability of the space charge bunches.

While I have shown my invention as applied to a magnetron device of the type in which a single resonant output circuit is employed it will be appreciated that my invention may likewise be incorporated in other re-entrant magnetron devices of the type incorporating cavity resonators between the anode segments. It will, of course, be understood that various modifications may be made without departing from the principles of the invention. The appended claims are therefore intended to cover any such modifications within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A traveling wave magnetron discharge device having facing cathode and anode surfaces defining a continuous space charge path around a cathode, and means for debunching the space charge comprising a portion of said facing surfaces defining a partial length of the space charge path having a low magnetron upper-current cutoff point relative to the magnetron upper-current cut-off of the remainder of said path.

2. A traveling wave magnetron discharge device having facing cathode and anode segment surfaces defining a continuous space charge path around a cathode, and means for debunching the space charge comprising a portion of said facing surfaces defining a partial length of the space charge path having a low ratio of cathode radius to anode radius relative to the ratio of the cathode radius to the anode radius of the remainder of said path.

3. In a traveling wave magnetron discharge device having facing surfaces between a cathode and a plurality of anode segments defining a continuous space charge path around a cathode between facing cathode and anode surfaces, means for debunching the space charge comprising a portion of said facing surfaces of the space charge path having a ratio of cathode diameter to anode diameter which is low for a substantial angle about said cathode compared to the corresponding ratio for other portions of the device whereby a relatively low magnetron upper-current cutoff point is obtained in said portion.

4. A traveling wave magnetron discharge device comprising an anode assembly having a plurality of spaced anode segments defining a re-entrant space charge chamber between their inner surfaces and an elongated cathode extending along an axis through said chamber, and means for debunching the space charge comprising a portion of said space charge chamber extending for a substantial angle about said cathode wherein the ratio of the cathode radius from said axis to the radius of the facing anode surfaces from said axis is relatively low as compared to the corresponding ratio for other portions of said chamber.

5. A traveling wave magnetron discharge device comprising an anode assembly having a plurality of spaced anode segments defining a re-entrant space charge chamber between their inner surfaces re-entrant having a curved cross section outline and an elongated cathode having a curved cross section outline extending through said chamber, and means for debunching the space charge comprising a portion of said space charge chamber extending for a substantial angle about said cathode wherein the ratio of the cathode radius of curvature to the radius of curvature of the facing anode surfaces is relatively low as compared to the corresponding ratio for other portions of said chamber.

6. A traveling wave magnetron discharge device comprising an anode assembly having a plurality of spaced anode segments defining a re-entrant space charge chamber between their inner surfaces and an elongated cathode extending along an axis through said chamber, and means for debunching the space charge comprising a portion of said space charge chamber extending for a substantial angle about said cathode wherein the ratio of the radius from the axis of a portion of the cathode cross section to the radius from the axis of the corresponding facing surface of said anode assembly is small compared to the ratio of the radius from the axis of another portion of the cathode cross section to the radius from the axis of the facing surfaces of a group of said anode segments in another region of said chamber.

7. A traveling wave magnetron discharge device comprising an anode assembly having a plurality of spaced anode segments defining a re-entrant space charge chamber between their inner surfaces having a curved cross section and an elongated cathode having a curved cross section extending through said chamber, and means for debunching the space charge comprising a portion of said space charge chamber extending for a substantial angle about said cathode wherein the ratio of the radius of curvature of the cathode cross section to the radius of curvature of the corresponding facing portion of said anode assembly is small compared to the ratio of the radius of curvature of another portion of the cathode cross section to the radius of curvature of the facing surfaces of a group of said anode segments in another region of said chamber.

8. A traveling wave magnetron discharge device comprising an anode assembly having a plurality of spaced anode segments defining a re-entrant space charge chamber between their inner surfaces and an elongated cathode extending along an axis through said chamber, and means for debunching the space charge comprising a portion of

said space charge chamber extending for a substantial angle about said cathode wherein the ratio of the radius from the axis of the cathode cross section to the distance from the axis to the corresponding facing portion of said anode assembly is small compared to the ratio of the radius from the axis of another portion of the cathode cross section to the distance from the axis to the facing surfaces of a group of said anode segments in another region of said chamber.

9. In a traveling wave magnetron discharge device having an anode assembly in which a plurality of spaced anode segments define a re-entrant space charge chamber between their inner surfaces having a curved cross section outline, an elongated cathode extending through said chamber and parallel to the axis thereof having a curved cross section including a portion having a relatively large radius of curvature with respect to its spacing from facing anode segment surfaces, and means for providing a region of relatively low upper-current cutoff limit comprising another portion of said space charge chamber extending for a substantial angle about said cathode wherein the radius of curvature of said cathode is relatively small with respect to its spacing from another facing anode segment surface.

10. In a traveling wave magnetron device of the type having an anode assembly comprising a plurality of spaced anode segments defining a re-entrant space charge chamber between their inner surfaces, a cathode assembly comprising two parallel elongated tubular members extending along an axis through said chamber, and means for debunching the space charge comprising a portion of said space charge chamber extending for a substantial angle about said cathode wherein the ratio of the radius of curvature of a cross section portion of one of said members to the radius of the facing surface of said anode assembly is small compared to the ratio of the radius of curvature of a cross section portion of the other of said members for the remaining angle of travel about said axis to the radius of its facing anode surface.

11. A traveling wave magnetron device of the type having an anode assembly comprising a plurality of spaced anode segments defining a re-entrant space charge chamber between their inner surfaces and an elongated cathode assembly extending through said chamber approximately equidistantly spaced from the facing anode surfaces, and means for debunching the space charge comprising a portion of said space charge chamber extending about said cathode wherein a portion of said cathode assembly along the length thereof is of a cross section with relatively small radius of curvature compared to other portions of said cathode assembly.

12. A traveling wave magnetron discharge device comprising an anode assembly having a plurality of spaced anode segments surrounding a cylindrical cathode to provide a re-entrant space charge path, and means for debunching the space charge comprising a portion of said space charge chamber extending for a substantial angle about said cathode wherein one of said segments has a large angular extent with respect to the other of said segments and the spacing of said one of said segments from said cathode is large with respect to the spacing of a group of other of said segments.

13. A discharge device of a traveling wave magnetron type comprising an elongated cathode surrounded by an anode assembly to provide a re-entrant space charge region, said anode assembly including a group of spaced adjacent anode output segments and a neutral segment, means for providing a static magnetic field in the space between said cathode and said anode assembly along said cathode axis, means for providing an electric field between said cathode and said anode assembly whereby electrons emitted by said cathode are provided with an average velocity about said cathode in a given direction, and means for debunching the space charge in the region between said cathode and said neutral segment wherein the ratio of the radius of a portion of said cathode facing said neutral segment to the neutral segment radius is substantially smaller than the ratio of the radius of another portion of the cathode facing said group of output segments to the output segment radius.

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