

Jan. 7, 1958

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2,819,449

MAGNETRON

Original Filed Sept. 21, 1949

2 Sheets-Sheet 1

Fig. 1

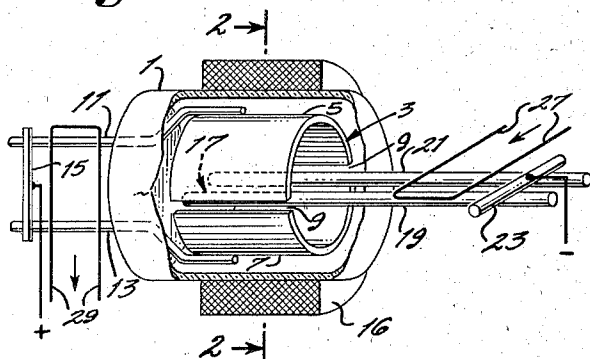


Fig. 2

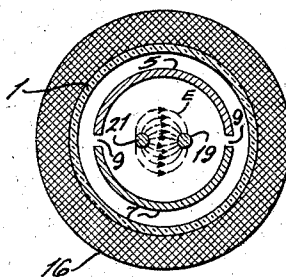


Fig. 3

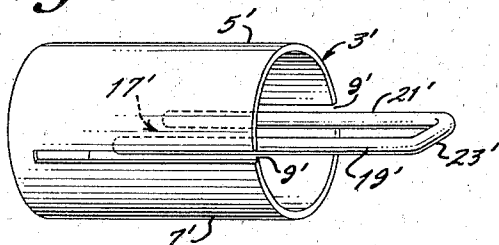


Fig. 4

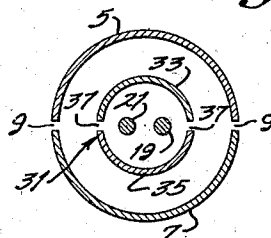


Fig. 5

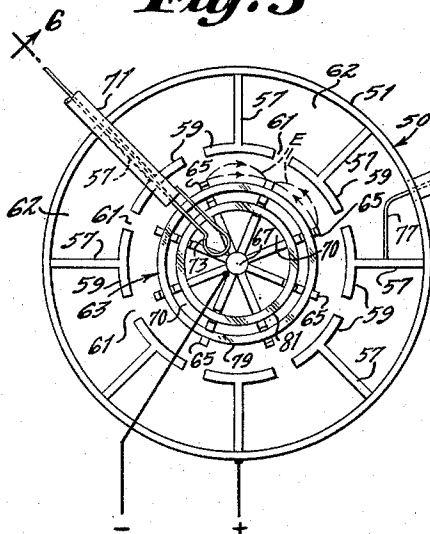
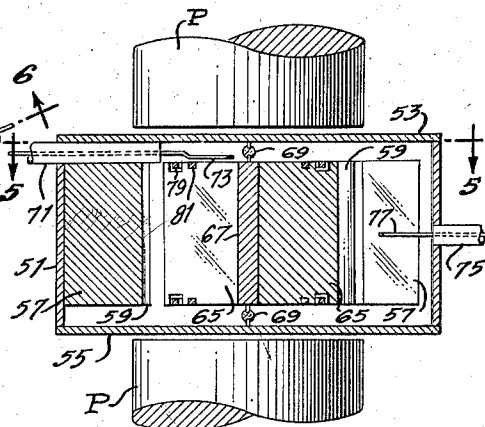


Fig. 6



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2 Sheets-Sheet 2

Fig. 7

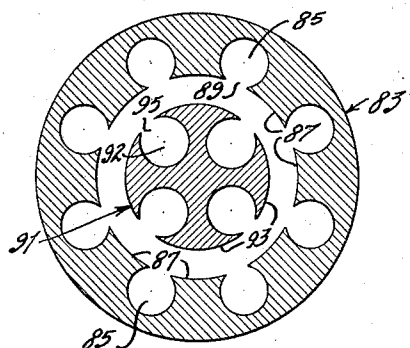


Fig. 8

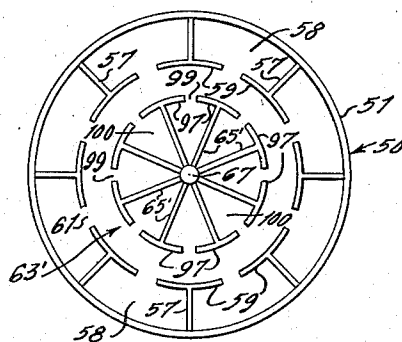


Fig. 9

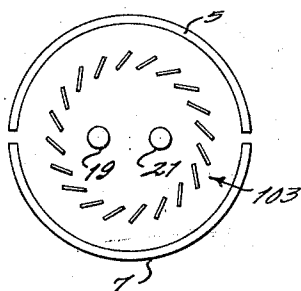


Fig. 10

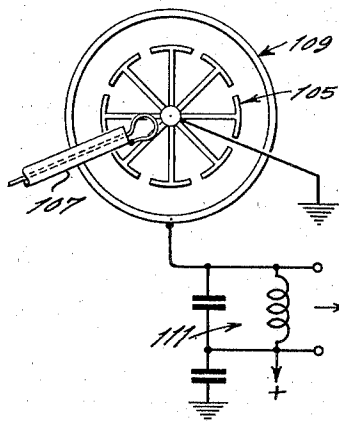


Fig. 11

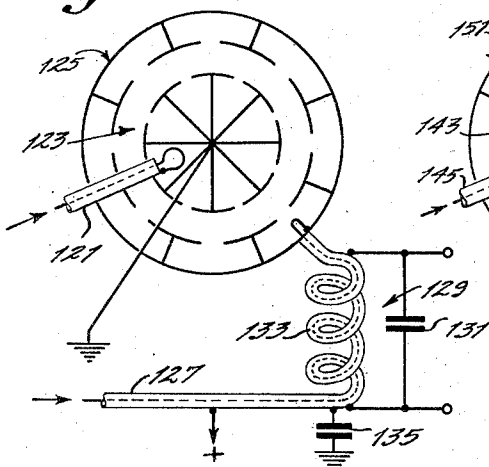
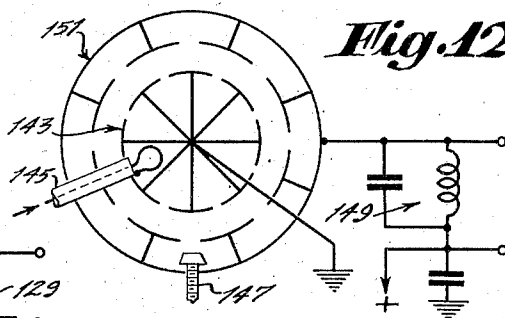


Fig. 12



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2,819,449

MAGNETRON

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Continuation of abandoned application Serial No. 116,909, September 21, 1949. This application January 21, 1954, Serial No. 405,346

31 Claims. (Cl. 332—5)

This invention relates to electron discharge devices, and particularly to such devices of the magnetron type suitable for use as radio frequency amplifiers at high frequencies.

This application is a continuation of my copending application Serial No. 116,909, filed September 21, 1949, and assigned to the assignee of this application, now abandoned.

My invention is concerned with making use of the highly efficient and advantageous characteristics of the traveling-wave magnetron for a radio frequency amplifier, by utilizing control action of a new type at or in the region of the cathode, while taking the amplified output from the anode. In accordance with my invention, therefore, the usual control action of the output or anode circuit on the electron stream is eliminated, or at least substantially reduced, and a control action by means of control electric fields at or near the cathode is substituted. In one form of the invention, a split cathode is used inside a split anode, with the input signal applied across the two halves of the split cathode, and the output taken from the split anode. In another form, a cathode structure comprising a multi-cavity, self-resonant structure is used inside a multi-cavity self-resonant anode. The control action of the anode is reduced by a suitable design of the anode structure which may be supplemented by use of an electron-pervious shield between the anode and cathode, and the desired control action is introduced by exciting the cavity resonator structure of the cathode in accordance with the signal to be amplified to provide control electric fields between adjacent cathode elements or parts. The cathode structure thus serves not only as an emitter but also as a control means for the tube. In the case of the multi-cavity cathode, the cathode elements forming the resonators may be "strapped" together, by low impedance conductors connecting alternate elements, as is conventional in multi-cavity-anode magnetrons, to facilitate operation in the usual π -mode wherein adjacent resonators operate in phase opposition. My invention further relates to the use of my novel tube in converter, mixer and frequency multiplier apparatus.

The principal object of my invention, therefore, is to provide a novel magnetron tube structure particularly adapted for use as an amplifier at high frequencies.

Another object is to provide means in a magnetron for introducing radio frequency control electric fields at or near the surface of the cathode.

Still another object of my invention is to provide an electron discharge device having a split, thermionic cathode which serves as a radio frequency control means as well as an emitter.

A further object is to reduce the control action of the anode on the electron stream in a multi-cavity magnetron.

Another object is to provide a magnetron amplifier tube having a multi-cavity cathode associated with a multi-cavity anode.

Other objects of the invention are to provide improved

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apparatus for use in converters, mixers and frequency multipliers.

These and other objects and advantages of my invention will be apparent from the following detailed description taken in connection with the appended drawing, in which:

Fig. 1 is a perspective side view of a split-anode magnetron incorporating my invention;

Fig. 2 is a transverse section view taken on the line 2—2 of Fig. 1;

Fig. 3 is a perspective side view showing a modification of the structure of Fig. 1;

Fig. 4 is a transverse section view similar to Fig. 2 of a modification including a shield between the cathode and the anode;

Fig. 5 is a plan view, on line 5—5 of Fig. 6, of a multi-cavity type magnetron incorporating my invention;

Fig. 6 is a longitudinal section view taken on line 6—6 of Fig. 5;

Figs. 7 and 8 are plan views similar to Fig. 5 of modifications thereof;

Fig. 9 is an end view showing a modification of the shield of Fig. 4;

Figs. 10 and 11 are schematic views showing my invention incorporated in mixer tubes; and

Fig. 12 is a schematic view showing my invention incorporated in a converter tube.

Referring to the drawing, Figs. 1 and 2 illustrate my invention incorporated in a split-anode magnetron. The numeral 1 indicates a glass envelope which contains a hollow anode 3 defining a cylindrical space therein and consisting of two semi-cylindrical segments 5 and 7 spaced apart to provide a pair of anode gaps 9. The anode segments 5 and 7 are supported by rods 11 and 13 which extend through one end of the envelope 1 and also serve as anode circuit leads. The outer ends of the rods 11 and 13 are connected by an adjustable shorting rod or bar 15 to form a Lecher type tuned output circuit. An axial magnetic field is provided by an electromagnet 16, for example, mounted on the outside of the envelope 1.

A thermionic cathode 17 is disposed axially within the hollow anode 3. In accordance with my invention, the cathode 17 is divided into two spaced parts which are illustrated, for example, in Figs. 1 and 2 as being in the form of elongated rods 19 and 21 forming a cathode gap therebetween. The cathode rods may be indirectly heated by conventional internal heaters, whose leads and construction are not shown, and the portions of the rods lying within the hollow anode 3 may be coated with electron-emissive material. The rods 19 and 21 extend through the end of the envelope opposite the anode leads 11 and 13 and serve as cathode supports and leads. An adjustable shorting bar 23 connecting the outer ends of rods 19 and 21 completes a Lecher type tuned input circuit. The input circuit 19—21—23 constitutes one form of radio frequency signal input means coupled to the cathode parts. The cathode parts 19 and 21 are insulated from each other within the glass envelope 1, and this input means constitutes the sole electrical connection between these parts. The cathode 17 and anode 3 define a single continuous electron interaction space therebetween.

In operation, the anode 3 and cathode 17 are connected to the positive and negative terminals, respectively, of a high voltage direct current source, as shown schematically in Fig. 1 by plus and minus signs, and the electromagnet 16 is energized, to produce the usual crossed direct current electric and magnetic fields in the space between the cathode 17 and anode 3. It is found that these fields can be so adjusted as to produce an amplifying and non-self-oscillating condition of the magnetron, in which there is

no alternating voltage generated in the output circuit in the absence of an input signal applied to the cathode circuit. To operate the tube as an amplifier, the input circuit to the cathode is excited in accordance with the signal to be amplified, as by means of a transmission line terminating in a loop 27 inductively coupled to the input circuit. The signal produces variable radio frequency electric control fields extending between the cathode parts 19 and 21 and fringing outwardly toward the anode 3. An important feature of the invention lies in the fact that a major portion of the control field is in a direction tangential to a circle surrounding the cathode region. Furthermore, the control electric field is applied near the cathode where the electrons are traveling slowly and are more susceptible to control. Electrons traveling from the cathode in their normal curved paths, as a result of the crossed magnetic and direct-current electric fields, are subjected to control electric field forces which are generally parallel to their direction of travel. As a result these forces affect the velocity of the electrons along their curved paths, as distinguished from known devices in which the control forces are applied to deflect or change the direction of the electrons. Thus, by a process involving velocity-modulation and inductive-output very similar to the control action of the anode in a conventional multi-cavity oscillating magnetron, the control electric fields in the vicinity of the cathode in Fig. 2, for example, cause the electrons to become "bunched" to produce a spoke-like space-charge configuration in the space between the cathode and the anode similar to that which is known to be produced by the anode of the conventional oscillating multi-cavity magnetron.

The dash lines E in Fig. 2 illustrate one possible instantaneous orientation of these control fields in the form of tube shown, neglecting the direct-current field due to anode voltage. It is to be noted that the electrons emitted from the two cathode parts 19 and 21 in all directions are subjected to control fields which predominantly accelerate or decelerate the electrons along their paths. With no input signal, the electron paths from the two cathode parts are symmetrical with respect to the anode segments, so that there is no tendency to induce differential currents between anode segments. On the other hand, as soon as an input signal is applied, at such an instant as shown by the field lines in Fig. 2, the electrons from one of the cathodes are reduced in speed while those from the other are increased in speed. These speed changes in turn cause the two groups of electrons to traverse paths of different curvature and a strong differential current is induced between anode segments. On the reverse half cycle of the input, the role of the cathodes is reversed.

The net effect of the control fields adjacent the cathode is to produce a corresponding current of increased amplitude to the two anode segments 5 and 7 and the output circuit connected thereto. Amplified signal energy may be extracted from the output circuit by any suitable means, such as a transmission line and coupling loop 29 inductively coupled to the output circuit.

In showing the approximate field pattern in Fig. 2 the effects thereon of the radio frequency electric field induced across the gaps between the anode segments have been neglected. Since it is this field which might, either through control of the electron stream, or through coupling to the input circuit, cause oscillation, the anode load circuit will ordinarily be coupled so tightly as to prevent high anode field. The two cathode parts 19 and 21 are oriented relative to the anode gaps 9 so that the cathode gap is substantially opposite the midpoint of the anode segments 5 and 7, as clearly shown in Fig. 2, for example, to reduce the coupling between the input and output circuits within the tube to a minimum. The control action of the anode on the electron stream is still further reduced by use of small anode gaps and large distance between the anode and cathode. As shown in Fig. 2, the spacing between the anode and the cathode is substantially greater than the

radius of the circle on which the cathode parts 19 and 21 are mounted. External shielding may be provided to avoid external coupling between the circuits.

Fig. 3 illustrates a modification in which the anode 3' and cathode 17' are self-resonant. In this form the anode 3' is in the form of a hollow cylindrical member having diametrically-opposed slits 9' extending from one end almost to the other end and providing spaced anode arms or segments 5' and 7'. The cathode 17' is U-shaped with side portions 19' and 21' and a connecting portion 23'.

The internal coupling between the input and output circuits may be further reduced by providing an internal electrostatic shield between the cathode and anode. For example, as shown in Fig. 4, the shield 31 may be in the form of a pair of semi-cylindrical segments 33 and 35 spaced to provide gaps 37 aligned with the cathode parts 19 and 21 and the anode gaps 9 to permit passage of electrons to the anode while shielding the cathode from the major part of the high frequency field of the anode.

Figs. 5 through 8 illustrate my invention as incorporated in cavity resonator structures particularly adapted for use as amplifiers at very high frequencies.

In Figs. 5 and 6 is shown a vane type structure including an anode structure 50 which is somewhat conventional but is modified to reduce its control action on the electron stream. The anode 50 comprises a hollow cylindrical metal member 51 closed at the ends by metal plates 53 and 55 to form a vacuum envelope. Extending radially inward from the cylindrical member 51 are eight T-shaped anode elements or vanes 57 having heads 59 extending toward each other around a circle to provide anode gaps 61 therebetween. The member 51 and vanes 57 provide anode cavity resonators 62. Axially positioned within the cylindrical space defined by the heads 59 of the anode elements 57 is a multi-part cathode 63, which consists essentially of a plurality of cathode vanes 65 extending radially from a central support 67 supported on the end plates 53 and 55 by insulators 69. The cathode vanes 65 provide cavity resonators 70 therebetween which can be excited to produce electric control fields adjacent to and extending between the outer ends or tips of the vanes. Each cathode resonator 70 constitutes a high frequency signal input means coupled to the cathode parts. As in Figs. 1-4, this input means constitutes the sole electrical connections between adjacent cathode parts. The useful emitting portions of the cathode are chiefly the vane tips. Thus, it may not be necessary to coat other portions of the cathode. A heater and electrical leads thereto, for raising the cathode to a thermionically-emitting temperature, although not shown, will ordinarily be provided in the usual way. The cathode 63 and anode 50 define a single continuous electron interaction space therebetween.

An axial magnetic field is provided by a permanent magnet whose pole pieces P are shown in Fig. 6. In operation, the anode and cathode are connected to a high voltage direct current source which is adjusted to produce an amplifying condition. A transmission line 71 and a coupling loop 73 inductively coupled to one of the cavity resonators 70 of the cathode are provided to excite the cathode resonators in accordance with a high frequency input signal to be amplified. An output line 75 and loop 77 coupled into one of the anode resonators 62 are provided for extracting amplified signal energy from the device. It is, of course, understood that the normal amplifier will have cathode and anode resonators tuned close to, or at, the normal operating frequency and, if required, tuning means of the types commonly used with oscillating magnetrons may be provided.

In Fig. 5, I have shown the high frequency control field pattern E at one instant neglecting the radial field due to the direct current anode voltage supply. It will be noted that the high frequency electric field components most effective in controlling the electrons are largely tangential to circles coaxial with and spaced slightly from the cathode. Thus, the electrons emitted by the cathode vane

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tips are subjected primarily to controlling accelerating and decelerating forces acting at right angles to the radial direct current electric field, or at right angles to the directions the electrons would travel in the absence of the magnetic field. In fact, the cathode control fields set up in accordance with my invention are closely analogous to the anode high frequency control fields in a conventional multi-cavity-anode oscillating magnetron, and hence, are effective to institute and control the spoke-like rotating bunches of electrons desired for optimum excitation of the output circuit. These spoke-like bunches occur only when a high frequency input signal is applied to the cathode circuit and they are responsive to the input signal, in both magnitude and frequency.

The control action of the anode is greatly reduced by large spacing, that is, large anode radius, by use of small anode gaps, and by locating the cathode vanes halfway between the anode vanes, as shown in Fig. 5. Moreover, reducing the high frequency electric field at the anode by coupling the output load tightly, so as to lower the resonator impedance effective across vane tips, will reduce the possibility of anode control and, at the same time, broaden the bandwidth advantageously.

Preferably, "strapping" means are employed on the input resonators to favor π -mode operation. Figs. 5 and 6 show a conventional form of strapping means comprising concentric rings 79 and 81 connected to alternate cathode vanes 65. Since the anode resonators are driven, strapping is not essential in the anode and, in fact, may even be undesirable in some cases in that the synchronous control by the anode, is then too greatly increased.

In the schematic modification of Fig. 7, a hollow anode 83 in the form of a thick metal ring is formed with a series of circular holes 85 opening through the inner wall of the ring. These holes 85 provide anode cavity resonators and the wall portions between the resonators provide anode segments 87 separated by anode gaps 89. The cathode is a cylindrical metal member 91 formed with circular holes 92 opening through the wall thereof and providing cathode cavity resonators. The cathode elements 93 between adjacent resonators are preferably coated only at the ends near the cavity gaps 95. As shown, the number of cathode resonators is one-half the number of anode resonators, and each cathode gap is disposed half way between two anode gaps to minimize coupling therebetween.

The modification shown in Fig. 8 is identical with that of Figs. 5 and 6, with the exception that the cathode vanes 65' in Fig. 8 are provided with heads 97 somewhat similar to the heads 59 on the anode vanes 57. The purpose of these heads is to increase the capacitance and lower the frequency of the cavity resonators without substantially changing the size thereof.

Fig. 9 illustrates the use of a "Venetian blind" electrostatic shield 103 interposed between the cathode and anode. It will be understood that this type of shield may also be used in magnetron amplifiers of the multi-cavity type shown in Figs. 5-8.

In each of the embodiments shown, the positions of the cathode and anode may be reversed from those described, that is, by using the outside structure as the cathode and the inside one as the anode. Although this may have advantages in minimizing the possibilities of self-oscillation and may be simpler to construct in some cases, it may require substantially greater cathode heating power and make cooling of the anode more difficult.

My invention may also be used for superheterodyne mixing or converting. As a mixer, as shown in Fig. 10, a radio frequency local oscillator voltage and a radio frequency signal may be applied together to a multi-cavity cathode 105, by means of an input line 107, and an output at an intermediate frequency taken as an amplitude variation in cathode-anode current by means of a tuned circuit 111 coupled between the cathode and a cylindrical anode 109. In Fig. 11, the oscillator voltage and

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signal are applied separately, one being applied by a coaxial line 121 to a multi-cavity cathode circuit 123 and the other being applied to a multi-cavity anode circuit 125 by means of a coaxial line 127. The intermediate frequency output is obtained from a tuned circuit 129 consisting of a capacitance element 131 in parallel with a coiled portion 133 of the coaxial line 127; the tuned circuit being coupled to the cathode by a capacitance element 135.

Fig. 12 shows my invention embodied in a self-contained mixer, or converter. In this case, the tube is operated in an oscillating state, so that the local oscillator voltage is generated within the tube, and the signal is applied to the cathode circuit 143 by an input line 145. In this embodiment, the tube structure would not include any shields, such as those shown in Figs. 4 and 9, or other structure for preventing self-oscillations. The frequency of the local oscillations may be adjusted by means of a tuning plunger 147 positioned within one of the anode resonators. The intermediate frequency output is taken from a tuned circuit 149 coupled between the cathode 143 and the anode 151.

It will be understood that my invention is not limited to structures in which the input and output portions have an equal number of gaps or cavity resonator elements. Furthermore, the devices I have described can be designed with particular advantage as frequency multipliers rather than as simple amplifiers or converters. In the case of frequency multipliers, it may be particularly important to select unequal numbers of gaps, as shown in Fig. 7, and appropriate tuned resonators for input and output suitable for the harmonic frequency desired.

The present state of the art does not permit an exact and rigorous understanding of all magnetron phenomena. For this reason, although I believe the explanation of the behavior of my invention to be substantially as I have described it, I would like to concede that my explanation may not be complete, or even entirely correct.

While I have indicated the preferred embodiments of my invention of which I am now aware, and have also indicated only a few specific applications for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the uses indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What is claimed is:

1. A magnetron including an anode and a thermionic cathode spaced from each other to form a continuous electron interaction space therebetween, said cathode comprising a plurality of spaced electron-emissive parts, means for providing a magnetic field in said space, radio frequency input means coupled to said cathode parts, and constituting the sole electrical connection between adjacent cathode parts, for establishing a radio frequency control electric field extending between adjacent cathode parts, and output means coupled to said anode.

2. A magnetron including a hollow anode defining a space therein, a thermionic cathode positioned within said space and comprising a plurality of spaced electron-emissive parts, means for providing a magnetic field in said space, radio frequency input means coupled to said cathode parts, and constituting the sole electrical connection between adjacent cathode parts, for establishing a radio frequency control electric field extending between adjacent cathode parts, and output means coupled to said anode.

3. A magnetron according to claim 2, wherein said input means comprises a radio frequency input circuit coupled between adjacent cathode parts.

4. A magnetron according to claim 3, wherein said input means further includes a transmission line coupled to said input circuit, for applying a radio frequency signal thereto.

5. A magnetron including: an envelope containing a hollow anode defining a space therein and a thermionic cathode positioned within said space and comprising a plurality of spaced electron-emissive parts, adjacent parts being electrically insulated from each other within said envelope; means for providing a magnetic field within said space; radio frequency input means coupled to said cathode parts for establishing a radio frequency control electric field extending between adjacent cathode parts; and output means coupled to said anode.

6. A magnetron including a hollow anode comprising a plurality of spaced anode segments defining a space therein, a thermionic cathode positioned in said space and comprising a plurality of spaced electron-emissive parts, means for providing a magnetic field within said space, radio frequency input means coupled to said cathode parts, and constituting the sole electric connection between adjacent cathode parts, for establishing radio frequency control voltages between adjacent cathode parts, and an output circuit coupled between adjacent anode segments.

7. A magnetron according to claim 6, further including an electron-pervious electrostatic shield interposed between said anode and said cathode for reducing the coupling therebetween.

8. A magnetron according to claim 7, wherein said shield comprises a "Venetian blind" structure.

9. A magnetron according to claim 6, wherein the number of said anode segments is an integral multiple of the number of said cathode parts, whereby said magnetron can be used as a frequency multiplier.

10. A magnetron including a hollow anode defining a space therein and comprising a plurality of spaced anode segments, a thermionic cathode positioned within said space and comprising a plurality of spaced electron-emissive parts forming at least one cathode gap therebetween, each cathode gap being located substantially opposite the midpoint of an anode segment to reduce the coupling between said cathode and said anode, means for providing a magnetic field within said space, radio frequency input means coupled to said cathode parts, and constituting the sole electrical connection therebetween, for establishing radio frequency control voltages between adjacent cathode parts, and an output circuit coupled between adjacent anode segments.

11. A magnetron including a hollow anode comprising a plurality of spaced anode segments defining a space within said anode, a thermionic cathode positioned in said space and comprising a plurality of spaced electron-emissive parts, means for providing a magnetic field within said space, a radio frequency input circuit coupled between adjacent cathode parts, and a radio frequency output circuit coupled between adjacent anode segments.

12. A magnetron according to claim 11, wherein each of said circuits comprises at least one cavity resonator.

13. A magnetron amplifier device including a hollow anode of circular cross section comprising a plurality of close-spaced arcuate anode segments defining a space within said anode, a thermionic cathode positioned within said space and comprising a plurality of spaced electron-emissive parts located on a circle concentric with said hollow anode, means adjacent said anode for providing a magnetic field within said space, radio frequency input means coupled to said cathode parts, and constituting the sole electrical connection therebetween, for establishing radio frequency control voltages between adjacent cathode parts, and an output circuit coupled between adjacent anode segments.

14. A magnetron according to claim 13, wherein the spacing between said anode and said cathode is substantially greater than the radius of said circle, to minimize the coupling between the anode and the cathode.

15. A magnetron amplifier device according to claim 13, wherein said anode and said cathode are multi-cavity-resonator structures.

16. A magnetron mixer device including an anode comprising a plurality of spaced anode segments defining a space within said anode, a thermionic cathode positioned in said space and comprising a plurality of spaced electron-emissive parts, means for providing a magnetic field within said space, a first radio frequency circuit coupled between adjacent cathode parts, and constituting the sole electrical connection therebetween, a second radio frequency circuit coupled between adjacent anode segments, an output circuit coupled between said anode and said cathode, and an input transmission line coupled to said first circuit, for applying a radio frequency signal thereto.

17. A magnetron mixer device according to claim 16, further including a second input transmission line coupled to said second circuit, for applying a second radio frequency signal thereto.

18. A magnetron mixer device according to claim 17, wherein said second transmission line comprises a coiled coaxial line forming a part of said output circuit.

19. A magnetron mixer device according to claim 16, wherein said anode and cathode are adapted to be self-oscillatory, to generate a second radio frequency oscillation within the device.

20. An amplifying device comprising an evacuated enclosure, a cathode comprising two allochiral thermionic electron emissive parts arranged in said enclosure, an anode means surrounding said cathode, a source of direct current connected between said anode and said cathode, means for providing a magnetic field parallel to said cathode, and means for applying an alternating current input signal between the parts comprising said cathode.

21. An amplifying device comprising an evacuated enclosure, a cathode comprising at least one allochiral pair of thermionic electron emissive parts arranged in said enclosure, an anode means surrounding said cathode, a source of direct current connected between said anode and said cathode, means for applying a magnetic field parallel to said cathode, and means for applying an alternating current input signal between adjacent parts of said cathode.

22. An amplifying device comprising an evacuated enclosure, an anode means arranged in said enclosure, a cathode comprising two thermionic electron emissive parts symmetrically arranged within said anode means, a source of direct current connected between said anode and said cathode, means for providing a magnetic field parallel to said cathode, and means for applying an alternating current input signal between said cathode parts.

23. An amplifying device comprising an evacuated enclosure, an anode means in said enclosure, a cathode comprising a plurality of thermionic parts symmetrically arranged within said anode means, means for providing a magnetic field parallel to said cathode, and means for applying an alternating current input signal voltage between adjacent cathode parts.

24. An electron discharge device comprising an evacuated envelope containing therein a cathode comprising a plurality of thermionic parts, an anode structure concentric therewith, means adjacent said anode structure for causing electrons from said cathode to move along curved paths about said cathode and means for producing a signal voltage between parts of said cathode in accordance with radio frequency energy fed into said cathode.

25. An electron discharge device comprising an evacuated envelope containing therein an electron source comprising a plurality of thermionic parts, an anode structure spaced from said source, means adjacent to said anode structure for causing electrons from said source to move along curved paths about said electron source, means coupled to said source for modulating electrons from said source in accordance with a signal voltage applied between parts of said source, and output means coupled to said anode, said output means being responsive to signals at the frequency of said applied signal.

26. An electron discharge device comprising an evacuated envelope containing therein a cathode having a plurality of thermionic elements, an anode structure concentric therewith, means adjacent to said anode structure for causing electrons from said cathode to move along curved paths about said cathode, and means coupled to said cathode for applying a high frequency voltage between elements of said cathode to vary the electrons adjacent to the cathode.

27. An electron-discharge device comprising an envelope containing an anode structure, a cathode structure comprising a plurality of thermionic cathode members, said cathode members comprising elongated conductors, the ends of adjacent conductors being conductively connected together, a high frequency input circuit coupled between adjacent cathode members, and means for producing a magnetic field in the space between said anode and cathode structures.

28. An electron-discharge device comprising an envelope containing an anode structure comprising a plurality of anode members, a cathode structure spaced from said anode structure, said cathode structure comprising a plurality of thermionic cathode members, the number of said cathode members being substantially equal to the number of said anode members, a high frequency input circuit coupled between adjacent cathode members, and means for producing a magnetic field in the space between said anode and cathode structures.

29. An electron-discharge device comprising an envelope containing an anode structure comprising a plurality of anode cavities substantially resonant at the operating frequency of said device, a cathode structure spaced

from said anode structure, said cathode structure comprising a plurality of thermionic cathode members, a high frequency input circuit coupled between adjacent cathode members, and means for producing a magnetic field in the space between said anode and cathode structures.

30. A magnetron including an anode and a thermionic cathode spaced from each other to form a continuous electron interaction space therebetween, said cathode comprising a plurality of spaced electron-emissive parts, means for providing a magnetic field in said space, and radio frequency input means coupled to said cathode parts for establishing a radio frequency control electric field extending between adjacent cathode parts.

31. A magnetron including an anode and a thermionic cathode spaced from each other to form a continuous electron interaction space therebetween, said cathode comprising a plurality of spaced electron-emissive parts, means for providing a magnetic field in said space, and radio frequency input means coupled to said cathode parts, and constituting the sole electrical connection between adjacent cathode parts, for establishing a radio frequency control electric field extending between adjacent cathode parts.

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