June 15, 1948. H. BENIOFF 2,443,179

ELECTRICAL APPARATUS

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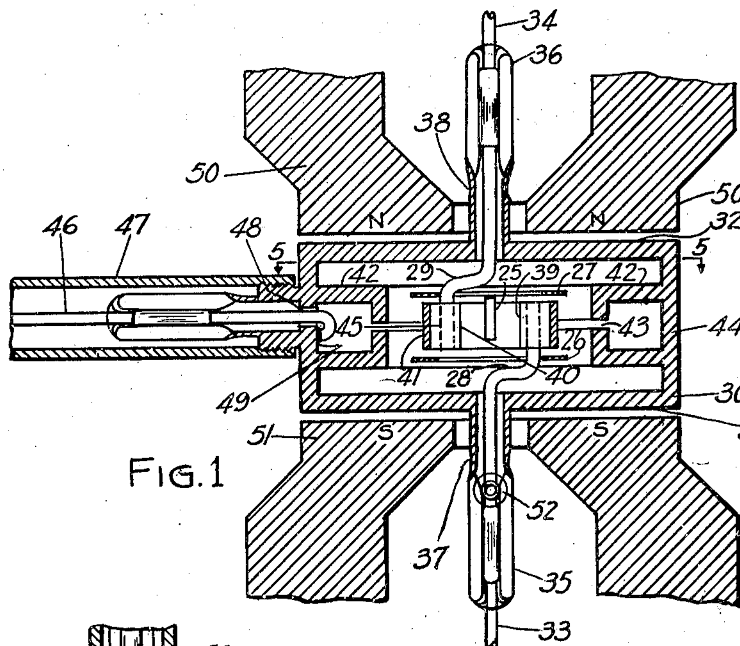

FIG. 1

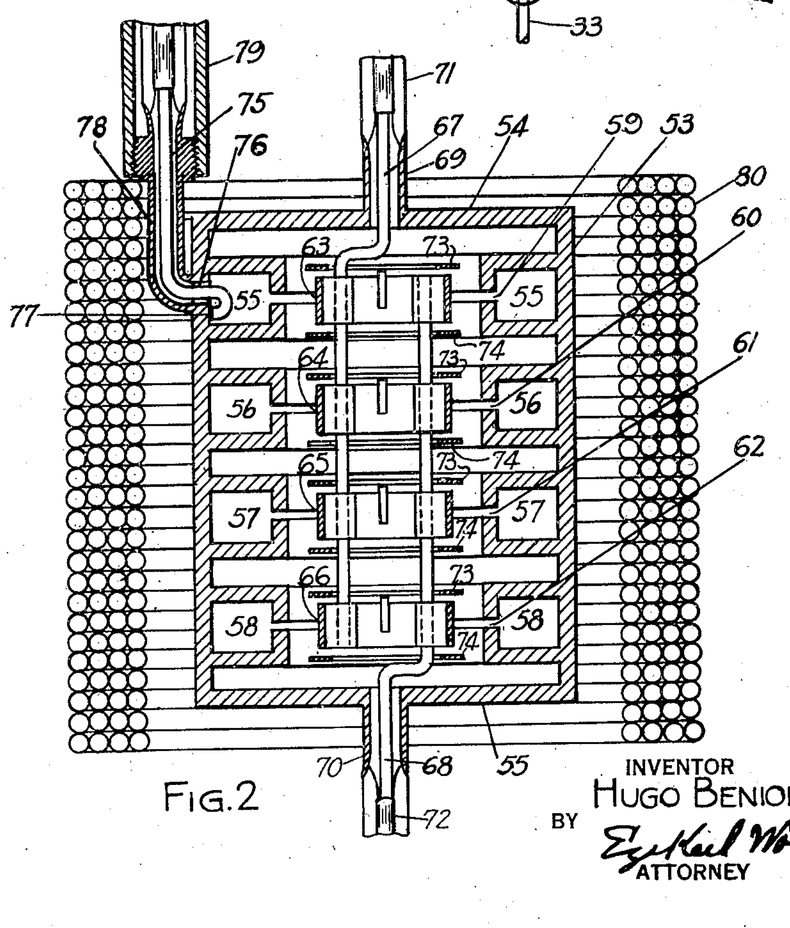

FIG. 2

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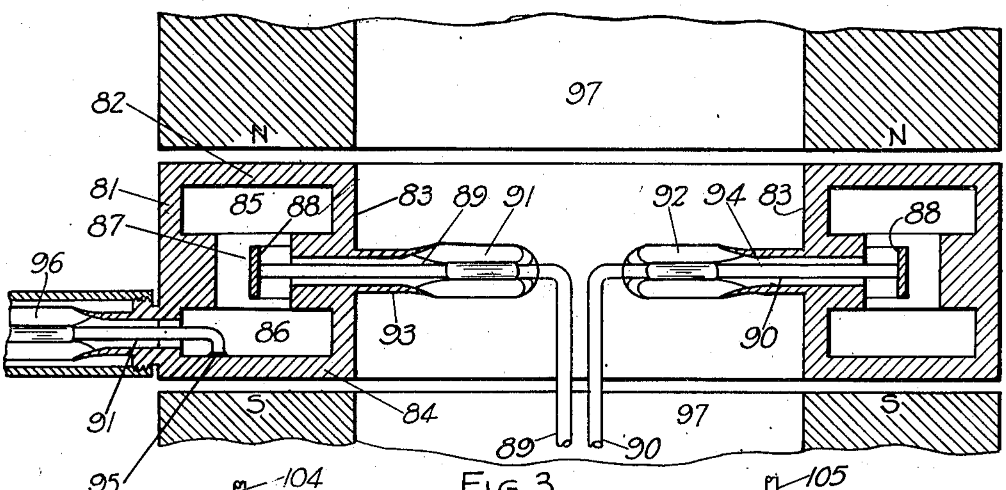

FIG. 3

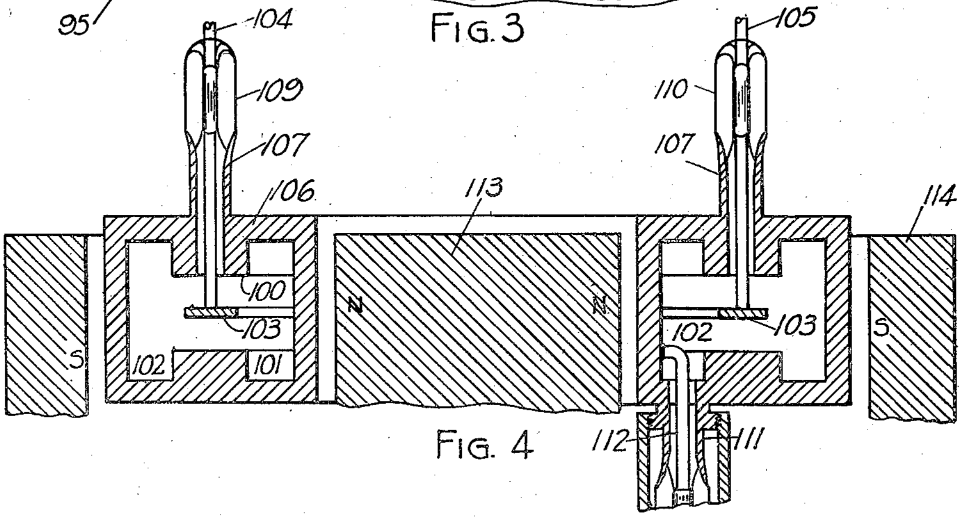

FIG. 4

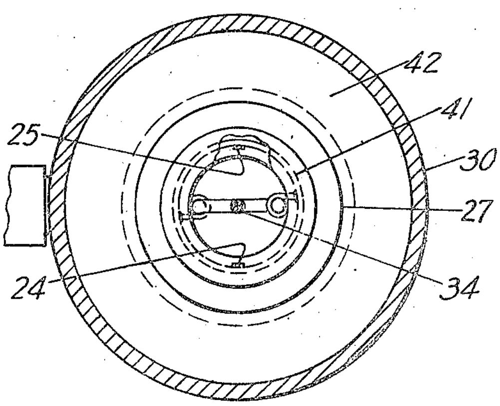

FIG. 5

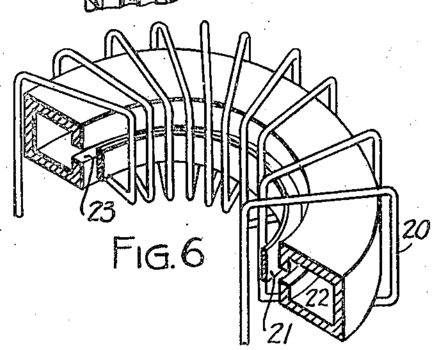

FIG. 6

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ELECTRICAL APPARATUS

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Application June 24, 1941, Serial No. 399,495

15 Claims. (Cl. 250—27.5)

The present invention relates to thermionic magnetron tubes of the type in which the tube element forms part of an oscillating circuit and is adaptable for use at extremely high radio frequencies in the range of 300 megacycles and higher, especially for high power. The invention herein described relates to that type of thermionic magnetron tube in which the tube elements themselves form parts of a resonant circuit. In particular, the anode is in the form of a cavity resonator of a toroidal shape having a concentric slot forming the mouth of the resonator. The cylindrical cathode is coaxial with the anode and mounted in relationship with the anode slot as will be more fully understood in the specification below. The cooperating constant magnetic field is adjusted to such a value as to make the electron orbital frequency substantially equal to the resonant frequency of the anode cavity resonator. The direction of the magnetic field so created may be either parallel to the toroidal axis of revolution or parallel to the circular toroidal axis of revolution or even perpendicular to the toroidal axis of revolution. In these cases the electric field will be arranged perpendicular to the magnetic field and the resultant plane of the electron orbital frequency will be perpendicular to the magnetic field.

The thermionic magnetron tube of the present type readily lends itself to constructions using a group of resonators which can be stacked axially to form multiple resonator systems.

The invention will be more fully described in the specification below which is to be read in connection with the drawings illustrating the invention in which Fig. 1 shows a vertical section through the center of the tube; Fig. 2 shows a vertical section of the modification shown in Fig. 1 in which a plurality of resonators are employed, the section being in relatively the same position as the section of Fig. 1; Fig. 3 shows a central section through a modified form of the invention shown in Fig. 1; Fig. 4 shows a similar central section through another modified form; Fig. 5 shows a section on the line 5—5 of Fig. 1; and Fig. 6 shows a still further modified form in perspective of the invention shown in Fig. 1.

In the device illustrated in Fig. 1 the envelope **30** is preferably made of metal, cylindrical in form, with two flat ends **31** and **32** through the center of which pass the cathode heating leads **33** and **34** which are sealed to the end walls **31** and **32**, respectively, by means of insulating glass seals **35** and **36** mounted on the ends of collars **37** and **38** extending from the flat ends **31** and

32. Within the envelope **30** the leads **33** and **34** extend outward from the central axis into the arms **28** and **29** and support at their vertically extending ends brackets **39** and **40**, respectively, by which the cathode **41** is supported. This cathode, as will be seen in Fig. 5, is a ring to which current is conducted by the arms **39** and **40** at opposite ends of a diameter so that two halves of the ring are substantially connected in parallel across the leads **28** and **29**. The cathode **41** also supports the top and bottom disc electron shields **27** and **26** by means of the brackets **25** and **24** extending from the cathode **41** and supporting the electron shield discs **26** and **27** in position above and below the ends of the cathode and overhanging the cathode outwardly in the direction of the anode resonator **42**. These shields equalize the field potential about the top and bottom of the hot cathode and prevent electron emission in the direction of the bottom and top covers **31** and **32**, respectively.

The anode **42**, as indicated in Fig. 1, is in the form a of a split hollow toroid with an annular slot **43** extending around the toroid concentric with the cathode **41** and preferably opposite the center. The back wall **44** of the toroid may be the wall of the envelope, the whole structure being substantially symmetrical with the central axis of the toroid. The cavity **45** formed by the wall **44** and the other toroidal walls is spaced from the end walls **31** and **32** and is placed at a positive potential as against the cathode **41** by means of the anode conductor **46** forming the central conductor of a concentric cable with the external conductor the conducting tube **47**. This conductor **46** passes through an insulating glass seal through an opening **48** in the cavity **45** where it is connected to the wall **44** at **49**, thus coupling with the high frequency cavity circuit oscillating at a resonance determined by the dimensions and operation of the device.

As illustrated in Fig. 1 a magnetizing field is established by the pole **50** which provides a cylindrical pole face over the end of the tube forming a north pole as indicated by the letter N at the top in conjunction with the pole **51** having a similar cylindrical pole face labelled S providing the south pole at the bottom side face of the tube. The envelope or housing is exhausted of air by suitable means after which it may be sealed off at the pumping connection **52** in the glass seal **35**.

In Fig. 2 a multiple unit is indicated. In this case the metallic housing **53** is made of a longer cylinder as compared with that shown in Fig. 1 but it has approximately the same diameter as that of the device of Fig. 1 with the result that the end cover plates 54 and 55 are similar in size to those of Fig. 1. However, if desired, the device may be made of a larger diameter and the spacing of the internal units varied in accordance with the design desired. In Fig. 2 the cylindrical wall 53 supports a plurality of resonating cavities 55, 56, 57 and 58 each of which is provided with annular slots 59, 60, 61 and 62, and with individual cathode elements 63, 64, 65 and 66, all parallelly connected across the cathode supply leads 67 and 68 which enter through the ends 54 and 55 of the unit in the collars 69 and 70 which are sealed off with glass seals 71 and 72. Each cathode unit may also be supplied with end shields 73 and 74 as illustrated in Fig. 2. It will suffice in the construction of Fig. 2 to take the output lead through a single cavity resonator as illustrated by the conductor 75 which passes through a hole 76 in the wall 53 into one of the resonators 55 where it is connected to the inside of the wall as indicated at 77. The metallic tube 78 joined to the cylinder 53 and extending from it forms with the conductor 75 a concentric cable, which concentric cable is continued as in Fig. 1 by means of the conducting tube 79 surrounding the central conductor 75. In Fig. 2 the direct current magnetization field is furnished by the elongated coil 80 in the center of which the magnetic field runs parallel to the axis of the coil.

In the arrangement shown in Fig. 3 a modified form of cavity resonator is shown. Here the tube assumes a toroidal form with the external walls 81, 82, 83 and 84 forming the toroid and the cavity resonator as twin chambers 85 and 86 with a restricted conducting passage 87 arranged betweeen the two cavities in the center of which is positioned the cathode ring 88 which is supported by the conductors 89 and 90 passing through the wall 83 and sealed to the wall by means of the glass seals 91 and 92 in connection with the extending necks 93 and 94 which may be formed as a part of the walls 83. The cathode heating current is supplied through the leads 89 and 90 and the cathode-anode potential is supplied between the leads 89 or 90 and the conductor 91 which links the anode resonator by passing through the wall of the resonator and being attached to the inner surface of the wall 84 at the point 95. As in the other figures the conductor 91 is preferably continued externally of the tube in a concentric cable.

The magnetic field is supplied in the device indicated in Fig. 3 by means of the magnet 97 which has a cylindrical north pole positioned opposite one end of the tube and a cylindrical south pole positioned opposite the other end of the tube. In this case the orbits of the electrons leaving the cathode 88 are maintained substantially in horizontal planes perpendicular to the magnetic field and the resonance of the oscillator is determined by the dimensions and construction of the cavity and the cathode.

In the modification illustrated in Fig. 4 the cavity 100 has the same geometrical form in cross section as that of Fig. 3. In this case, however, the neck between the two twin chambers 101 and 102 extends in a horizontal plane rather than as a vertical cylinder. The cathode 103 in this case takes the form of a flat ring in which the cathode surface is positioned in the plane of the ring. The cathode is supported by means of the current supply leads 104 and 105 passing through the top wall 106 of the resonator through the tubes 107 and 108 and the glass sealing elements 109 and

110 as described in connection with the previous figures. The anode lead 112 passes through the tube 111 into the interior of the resonator 102 and is connected to one of the walls at the inside of the resonator as indicated in the figure. Some latitude is permitted as to the point of connection of the conductor 112. The conductor 112 is brought out of the resonator in a concentric cable as illustrated in Fig. 1. In this arrangement the magnetic flux travels radially from a central north pole core 113 to a cylindrical south pole core 114, the core 113 being placed within the toroidal element and the cylindrical pole 114 being outside of the element so that the lines of flux travel radially in the same plane or in parallel planes to the cathode 103.

In the arrangement shown in Fig. 6 a perspective view of a further construction is illustrated in which the coil 20 surrounds the resonating cavity 22 which has a slot 23 in the inside surface of the resonator wall taking a cylindrical form. The cathode 21 is in the form of a band or ring opposed to the inner wall of the cavity opposite the slot just described. In this construction the magnetic field extends in a direction paralleling the curve of the cathode 21 and the orbit of the electrons from the cathode 21 is in radial planes perpendicular to the cathode.

Having now described my invention, I claim:

1. A thermionic magnetron tube comprising conductive means having thereon a resonator shell forming the anode of the magnetron tube and having a ring slot forming an opening in said resonator shell and providing a capacity across said opening, a concentric cathode element positioned in spaced opposed relation to said slot and means for supplying a magnetic field having its lines of force extending in a direction substantially perpendicular to the median plane of the cathode, said cathode being immersed in said magnetic field.

2. A thermionic magnetron tube comprising conductive means having therein a resonator shell forming the anode of the magnetron tube and having a ring slot forming an opening in said resonator shell and providing a capacity across said opening, a coaxial cathode element spaced from said anode opposite said slot and means for supplying a magnetic field for the space between the cathode and the anode, said field extending in a direction perpendicular to the path of the electric field between the cathode and the anode.

3. A thermionic magnetron tube comprising a metallic cylindrical casing closed at both ends, a toroidal conductive resonator shell forming the anode of the magnetron tube and having one wall common with a wall of said cylindrical casing, said toroidal resonator shell having a ring slot therein forming the mouth of the resonator shell on the inner side of said resonator shell, a cathode member coaxial with said resonator shell and means supporting and positioning said cathode member in spaced opposed relationship to said resonator slot.

4. A thermionic magnetron tobe comprising a metallic cylindrical casing closed at both ends, a toroidal conductive resonator shell forming the anode of the magnetron tube and having one wall common with a wall of said cylindrical casing, said toroidal resonator shell having a ring slot therein forming the mouth of the resonator shell on the inner side of said resonator shell, a cathode member coaxial with said resonator shell and means supporting and positioning said cathode member in spaced opposed relationship to said

resonator slot, said supporting means being the conductive means for heating said cathode.

5. A thermionic magnetron tube comprising a metallic cylindrical casing closed at both ends, a toroidal conductive resonator shell forming the anode of the magnetron tube and having one wall common with a wall of said cylindrical casing, said toroidal resonator shell having a ring slot therein forming the mouth of the resonator shell on the inner side of said resonator shell, a cathode member coaxial with said resonator shell, means supporting and positioning said cathode member in spaced opposed relationship to said resonator slot and an electric shield supported from said cathode and extending over the ends of the cathode.

6. A thermionic magnetron tube comprising a metallic cylindrical casing closed at both ends, a toroidal conductive resonator shell forming the anode of the magnetron tube and having one wall common with a wall of said cylindrical casing, said toroidal resonator shell having a ring slot therein forming the mouth of the resonator shell on the inner side of said resonator shell, a cathode coaxial with said resonator shell, means supporting and positioning said cathode in spaced opposed relationship to said resonator slot, said supporting means comprising two conductive members insulatingly sealed in said casing, said conductive members having elements supporting and providing electrical connections to said cathode at opposite sides of the said cathode.

7. A thermionic magnetron tube comprising a metallic cylindrical casing closed at both ends, a toroidal conductive resonator shell forming the anode of the magnetron tube and having one wall common with a wall of said cylindrical casing, said toroidal resonator shell having a ring slot therein forming the mouth of the resonator shell on the inner side of said resonator shell, a cathode ring coaxial with said resonator shell, means supporting and positioning said cathode ring in spaced opposed relationship to said resonator slot, said supporting means comprising two conductive members insulatingly sealed in said casing, said conductive members having elements supporting and providing electrical connections to said cathode at opposite ends of the same diameter of said cathode ring and an electric shield supported from said cathode and extending over the ends of said cathode.

8. A thermionic magnetron tube comprising a hollow cylindrical casing having both ends sealed, a plurality of coaxial toroidal conductive resonator shells positioned within said casing with the cylindrical wall of said casing forming one wall of each resonator shell and forming the anode of the magnetron tube, said resonators each having ring slots providing a mouth for each said resonator shell, said slots extending around the inner walls of said resonator shells, a plurality of cathode members coaxial with themselves and with said resonator shells, one cathode member positioned and spaced from each said slot in each of said resonator shells and means supporting said cathodes in said position within said casing.

9. A thermionic magnetron tube comprising a hollow cylindrical casing having both ends sealed, a plurality of coaxial toroidal conductive resonator shells positioned within said casing with the cylindrical wall of said casing forming one wall of each resonator shell and forming the anode of the magnetron tube, said resonators each having ring slots providing a mouth for each said resonator shell, said slots extending around the inner walls of said resonator shells, a plurality of cathode members coaxial with themselves and with said resonator shells, one cathode member positioned and spaced from each said slot in each of said resonator shells and means supporting said cathodes in said position within said casing comprising a pair of conductive members supporting said cathodes at opposite ends of the same diameter for supplying current thereto.

10. A thermionic magnetron tube comprising a hollow cylindrical casing having both ends sealed, a plurality of coaxial toroidal conductive resonator shells positioned within said casing with the cylindrical wall of said casing forming one wall of each resonator shell and forming the anode of the magnetron tube, said resonators each having ring slots providing a mouth for each said resonator shell, said slots extending around the inner walls of said resonator shells, a plurality of cathode members coaxial with themselves and with said resonator shells, one cathode member positioned and spaced from each said slot in each of said resonator shells, means supporting said cathodes in said position within said casing and a plurality of electric shields supported and connected to said cathodes and extending over the ends thereof.

11. An ultra high frequency electric discharge device of the magnetron type, including a cathode, an electron-pervious anode member coaxial with and surrounding said cathode in spaced relation thereto, said anode member being substantially U-shaped in cross-section and being disposed with its cross-sectional configuration in a plane parallel to the axis of said cathode, means adjacent said anode member for establishing a magnetic field in the space between said anode member and said cathode, and means coupled to said anode member for extracting high frequency energy therefrom.

12. An ultra high frequency electric discharge device of the magnetron type, including an elongated cylindrical cathode, means adjacent said cathode for establishing a magnetic field parallel to the principal axis of said cathode, an electron-pervious anode structure comprising a substantially hollow conductive member of substantially U-shaped cross-section surrounding said cathode in spaced relation thereto, said anode member being disposed with its cross-section configuration in a plane parallel to said principal axis of said cathode, and means coupled to said anode member for extracting ultra high frequency energy therefrom.

13. An ultra-high frequency electric discharge device of the magnetron type, including an elongated thermionic cathode, means adjacent said cathode for establishing a magnetic field longitudinally of the axis of said cathode and adjacent thereto, an electron-pervious anode structure comprising a substantially hollow conductive member in spaced relation with respect to said cathode and having a U-shaped cross-section the open end of which faces said cathode and lies in a plane parallel to the axis thereof, and output electrode means extending into said anode structure.

14. An ultra high frequency electric discharge device of the magnetron type, including a plurality of enclosed electrodes including an elongated cathode and a substantially hollow conductive anode member substantially surrounding said cathode and in spaced relation thereto, means adjacent said cathode and said anode member for establishing a magnetic field in the

space between said cathode and said anode member, said anode member having an open face opposite and in a plane parallel to said cathode and defining an electron-permeable space resonant region, and output electric means extending into the region defined by said anode member.

15. An ultra-high frequency electric discharge device of the magnetron type, including a plurality of electrodes comprising a thermionic cathode and an annular hollow anode member surrounding said cathode and having an inner circumferential opening facing said cathode, said anode member constituting a cavity resonator and said circumferential opening having its cross-sectional configuration disposed in a plane parallel to said cathode, means adjacent said cathode and said anode member for establishing a magnetic field longitudinally of the axis of said cathode in the space between said anode member and said cathode, and output electrode means coupled to said resonator for extracting energy from said resonator.

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