Feb. 11, 1947. H. B. DE VORE 2,415,470

MAGNETRON

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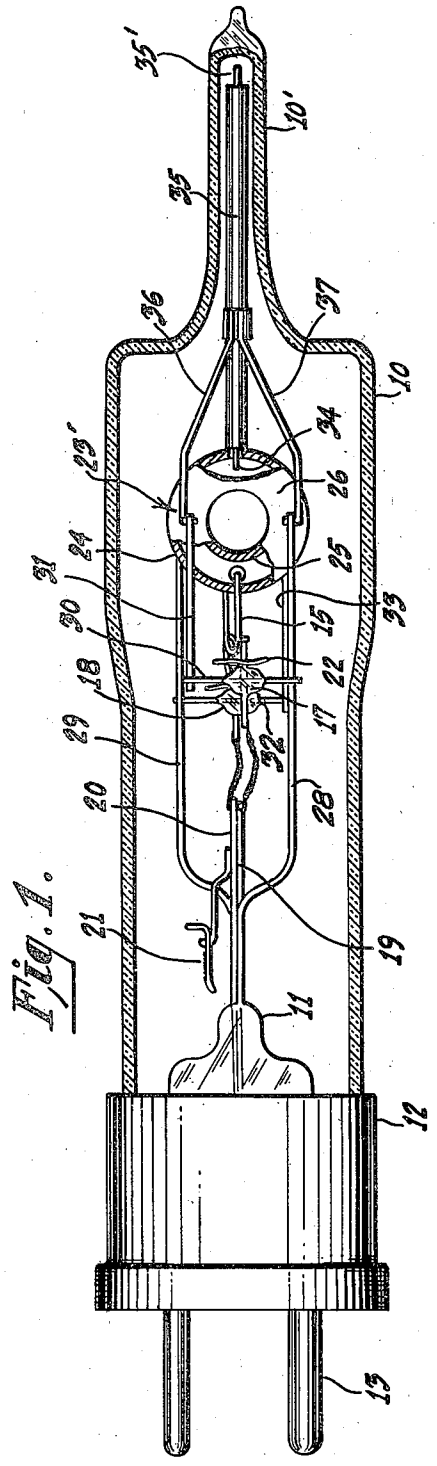


Fig. 1.

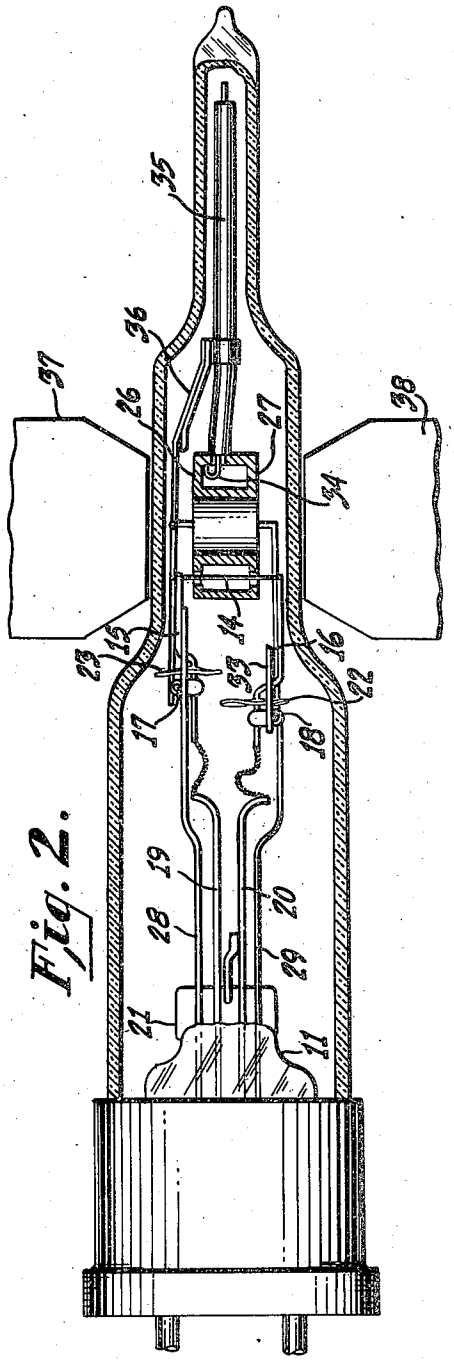


Fig. 2.

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Fig. 5.

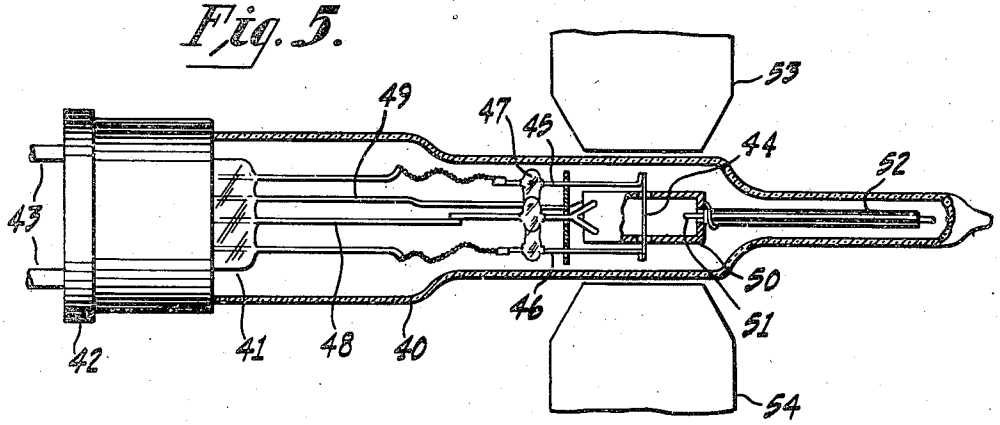
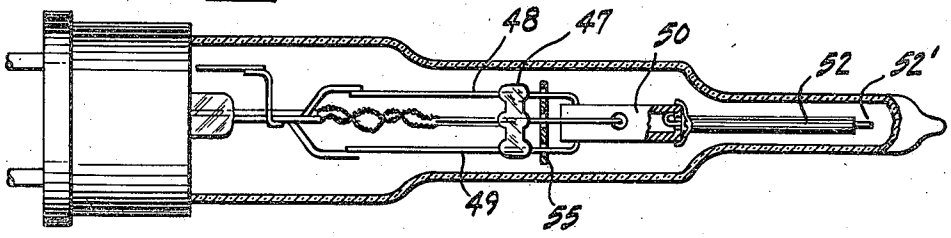


Fig. 6.



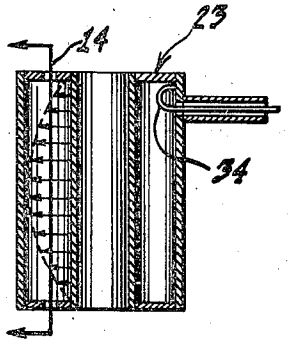


Fig. 3.

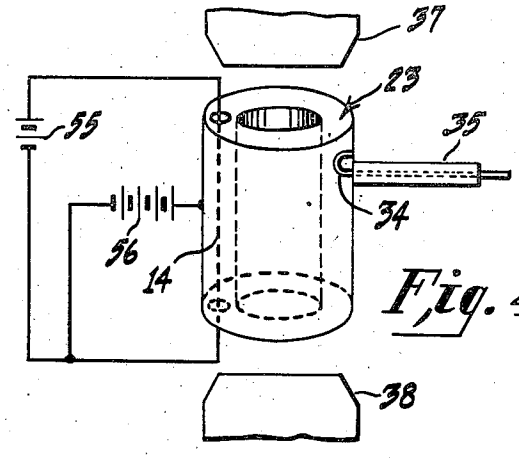


Fig. 4.

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Patented Feb. 11, 1947 2,415,470

UNITED STATES PATENT OFFICE

2,415,470

MAGNETRON

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Application April 21, 1943, Serial No. 483,848

13 Claims. (Cl. 250—27.5)

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My invention relates to electron discharge devices suitable for use at ultra high frequencies, particularly to such devices of the magnetron type.

Magnetrons of the split-anode type represent one of the most convenient means for generation of ultra high frequency oscillations. In this form of tube an elongated cathode is surrounded by two anode segments which are connected together through a resonant circuit. A magnetic field is applied nearly parallel to the cathode and between the cathode and anode segments. The angle between the cathode and field may be a few degrees; for example, three to six degrees has been found to be effective. When the two anode segments are connected together through a resonant circuit, this presents a severe limitation in the size of the anode segments, and hence in the power which may be dissipated when such a tube is designed to generate oscillations above about 10,000 megacycles frequency. For, in order that the capacitance between the anode segments be made small enough to form a circuit resonant of these frequencies, the segments must be made very small.

An object of my invention is to provide an electron discharge device particularly useful at ultra high frequencies.

More particularly it is an object of my invention to provide such a device of the magnetron type capable of large power outputs.

A still further object of my invention is to provide a magnetron which is particularly suitable for ultra high frequency oscillation but in which nevertheless the electrode elements are relatively large so that the heat dissipating surfaces permit a large power input to the tube and hence a large power output, the large size of the electrodes permitting simplification of construction.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a partial longitudinal section of one form of electron discharge device made according to my invention, Figure 2 is a longitudinal section taken 90° to Figure 1, Figure 3 is a schematic diagram showing the voltage distribution during operation of a device made according to my invention, Figure 4 is a schematic diagram of an electron discharge device made according to my invention and associated voltage sources, Figure 5 shows a longitudinal view partially in section of a modification of the device shown in Figure 1, and Figure 6 is a longitudinal view partially in section and taken 90° with respect to Figure 5.

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Referring to Figure 1, an electron discharge device made according to my invention includes an evacuated envelope 10 provided with a press 11 and the usual base 12 and pins 13. The electrode mount assembly includes a filamentary type cathode 14 connected to and supported by the cathode leads and supports 15 and 16, which in turn are supported by the glass bead members 17 and 18, the cathode leads 19 and 20 being extended through the press. A conventional getter 21 may be supported by the lead 20. Shields 22 and 23 are supported on the cathode leads for protecting the glass beads 17 and 18 from metal evaporation and deposition from the electrode assembly.

According to my invention the anode is in the form of a resonant cavity circuit or resonator resonant to electromagnetic radiation or oscillation at the frequency to be generated.

The anode elements are incorporated in the walls of resonant cavity circuit or resonator 23' through which the cathode 14 extends. This resonator comprises a pair of coaxial coextensive tubular members 24 and 25 closed at the top and bottom ends by means of the annular shaped members 26 and 27. The transverse section of the resonator parallel to the longitudinal axis of the tube is an annulus, and the space enclosed is of annular shape.

This resonator is supported from the press by means of the lead and support wires 28 and 29 and by means of a cross member 30 secured to element 31 and cross member 32 secured to element 33.

A coupling loop 34 extends within the resonator 180° removed from the cathode and is merged into a coaxial line, the outer conductor 35 of which extends into the tubular extension 10' of the envelope. This coaxial line is supported by means of the elements 36 and 37. The end of the inner conductor 35' preferably extends ¾ of a wavelength beyond the end of conductor 35 and serves as a radiator and may be coupled to a wave guide. Other coupling means could be used, of course, such as probes or apertures opening into wave guides.

The magnetic field for bringing about magnetron operation is provided by means of the magnets 37 and 38 mounted on opposite sides of the resonator so that the magnetic field is produced between the cathode and the walls of the resonator, and preferably nearly parallel to the cathode. The walls 24 and 25 of the resonator

serve as the anodes of the magnetron. The cathode is positioned to emit and direct electrons into a region of the resonator in which the oscillating electric field can exist.

As shown in Figure 4, the cathode is supplied by means of the battery **55**, and the voltage on the resonator and anode by means of the voltage source **56**. The voltage distribution in an oscillating electromagnetic field within the resonator during operation is shown in Figure 3, the magnitude of the voltage E being represented by the radially directed arrows. Maximum voltage differential in the form of a standing wave occurs at the position of the cathode, the loop **34** being coupled to the oscillating magnetic field within the resonator which is generated during operation of the tube. Thus, each of the tubular members **24** and **25** serves as an elongated anode of large size, having large heat dissipating capacity and because of the large size of the anode construction is facilitated and at the same time the mode of oscillation of the electromagnetic field within the resonator cavity is such that while the anode is large nevertheless high frequency can be generated. Because of the enclosed field undesired radiations and loss of energy is prevented, thereby increasing the efficiency of operation and permitting direction of the energy to the radiator **35'** with very small losses.

A modification of the device shown in Figures 1 and 2 is shown in Figures 5 and 6. In this modification the resonator takes the form of an elongated box-like structure.

The envelope **40** is provided with the usual press **41** and base **42** and pins **43**. The amount includes the cathode filament **44** connected to and supported by the leads and support wires **45** and **46**, these leads extending through the insulating separator **47**. A pair of leads and support wires **48** and **49** support the resonator **50** which encloses the cathode and is an elongated box-like structure. The coupling loop **51** within the cavity extends into the outer tubular member **52** and forms therewith a coaxial line and terminates in a radiator **52'**. The magnets **53** and **54** supply the necessary magnetic field preferably nearly parallel to the cathode. A shield **55** supported by the cavity supports may be utilized to prevent deposition of vaporized metal on the insulating spacer **47**. The operation of this structure is similar to that shown in Figures 1 and 2.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application 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 use 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 I claim as new is:

1. An electron discharge device including an anode comprising a single cavity resonator enclosing a space and resonant to electromagnetic radiation at the frequency to be generated, a cathode within said anode for supplying electrons within said space and in a region in which an oscillating electric field can exist, and means adjacent said cathode for providing a fixed magnetic field within said anode and between said cathode and said anode and to which said electrons are subjected.

2. An electron discharge device including an anode comprising a cavity resonator enclosing an annular-like space and resonant to electromagnetic radiation at the frequency to be generated, a cathode within said anode for supplying electrons within said space and in a region in which an oscillating electric field can exist, a means adjacent said cathode for providing a magnetic field between said cathode and said anode and within said cavity resonator to which said electrons are subjected, and means coupled to said resonator for coupling to the oscillating electromagnetic field within said cavity resonator and including a wave guide constituting a radiator.

3. An electron discharge device having a cavity resonator including a pair of coaxial tubular members coextensive with each other, said tubular members having both ends closed, a cathode positioned between and out of contact with said tubular members and parallel to the longitudinal axis of said tubular members and means adjacent said cathode for providing an electromagnetic field between said cathode and said tubular members and a coupling means extending within said cavity resonator and terminating in a coaxial line, said coaxial line including an inner conductor and outer conductor, said inner conductor extending beyond the end of said outer conductor and providing a radiator for said electron discharge device.

4. An electron discharge device including an anode comprising a cavity resonator enclosing an annular-like space and resonant to electromagnetic radiation at the frequency to be generated, a cathode only within said anode and out of contact with the walls thereof for supplying electrons within said space in a region in which an oscillating electric field can exist, and a means adjacent said cathode for providing a magnetic field between said cathode and said anode and within said cavity resonator to which said electrons are subjected.

5. An electron discharge device including an elongated cathode, a cavity resonator enclosing said cathode, a transverse section of the walls of the said cavity resonator bounding a rectangular-shaped area, said cathode lying parallel to the longest side of said area and between and out of contact wtih the walls of the cavity resonator, said cathode being the only electrode within said resonator, said walls providing an anode for said electron discharge device and means adjacent said cathode for providing a magnetic field between said cathode and the walls of said cavity resonator, a coaxial line coupled to the space within the cavity resonator and including an outer conductor and inner conductor, said inner conductor extending beyond the end of said outer conductor and providing a radiator.

6. An electron discharge device including a linear cathode, a single cavity resonator enclosing only said cathode, the space enclosed by said cavity resonator having a geometrically shaped transverse section, said cavity resonator having a dimension along said cathode no greater than said cathode, the walls of said resonator providing the anode of said electron discharge device, and means adjacent said cathode for providing a fixed magnetic field between said cathode and the walls of said cavity resonator.

7. An electron discharge device including a cathode, a cavity resonator enclosing only said cathode, the space enclosed by said cavity resonator having a rectangularly shaped transverse

section, said cathode lying parallel to opposite walls of said cavity resonator and means adjacent said cathode for providing a magnetic field between said cathode and the walls of said cavity resonator.

8. An electron discharge device including an elongated cathode, a cavity resonator enclosing only said cathode, the space enclosed by said cavity resonator having a rectangularly shaped transverse section, said cathode being positioned within said cavity resonator to lie transverse to the electric field within said cavity resonator and means adjacent said cathode for providing an electromagnetic field nearly parallel to said cathode and between said cathode and the walls of said cavity resonator.

9. An electron discharge device having a cavity resonator and including a pair of coaxial tubular members coextensive with each other and closed at both their ends, a cathode positioned between and out of contact with said tubular members and parallel to the longitudinal axis of said tubular members, and means adjacent said cathode for providing an electromagnetic field between said cathode and said tubular members, and a coupling means extending within said cavity resonator and terminating in a coaxial line.

10. An electron discharge device having an envelope containing a cavity resonator said resonator including a pair of coaxial tubular members coextensive with each other and closed at both their ends, a cathode positioned between and out of contact with said coaxial tubular members and parallel to the longitudinal axis of said tubular members, and means adjacent said cathode for providing an electromagnetic field between said cathode and said tubular members, and a coupling loop extending within said cavity resonator and terminating in a coaxial line, said envelope being provided with an elongated tubular extension, said coaxial line extending within said extension, said coaxial line having an inner conductor and an outer conductor, said inner conductor extending beyond the end of the outer conductor and constituting a radiator.

11. An electron discharge device including an elongated cathode, a cavity resonator enclosing only said cathode, the transverse section of the

walls of said cavity resonator bounding a rectangularly shaped area, said cathode lying parallel to the longest side of the area and between and out of contact with the walls of the cavity resonator, said walls providing an anode for said electron discharge device, and means adjacent said cathode for providing a magnetic field substantially parallel to said cathode and between said cathode and the walls of said cavity resonator.

12. An electron discharge device having a cavity resonator and including a pair of coaxial tubular members coextensive with each other and closed at both their ends, a cathode positioned between and out of contact with said tubular members and parallel to the longitudinal axis of said tubular members, and means adjacent said cathode for providing an electromagnetic field between said cathode and said tubular members.

13. An electron discharge device having a cavity resonator and including a pair of coaxial tubular members coextensive with each other and closed at both their ends, a cathode positioned between and out of contact with said tubular members and parallel to the longitudinal axis of said tubular members, and means adjacent said cathode for providing an electromagnetic field between said cathode and said tubular members, and a coupling means extending within said cavity resonator for extracting energy from said cavity resonator.

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