

March 27, 1945.

C. V. LITTON

2,372,213

ULTRA-HIGH FREQUENCY TUBE

Filed May 11, 1940

3 Sheets-Sheet 1

FIG. 2.

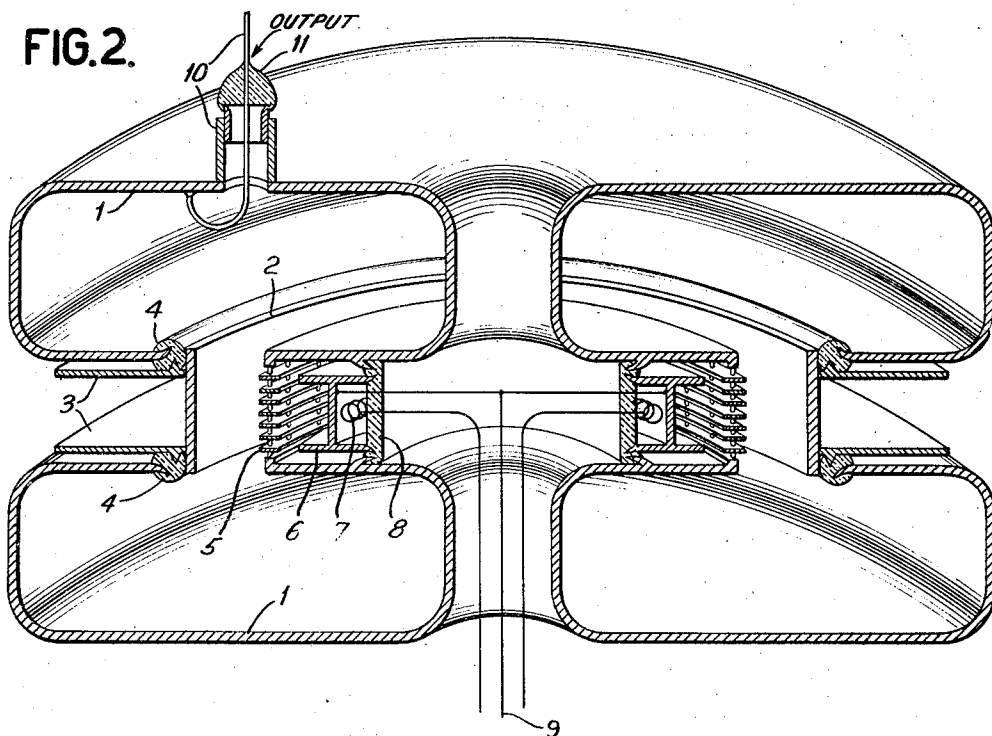
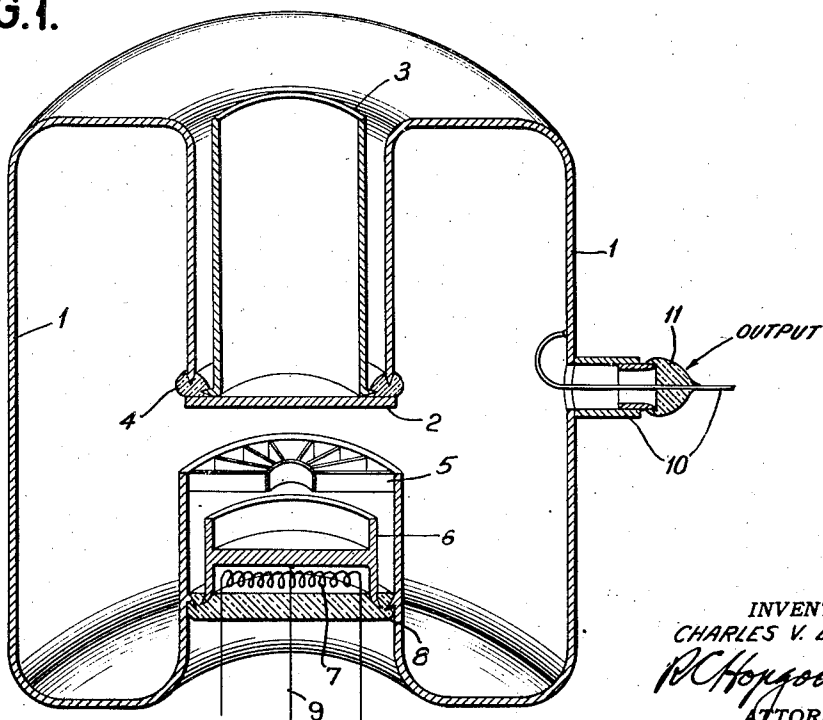


FIG. 1.



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FIG.3.

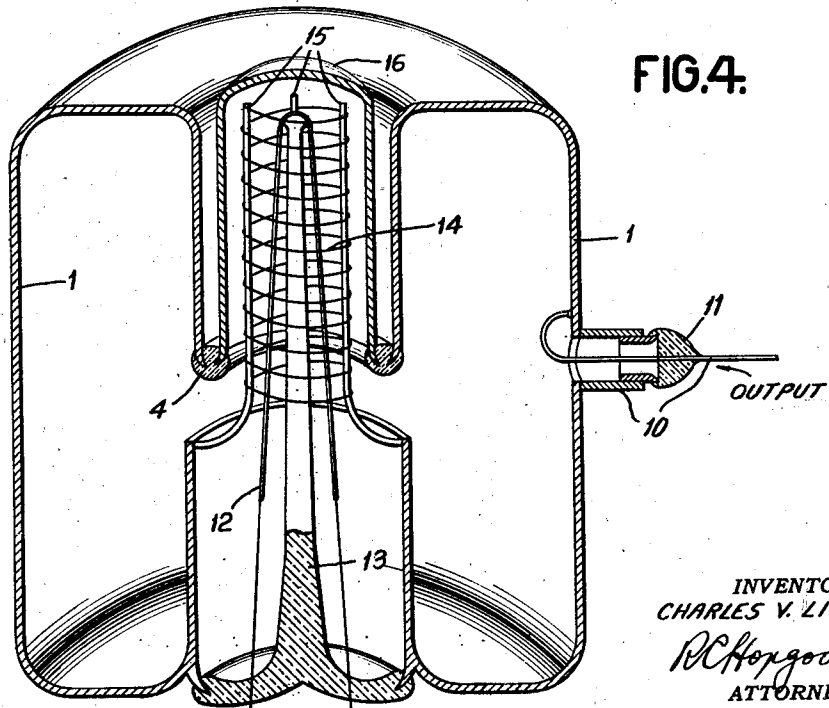
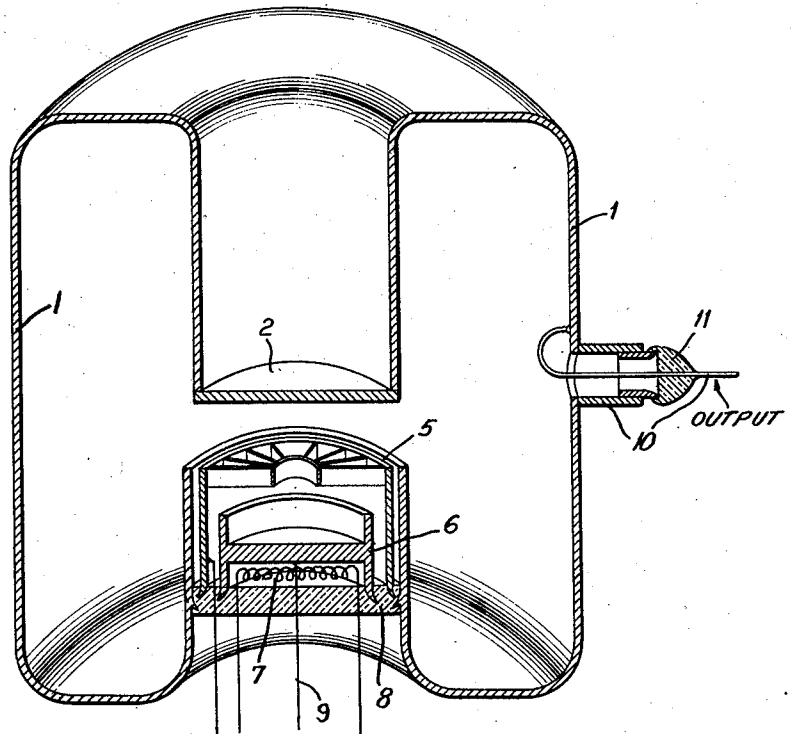


FIG.4.

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FIG. 6.

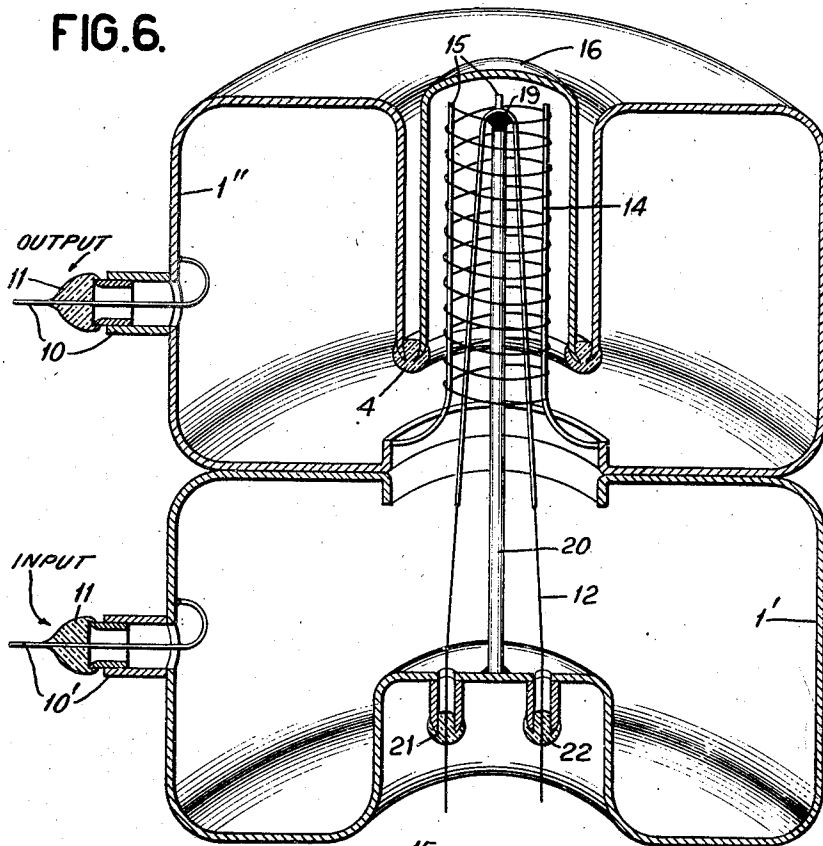
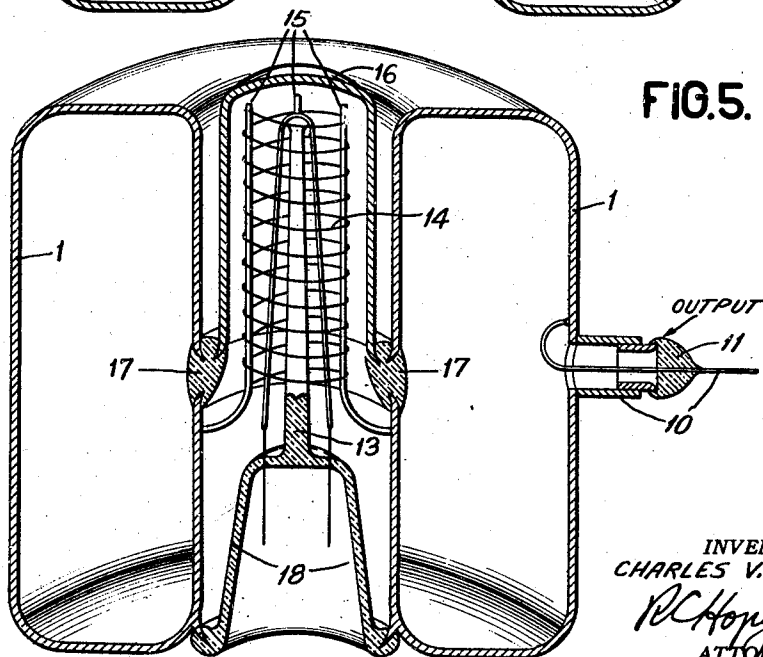


FIG. 5.



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UNITED STATES PATENT OFFICE

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ULTRA-HIGH-FREQUENCY TUBE

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Application May 11, 1940, Serial No. 334,535

20 Claims. (Cl. 250—27.5)

My invention relates to ultra-high frequency tubes and more specifically to tubes having envelope structures adapted for use in ultra-high frequency circuits.

Ultra-high frequency amplifiers and oscillators, of the type wherein the grouping of electrons into bundles depending on their velocities is not the primary frequency determining factor, are subject to frequency and power handling limitations, due to the circuit constants of tuned circuits external to the amplifier or oscillator tube and close inter-electrode spacings which in turn require small electrode structures. By my invention I reduce these limitations of frequency and power handling capacity by forming the tube envelope as a circuit of the resonant cavity type. With this type of tube construction greater power output and higher frequencies can be obtained since increased electrode area and resonant circuits having a high Q are provided.

An object of my invention is to provide an ultra-high frequency tube having increased electrode areas.

A further object of my invention is to provide a tube that operates at higher efficiencies at high frequency.

Further objects and advantages of my invention will appear in the description in connection with the attached drawings wherein:

Fig. 1 is a sectional perspective view of an oscillator tube according to my invention;

Figs. 2 and 3 illustrate modifications in sectional perspective of the oscillator tube of Fig. 1;

Fig. 4 illustrates in sectional perspective an oscillator tube according to my invention;

Fig. 5 illustrates a modification of the oscillator tube of Fig. 3;

Fig. 6 illustrates in sectional perspective an amplifier tube according to my invention.

In Fig. 1 a cavity type resonator in the shape of a toroid forms the major portion of the envelope of the tube 1. A plate or anode 2 having a tubular section 3 attached thereto is sealed to the envelope 1 by means of the glass seal 4. Adjacent the plate 2 and sealed to the envelope or resonator is a grid 5 which controls the number of electrons flowing from an indirectly heated cathode 6 to the plate. The cathode 6 is heated by a filament 7 supported by a glass seal 8 which seals the cathode to the tube envelope. If desired, suitable direct current potentials may be applied to the grid by attaching a lead to the tube envelope, to the plate by attaching leads to the tubular extension 3, and to the cathode by means of the lead 9.

As is well known in the art the resonator may

be tuned by varying the physical dimensions thereof and a resonator of this type has a particularly high Q . Accordingly, with this invention it is possible to provide a varying high impedance circuit for the absorption of radio frequency energy that may be generated by the tube. This in turn means that relatively high voltages can be used with consequent low time for flight and hence much better performance may be obtained from an oscillator tube of this type than is possible with an oscillator tube having an external tuned circuit.

Feedback between the plate of the tube and the tuned circuit galvanically coupled to the grid is obtained by means of the capacity between the tubular extension 3 and the adjacent portion of the resonant envelope. This tubular extension 3 also aids in the dissipation of heat from the plate.

This tube with its resonant circuit may be used in any well known high frequency circuits by taking the energy from the tube by means of the coaxial line 10, sealed to the tube envelope by a seal 11.

Fig. 2 illustrates a modification of the tube of Fig. 1 which has a larger power handling capacity than the oscillator previously described. The symmetrical construction of the tube of Fig. 2 is especially adapted to use as a Barkhausen type of oscillator having a positive grid and a plate that is negative with respect to the grid. In this figure, as in all the figures, similar reference numerals refer to corresponding parts of the tube structures. An annular plate 2 having discs 3 attached thereto is sealed to the resonant envelope 1 by means of glass seal 4. A cathode 6 heated by a filament 7 is sealed to the envelope by means of the seal 8. Between the cathode 6 and the plate 2 is a grid 5 directly attached to the tube envelope. By this toroidal type of construction large electron currents may be produced and utilized, thereby allowing large power output. As in the embodiment of Fig. 1 the output of the tube may be utilized by means of the coaxial line 10.

In Fig. 3 is shown another modification of the embodiment of Fig. 1 wherein the grid 5 is insulated from the envelope 1 by the glass seal 8. The grid is coupled to the resonant envelope by means of its tubular construction and proximity to the envelope. While in this figure I have shown the plate 2 directly connected to the envelope and the grid capacity coupled thereto, it is also possible to construct the tube so that both the plate and the grid are coupled to the envel-

ope. This type of construction has the further advantage that it is necessary to form a seal only at only one part of the tube.

It is apparent that the features of the modifications shown in Figs. 1 and 3 could be combined with those of Fig. 2 to form a tube in the shape of two toroidal chambers, one toroid having an outer diameter smaller than the inner diameter of the other toroid, and the electrodes would then be annular rings in horizontal planes rather than annular rings in vertical planes as shown in Fig. 2.

In Fig. 4 is illustrated an embodiment containing features of the tube described above. In this figure is shown a ribbon type cathode 12 mounted on a glass rod 13 whose base terminates in a seal for the tube envelope 1. Surrounding the cathode is a wound wire grid 14 mounted on rods 15. Surrounding the wound wire grid is a tubular member 16 which forms the plate of the tube. The tubular member 16 is sealed to the resonant envelope 1 by means of seal 4 and as in the other embodiments feedback is obtained by the capacitance between the member 16 and the resonant envelope 1.

In the embodiments thus far described the entire tube envelope has been exhausted. The removal of air from the envelope and the sealing thereof takes place in any well known manner and therefore need not be described in detail herein. If it is desired to avoid evacuating a large chamber such as shown in Figs. 1 through 3, the tube structures of this invention may be formed in accordance with the embodiment of Fig. 5. Fig. 5 illustrates how the glass seal which seals the plate to the tube envelope may be extended so that only the interior of the tubular plate or anode and a small portion of the remaining volume of the tube need be exhausted. This glass seal is designated by reference numeral 17. The glass rod 13 is supported by a glass foot which extends a considerable distance into the interior of the resonant envelope, a seal being effected by the base of the foot and the tube envelope. This type of tube construction may be employed with any of the embodiments described, as is readily apparent to those skilled in the art.

In Fig. 6 I have shown an amplifier tube whose input 10' is fed from a separate source. In this embodiment the tube envelope is divided into two resonant chambers, 1' and 1'', which are provided for the plate and grid, respectively. On the base of the lower resonant chamber 1' is mounted a rod 20 having an insulator 19 on the end thereof which supports the ribbon type cathode 12. Surrounding this cathode is a wound grid 14 mounted on rods 15 and the grid is, in turn, surrounded by a tubular plate or anode 16. The output circuit of the tube is connected to the upper resonance chamber by a coaxial line 10, sealed thereto by seal 11. Glass beads 21 and 22 may be used to seal the cathode leads to the tube envelope.

In all of the embodiments shown it is apparent that the resonant envelope or chamber is tuned to the operating frequency. It is also apparent that the tube described in Fig. 6 may be used as an oscillator tube by inter-coupling the input and output circuits.

In the various embodiments and modifications I have described particular types of cathodes and grids, but other types of grids and cathodes known to those skilled in the art may be substituted without departing from the scope of my invention.

While I have described particular embodiments of my invention for purpose of illustration, it will be understood that various modifications and adaptations thereof may be made within the spirit of the invention as set forth in the appended claims.

What is claimed is:

1. A high frequency tube including a conducting toroidal resonant shell having a gap extending generally circumferentially of an inner portion of the surface of said toroidal shell, an anode sealed to said shell on one side of said gap and electrically insulated therefrom, said anode including a generally cylindrical extension having a diameter smaller than the inner diameter of said shell and extending away from said gap, a portion of said cylindrical extension being longitudinally coextensive with a portion of said shell, a cathode, and a grid connected to said shell on the opposite side of said gap, said grid being positioned between said anode and said cathode for controlling the number of electrons flowing therebetween.

2. A high frequency tube according to claim 1 wherein a vacuum tight seal of insulating material bridges the gap and the portion of said tube enclosing said grid is exhausted.

3. A high frequency tube according to claim 1 wherein said shell is divided into an upper and lower section each having similar gaps, said cathode being sealed to said lower section below the lower of said gaps, and means for connecting external circuits to said upper and lower sections.

4. A high frequency tube including a conducting envelope in the form of resonant shells, said shells being in the shape of toroids having annular gaps provided in opposed adjacent surfaces thereof, an annular anode capacitatively coupled to said shells on one side of said gaps, an annular cathode insulantly sealed to said shells, and an annular grid coupled to said shells on the opposite side of said gaps, said grid being positioned between said anode and said cathode for controlling the number of electrons flowing therebetween.

5. A high frequency electron discharge device including a conducting toroidal resonant shell having an annular gap in a portion of the surface thereof, an anode insulantly sealed to said shell on one side of said gap, said anode including a portion spaced from and substantially parallel to the portion of the surface of said toroidal shell to which said portion of said anode is sealed, a grid connected to the other side of said gap, and a cathode insulated from said shell.

6. A high frequency electron discharge device having electrodes including a cathode, a grid, and an anode, enclosing means of conductive material substantially enclosing said electrodes, said enclosing means being tuned substantially to the operating frequency of said discharge device, means dividing said enclosing means electrically into a plurality of resonant parts, and means coupling said grid and said anode to said enclosing means.

7. A high frequency electron discharge device including a plurality of conducting toroidal resonant shells having annular gaps in portions of the surfaces thereof, anode means common to two of said shells and sealed thereto on one side of said gaps, grid means common to said two of said shells, and cathode means common to said two of said shells and sealed on the other side of said gaps.

8. A high frequency electron discharge device

according to claim 7, wherein said anode means is insulatingly sealed to one side of said gaps and wherein coupling means is provided for coupling said anode to each of the shells to which it is common.

9. A high frequency electron discharge device having a pair of electrodes including a substantially ring-shaped cathode whose radius is substantially greater than its axial dimension, an annular anode surrounding the periphery of and concentric with said cathode, and means forming a hollow annular resonant chamber capacitatively coupled to and coaxial with both of said electrodes.

10. A high frequency electron discharge device comprising a substantially ring-shaped cathode whose outer radius is substantially greater than its axial dimension, an annular grid surrounding the periphery of and concentric with said cathode, an annular anode surrounding and concentric with said annular grid, and means forming a hollow annular resonant chamber capacitatively coupled to said cathode and directly connected to said grid, and mounted coaxially with all of said electrodes.

11. A high frequency electron discharge device having a pair of electrodes including a substantially ring-shaped cathode whose outer radius is more than approximately twice its longitudinal dimension, a second ring-shaped electrode in the path of the electron stream from said cathode, and surrounding the periphery of and concentric with said cathode, means forming a hollow annular resonant chamber coupled to and coaxial with said electrodes, and sealed envelope-forming means enclosing said electrodes.

12. The combination according to claim 11, in which said resonant chamber-forming means is capacitatively coupled to one electrode and directly connected to the other electrode.

13. The combination according to claim 11, in which said resonant chamber-forming means is capacitatively coupled to both of said electrodes.

14. The combination according to claim 11, in which said resonant chamber-forming means is a conductive shell and forms part of said sealed envelope-forming means.

15. A high frequency electron discharge device comprising a substantially ring-shaped cathode whose outer radius is more than approximately twice its longitudinal dimension, a ring-shaped grid surrounding the periphery of said cathode concentric with said cathode, a ring-shaped anode surrounding and concentric with said grid, means

forming a hollow annular resonant chamber coupled to said cathode and one of said other electrodes, and mounted co-axially with all of said electrodes, and sealed envelope-forming means enclosing said electrodes.

16. The combination according to claim 15, in which said resonant chamber-forming means is a conductive shell and forms a part of said sealed envelope-forming means.

17. A high frequency electron discharge device, including two juxtaposed longitudinally spaced conducting toroidal shells having annular gaps in portions of the surface thereof, anode means common to said shells and connected thereto on one side of said gaps, a substantially cylindrical control grid means, common to said two shells mounted within said anode means, coaxial with said grid means, and means sealing said shells and forming an air-tight envelope.

18. A high frequency tube having a conducting envelope, resonators forming part of said envelope, said resonators being in the shape of toroids having annular gaps provided in opposed adjacent surfaces thereof, an annular anode coupled to said resonators on one side of said gaps, a substantially ring-shaped cathode whose outer radius is substantially greater than its longitudinal thickness coupled to said resonators, and an annular grid coupled to said resonators on opposite sides of said gaps, said grid being positioned between said anode and said cathode for controlling the flow of electrons therebetween.

19. A high frequency tube including a conducting envelope, a hollow resonator forming part of said conducting envelope, a ring-shaped anode coupled to one side of said resonator, a substantially ring-shaped cathode whose radius is more than approximately twice its longitudinal dimension, coupled to the other side of said resonator, and a ring-shaped grid coupled to said resonator and positioned between said anode and cathode for controlling the flow of electrons therebetween.

20. A high frequency electron discharge device, including a pair of hollow resonators, ring-shaped anode means common to said resonators and coupled to one side thereof, ring-shaped grid means common to said resonators and mounted concentrically within said anode means, and a substantially ring-shaped cathode whose radius is more than approximately twice its longitudinal dimension, common to said resonators and mounted concentrically within said grid means.

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CERTIFICATE OF CORRECTION.

Patent No. 2,372,213.

March 27, 1945.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 62, claim 6, strike out the word "electrically" and insert the same before "coupling" in line 64, same claim; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of August, A. D. 1945.

Leslie Frazer

(Seal)

First Assistant Commissioner of Patents.