

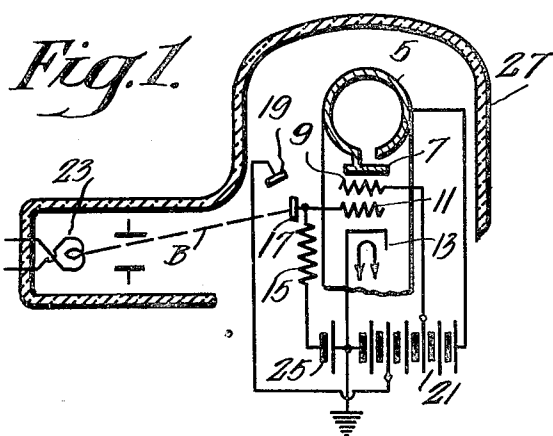
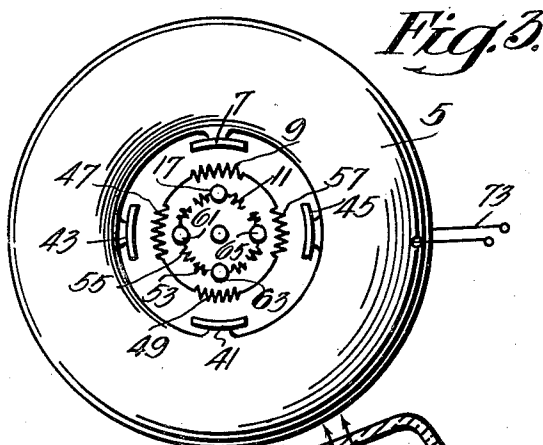
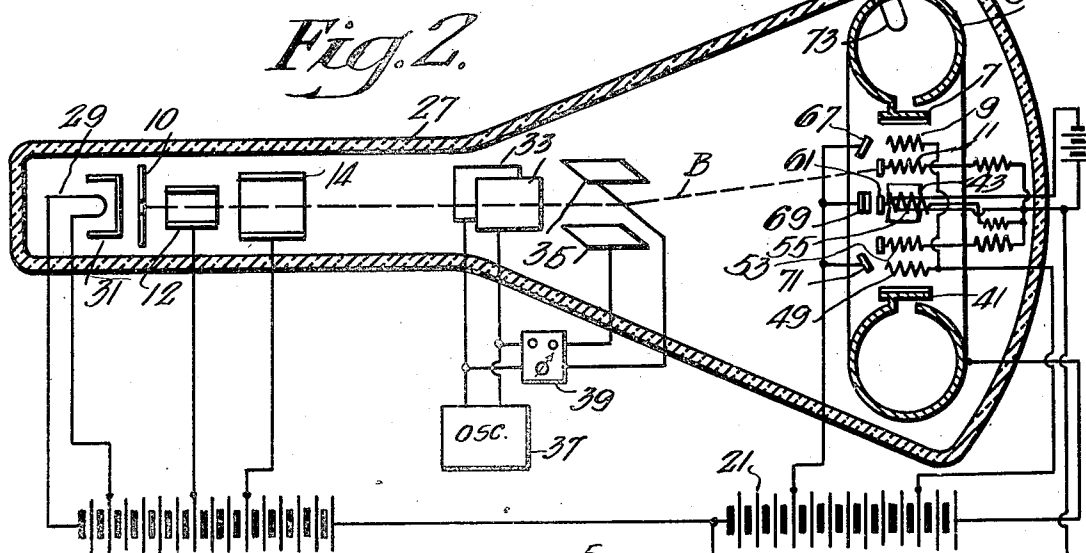
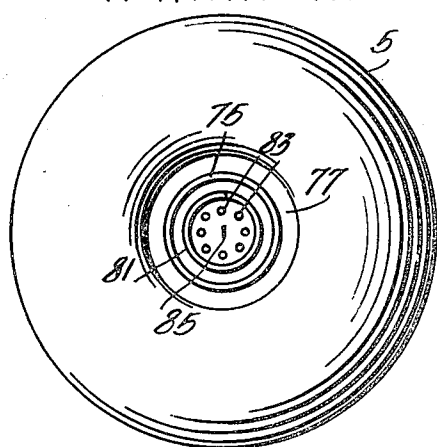
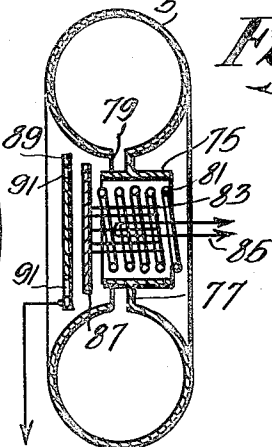
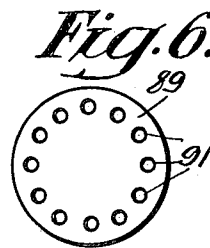
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C. A. ROSENCRANS

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HIGH FREQUENCY GENERATOR

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Inventor

Charles A. Rosencrans

By

J. J. Huff

Attorney

UNITED STATES PATENT OFFICE

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HIGH FREQUENCY GENERATOR

Charles A. Rosencrans, Haddonfield, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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10 Claims. (Cl. 315—5)

This invention relates to ultra high frequency generators, and particularly to generators of the rotating electron beam type.

In copending application Serial No. 326,890, filed March 30, 1940, I have described an electron beam frequency multiplier employing a hollow toroidal resonant cavity electrode having a circumferential slot, the opposing edges of which constitute alternate commutator segments which are successively impinged by a rotating electron beam. A high frequency oscillatory current is generated in the cavity electrode, the frequency of which is determined by the dimensions of the electrode. The principal object of the present invention is to provide an improved rotating beam multiplier of this type. A more specific object of this invention is to modify the device described in said copending application by the inclusion of thermionic tube elements within the resonant electrode to amplify the commutated currents, the rotating beam impinging directly on a secondary emissive target which is connected to a grid electrode.

This invention will be better understood from the following description when considered in connection with the accompanying drawing, and its scope is indicated by the appended claims. Referring to the drawing, Figure 1 is a schematic diagram illustrating the principle of operation of this invention; Figure 2 is a partly sectional view of a high frequency generator in accordance with the present invention; Figure 3 is a plan view of the toroidal electrode and thermionic tube assembly of the type illustrated in Fig. 2; Figure 4 is a plan view of the electrode portion of a preferred form of frequency multiplier; Figure 5 is a sectional view of the arrangement illustrated in the preceding figure, and Figure 6 is a plan view of a chopper electrode.

Fig. 1 represents schematically the essential elements of the invention. The oscillatory circuit includes a hollow metallic resonator 5, a part of which is shown in section, having a circumferential slot around its inner circumference. A metallic anode electrode 7 is connected to the toroid at a point on the edge formed by this slot. Immediately adjacent the anode 7 is a screen grid electrode 9 which may be of conventional construction. Next in order is a control grid 11, while a thermionic cathode 13 is centrally located within the toroid by any convenient mounting means. The grid electrode 11 is connected to the cathode by a high resistance grid leak resistor 15. A small target 17 of secondary-electron emissive material is also connected to the grid 11. Nearby

the secondary electron-emissive target 17 is positioned a collecting electrode 19. Potentials positive with respect to the cathode 13 are applied to the anode 7, the screen grid 9, and the collecting electrode 19 by means of a battery 21, or the like. A source of electrons for producing an electron beam is represented by filament 23, the electron beam B being deflected so as to impinge on the secondary emissive surface 17 at intervals.

It is to be understood that the schematic drawing of Fig. 1 is not intended to illustrate a completely operative device, but represents the essential elements in a simplified arrangement to aid in the explanation of its operation. In practice, a large number of similar sections may be positioned radially within the toroid, the number of such sections being determined largely by the physical size of the elements involved, and the frequency multiplication desired.

The electron beam B, as noted above, is caused to impinge on the secondary emissive surface 17 at intervals. As a result, a larger number of electrons are given off from the electrode than impinge thereon. The electrons which are released are attracted to and are collected by the collecting electrode 19. The loss of electrons by reason of the secondary emission phenomenon causes the potential of the control grid 11 to become more positive, thus increasing the cathode-anode current which normally flows between the cathode 13 and anode 7. When the beam leaves the secondary emissive surface, the grid leak reduces the potential of the grid to its normal value, again reducing the plate current of the tube. If desired, a small biasing battery 25 may be employed to reduce the normal potential of the grid.

Each time the electron beam strikes the secondary emissive electrode, it will be appreciated that a sudden surge of current flows from the anode to the cathode. This current is an excitation current equivalent to that produced directly by the electron beam when it impinges on the commutator elements of the high frequency generator illustrated in my copending application referred to above. At a time a half cycle later, the electron beam impinges on another secondary emissive electrode which is connected to a similar grid which controls the current from another anode connected to a point on the toroidal oscillatory electrode which is substantially a half wave from the first anode 7. This is illustrated in greater detail in Figs. 2 and 3 to which reference is now made.

The toroidal oscillatory circuit 5 is mounted within an evacuated glass envelope 27 in any con-

venient manner. At one end of the tube a heater 29 energizes a cathode 31 to produce electrons which are formed into a beam and directed towards a pair of deflecting electrodes 33 and 35 by the conventional beam forming electrodes 10, 12 and 14. The electron beam, indicated by the broken line B, passes between the horizontal and vertical deflecting electrodes 33 and 35 which are positioned on opposite sides of the beam axis. It is to be understood that the equivalent magnetic deflecting coils or other suitable means may be substituted for the electrostatic deflecting electrodes.

The electron beam is caused to rotate about its normal axis by applying alternating voltages from a suitable source, such as control oscillator 37, to the deflecting electrodes. The deflecting voltages are in quadrature phase relation, as is well known. By way of example, the desired phase relation may be achieved by connecting a 90° phase shifting network 39 between the oscillator 37 and the vertical deflecting electrodes 35.

In the illustrated example, four thermionic amplifier tube elements are included within the space surrounded by toroidal oscillatory electrode 5. It is to be understood that a larger number of amplifier elements may be used. The anode 7 at the top of the toroid is connected to its inner edge, that is, the edge toward the electron source. Diametrically opposite this anode is another similar anode 41 connected to the same edge of the toroid. Intermediate between the anodes 7 and 41 are two other anodes 43 and 45, both of which are connected to the outer edge of the toroid electrode. In addition to the screen grid electrode 9 associated with the first anode 7, three other screen grid electrodes 47, 49 and 51 are provided, associated respectively with anodes 43, 41 and 45. If desired, these screen grid electrodes may be interconnected as shown. They are also energized by a connection to a suitable tap on the battery supply 21.

The thermionic cathode 13, centrally located on the axis of the toroid, is common to all the amplifier tubes. Between the cathode and each of the screen grid electrodes, however, a control grid of conventional construction is located. Control grids 11 and 53 are shown in Fig. 2 while the remaining grids 55 and 57 are seen more clearly in Fig. 3. The grids 11, 55, 53 and 57 are connected to small target electrodes 17, 61, 63 and 65, respectively. The inner surface, that is, the surface facing the electron beam of each target electrode, is of highly secondary-emissive material. The electron beam successively impinges on these targets as it rotates about its normal axis. The secondary-emissive electrodes are provided with collecting electrodes 67, 69, 71, 73 which are suitably biased to attract the emitted electrons. These collecting electrodes are not seen in Fig. 3, since to include them would obscure the other elements, but three of them may be seen in Fig. 2, the fourth not appearing in the sectional drawing. The collecting electrodes are positioned outside the secondary emissive electrodes so as not to interfere with the electron beam.

The arrangement illustrated is essentially a frequency doubler, since each revolution of the beam, corresponding to one cycle of the frequency of the control oscillator 37, two complete cycles of oscillation are produced in the oscillatory toroid. It will be appreciated that the rate of rotation of the beam must be suitably related to the resonant frequency of the toroid, and that

the beam must impinge the secondary emissive electrodes at successive intervals corresponding to a half cycle of the desired output frequency. Output currents are derived from the oscillatory toroid by means of a coupling loop 13.

A preferred embodiment of this invention is illustrated in Figs. 4, 5 and 6. The separate anode electrodes of the system described above are replaced by a single tubular anode which is sealed to an inwardly extending flanged edge 17 within and concentric with the hollow toroidal tank circuit 5. In this case, the opposite edge 79 of the toroid is not connected to the anode. A screen grid 81 is included, as well as a control grid 83 and a filamentary cathode 85. In the present instance, the control grid 83 comprises a plurality of wires surrounding and parallel to the cathode. In the former case, the grid electrodes were not interconnected, but in the present embodiment, all grids are tied together and connected to a disc 87 which is insulatingly mounted perpendicular to the axis of the anode and cathode. The outer surface of this disc is coated with highly secondary-emissive material. Adjacent and parallel to the secondary-emissive disc is a perforated chopper disc 89, shown in plan view in Fig. 6, which also functions as a collector of the secondary electrons released from the disc 87. The emissive disc and grids are connected to the cathode through a grid leak, as shown in Fig. 1, and a positive potential is applied to the chopper disc. The electron beam is caused to rotate about the common axis of the elements so as to coincide with the centers of the holes 91 in the disc 89. As a result, electrons impinge on the secondary emissive electrode 87 in successive groups whose frequency is determined by the speed of rotation of the beam and the number of holes in the disc. The operation of this embodiment is similar to that of the device previously described. There is one important difference, however. It will be recalled that in the first arrangement adjacent anodes were connected to alternate ends of the oscillatory tank circuit. Consequently, the rotating beam excited the oscillatory tank circuit twice during each cycle of oscillation, once during the positive half and once during the negative half cycle. In the present case, however, only one anode and one grid is used. When the secondary-emissive electrode is struck by the beam, the grid becomes more positive, the plate current increases, and the tank circuit is excited, and this takes place once during each cycle of the output voltage, there being no commutator to reverse the polarity of alternate impulses. Consequently, for a given beam rotation and a given number of beam interruptions, the output frequency of the embodiment illustrated in Fig. 5 will be twice that of the embodiment illustrated in Fig. 2, and the dimensions of the hollow tank circuit must be chosen accordingly.

I have thus described a high frequency generator having improved efficiency by reason of the extremely high efficiency of the toroid oscillatory circuit, and having high gain by reason of the use of the secondary emissive phenomena in conjunction with a thermionic amplifier. It is to be understood that the present invention is not limited to the particular arrangement illustrated but various modifications may be made by those skilled in the art within the scope of the appended claims.

I claim as my invention:

1. An ultra high frequency generator compris-

ing means for producing an electron beam, means for rotating said beam at a predetermined frequency, secondary-emissive target electrode means in the path of said beam, a hollow resonant oscillatory electrode, anode electrode means 5 connected to said oscillatory electrode, a thermionic cathode centrally located within said anode electrode means, grid electrode means between said cathode and said anode electrode means, and means connecting said grid electrode means to said target electrodes. 10

2. An ultra high frequency generator comprising means for producing an electron beam, means for rotating said beam at a predetermined frequency, a plurality of secondary-emissive target electrodes in the path of said beam, a toroidal oscillatory electrode having a circumferential slot around its inner circumference, a centrally located cathode within said toroidal electrode, a plurality of anodes connected alternately to opposite edges of said toroidal electrode, a grid electrode between said cathode and each of said anodes, said secondary-emissive electrodes being connected respectively to said grid electrodes. 15

3. A device of the character described in claim 2 which includes a collecting electrode adjacent each of said secondary-emissive electrodes. 20

4. A device of the character described in claim 2 which includes, in addition, a screen grid electrode between each of said anode and grid electrodes. 25

5. An ultra high frequency generator comprising means for producing an electron beam, secondary emissive target means, means for causing said beam to impinge on said target means at successive intervals, a hollow toroidal oscillatory tank circuit, an anode within and concentric with said tank circuit, cathode and grid electrodes within said anode, and means coupling said target means to said grid electrode. 30

6. An ultra high frequency generator comprising means for producing an electron beam, secondary emissive target means, means for causing said beam to impinge on said target means at predetermined intervals to thereby change the 35 potential of said target, a hollow toroidal oscillatory tank circuit, a cylindrical anode within and concentric with said tank circuit, cathode and grid electrodes within said anode, and means coupling said target means to said grid electrode, the resonant period of said tank circuit being equal to said predetermined intervals. 40

7. An oscillation generator including independent means for producing at least two electron beams, a plurality of grid electrodes for alternately controlling the intensity of one of said beams, means for producing movement of the other of said beams, and means responsive to said movement for alternately controlling the potential of each of said electrodes. 45

8. An oscillation generator including means for producing at least two independent electron beams, a plurality of grid electrodes for alternately controlling the intensity of one of said beams in accordance with its potential, means for producing movement of the other of said beams, and means including a plurality of secondary electron emissive surfaces interposed in the path of said movement and each connected to a separate one of said electrodes for alternately controlling the potential of each of said electrodes. 50

9. An electron discharge device including at least two independent electron beam producing means, a plurality of grid electrodes for alternately controlling one of said beams, means for producing movement of the other of said beams, and means responsive to said movement for alternately controlling the potential of each of said grid electrodes. 55

10. An electron discharge device including at least two independent electron beam producing means, a plurality of electrodes for alternately controlling one of said beams, means for producing movement of the other of said beams, and means including a plurality of secondary electron emissive surfaces interposed in the path of said movement and each connected to a separate one of said electrodes for alternately controlling the potential of each of said electrodes. 60

CHARLES A. ROSENCRANS.