Oct. 26, 1937. L. MALTER ET AL 2,096,817

HIGH FREQUENCY OSCILLATOR

Filed May 26, 1936

Fig. 1.

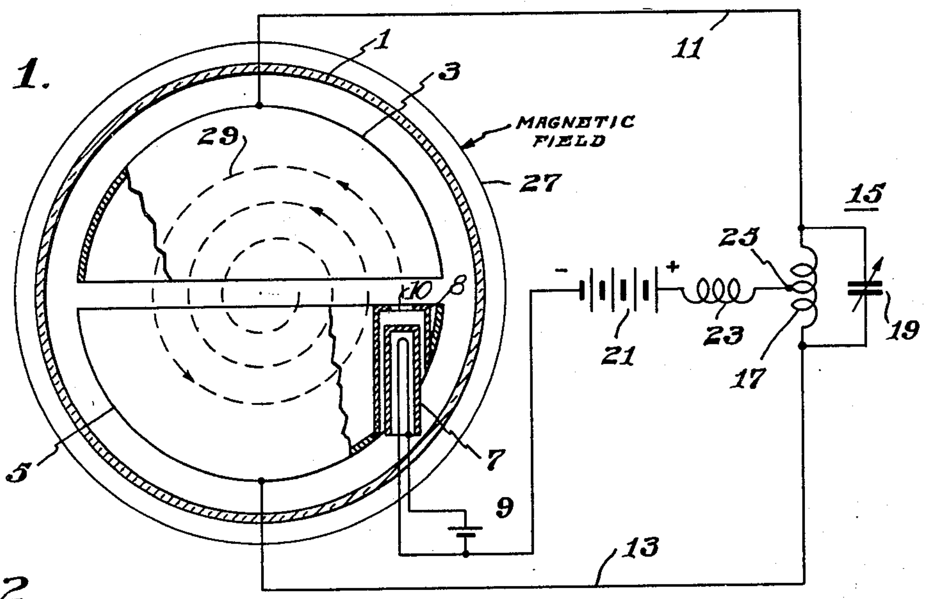


Fig. 2.

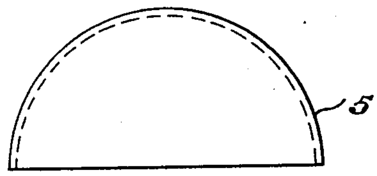


Fig. 3.

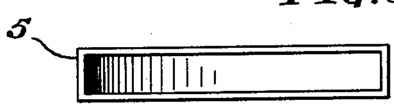
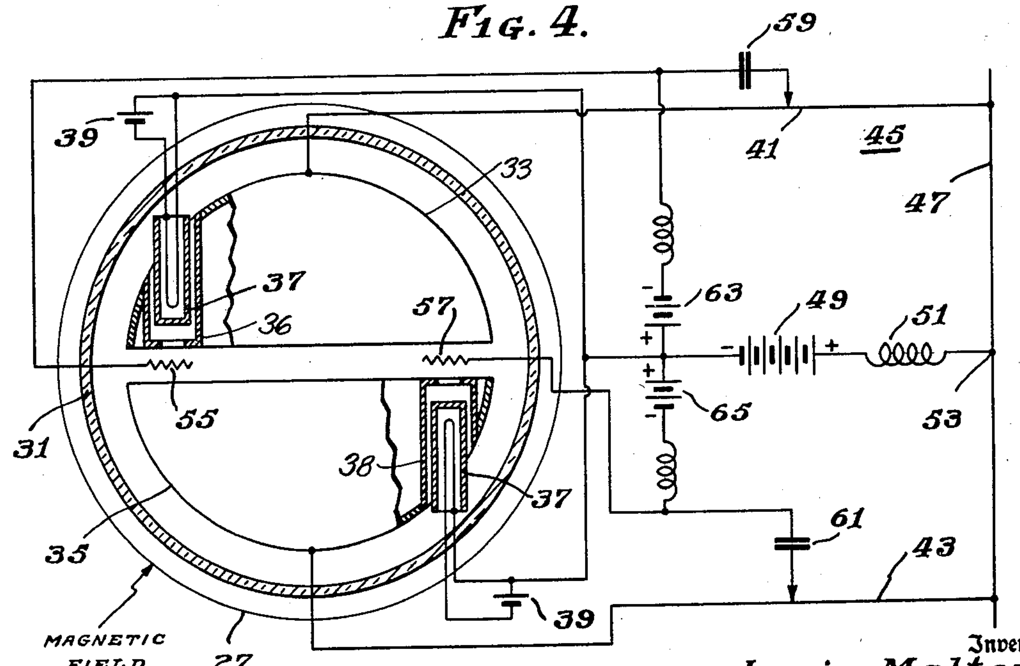


Fig. 4.



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2,096,817

HIGH FREQUENCY OSCILLATOR

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10 Claims. (Cl. 250—36)

This invention relates to high frequency oscillators. More specifically, this invention is an oscillator in which the electrons travel curved paths between electrodes in an electronic tube in a time period which bears an integral relation to the oscillatory period.

Electronic oscillators have been fabricated in which the electron transit time is of appreciable duration as compared to the oscillatory period. The magnetron may be operated as an electronic oscillator of the above described type. In general, such magnetrons have a centrally located cathode which is surrounded by a cylindrical anode or a pair of semi-cylindrical anodes. The electrons emitted by the cathode follow a curved path which generally terminates in the anode electrode.

In the present invention the electronic oscillator is comprised of a pair of hollow sections of semi-cylindrical shape and an electron gun. The electron gun is disposed near the circumference and within the anode. The electrons projected from the gun, influenced by the magnetic field, travel circular or curved paths of decreasing radius within the hollow anodes. In passing from one another to the other, the electrons deliver energy to an oscillatory circuit.

In Figure 1, an embodiment of our invention is illustrated partly in a sectional view and partly as a circuit diagram.

Figures 2 and 3 are, respectively, plan and elevational views of one form of anode electrode, and

Figure 4 is a schematic illustration of an electronic oscillator, embodying our invention, coupled by a transmission line to a dipole antenna.

In Figure 1, within an evacuated envelope 1 are suitably mounted a pair of hollow semi-cylindrical anodes 3, 5, having open ends. These anodes may be fabricated from any suitable metal such as tantalum or the like, as shown in Figs. 2 and 3. The pairs of anodes are mounted on the same plane but spaced from each other at their open ends as shown. An electron gun 7, suitably insulated and electrically shielded from the anodes, is disposed within the hollow anode 5 and near its open end. The shield 8 may be connected to the anode but the electron gun is insulated from the anode. An aperture 10 in the shield 8 permits electrons emitted from the electron gun to pass within the anodes, as will be hereinafter described. The electron gun may be energized by a battery 9 or the like.

The anodes are connected by leads 11, 13 to a tunable circuit 15 which may be composed of an inductor 17 and a capacitor 19. An anode circuit battery 21, and a radio frequency choke 23 are serially connected from the electron gun 7 to a point 25 intermediate the terminals of the tunable circuit 19. A magnetic field, represented by a circular line 27 labeled "magnetic field", is applied to the anodes in a direction substantially perpendicular to the planes of their top and bottom sides.

In the operation of the circuit arrangement of Figure 1, a transient current may be assumed to start in the tuned circuit 19, thereby making the upper terminal momentarily positive and the lower terminal momentarily negative. Electrons emitted by the gun 7 under the attractive force of the electric field created by the battery 21 and the transient current will start outward from the gun. The influence of a magnetic field of suitable strength disposed perpendicular to the electron paths, will cause the electrons to follow a curved or circular path, represented by the dash line 29 through the hollow anode 3.

If the constants of the tuned circuit, battery voltage, and magnetic field are properly proportioned, the electrons will reach the open end of the hollow anode 3 after the transient current has reversed and anode 3 has attained its maximum positive potential and anode 5 its maximum negative potential. The electrons deliver energy to the tuned circuit in passing through the electric field between the open ends of the anodes. These electrons will then follow a curved path of smaller radius through the hollow anode 5 but in the same transit period as required to follow the path through anode 3. When these electrons, following the path of decreased radius, reach the open end between anodes 3 and 5, the oscillatory current in the tuned circuit will again have reversed. The electrons passing through the electric field thus created between the anodes will again deliver some of their energy to the tuned circuit.

This cycle is repeated, the electron paths following curved paths of decreasing radii as the electrons continue to deliver energy. The time for the electrons to traverse the semi-circular or curved paths remains constant. The electrons, having given up substantially all of their energy, finally reach one of the anode electrodes. The energy delivered to the tuned circuit sustains the oscillatory currents therein. The tuned circuit may be coupled by any conventional means to an output or work circuit.

Instead of adjusting the various circuit constants so that the transit time of the electrons is equal to the period of the tuned circuit, these constants may be varied whereby the time required to traverse the semi-circular or curved path is equal to an integer multiple other than one or a sub-multiple of the oscillatory period. Likewise, the arrangement of Figure 1 may be modified to include one or more additional electron guns. Such a modification is shown in Figure 4.

In Figure 4, within an evacuated envelope 31 are mounted a pair of hollow semi-cylindrical anodes 33, 35. An electron gun 37 is mounted within each of the anodes 33, 35, insulated and electrically shielded therefrom, so that the emissive ends of the electron guns are adjacent the open ends of the hollow anodes as shown. The apertured shields 36, 38 may be respectively connected to the anodes 33, 35, but the electron guns 37 are insulated therefrom. The guns may be energized by any suitable source 39. The hollow semi-cylindrical anodes 33, 35 are respectively connected to the wires 41—43 of a transmission line 45. The transmission line 45 is preferably resonant to the oscillatory frequency. A dipole antenna 47 may be connected to the transmission line.

A biasing battery 49 and a radio frequency choke coil 51 are serially connected between the mid-point 53 of the dipole 47 and the electron guns 37, 37. The negative pole of the battery is connected to the electron guns. The circuit of Figure 4, as thus described, will operate essentially as the circuit of Figure 2. In both circuits the continuous emission of electrons has a deleterious effect because some of the emitted electrons will be out of phase with respect to the circulating electrons which deliver energy to maintain oscillations in the tuned circuit. Some of the electrons, whose motions are out of phase, will abstract energy from the tuned circuit and others may impinge on the walls of the anodes. In any event, these out of phase electrons detract from the operating efficiency.

We propose to control the electron emission to avoid such out of phase electron movements. A pair of control grid electrodes 55, 57 are respectively connected through blocking capacitors 59, 61 to the transmission lines 41, 43. These grids are biased negatively by batteries 63, 65. By adjusting the connection from the grids to the transmission lines, negative potentials in the proper phase may be applied to the grids to prevent the emission of electrons at times when their emission would be out of phase with respect to the oscillatory currents. The control grids may also increase the emission of electrons of proper phase to deliver energy to sustain the oscillatory currents.

We claim as our invention:

1. An electronic oscillator comprising an evacuated envelope, a pair of hollow anodes having adjacently disposed open ends, means for emitting electrons, means for projecting said electrons into one of said anodes, means for driving said electrons through said hollow anodes in curved paths of decreasing radii, and a tuned circuit connecting said anodes and arranged to subtract energy from said electrons to thereby generate oscillatory currents in said tuned circuit.

2. An electronic oscillator comprising an evacuated envelope, a pair of hollow anodes having adjacently disposed open ends, means disposed within one of said hollow anodes for emitting electrons, means for electrically shielding said electron emissive means from said anode, means for projecting said electrons into the other of said hollow anodes, means for causing said electrons to traverse curved paths of decreasing radii through said hollow anodes, and a tuned circuit connecting said anodes and arranged to subtract energy from said electrons to thereby generate oscillatory currents in said tuned circuit.

3. An electronic oscillator comprising an evacuated envelope, a pair of hollow anodes having adjacently disposed open ends, an electron gun located within one of said hollow anodes, means for discharging electrons from said gun into one of said hollow anodes, means for causing said electrons to traverse curved paths of decreasing radii through said anodes, and a tuned circuit connecting said anodes and arranged to subtract energy from said electrons to thereby generate and sustain oscillatory currents in said circuit.

4. An electronic oscillator comprising an evacuated envelope, a pair of semi-cylindrical hollow anodes having adjacently disposed open ends, means for emitting electrons, means for projecting said electrons into one of said anodes, means for driving said electrons in curved paths of decreasing radii through said anodes, and a tuned circuit connecting said anodes and arranged to subtract energy from said electrons and thereby create and sustain oscillatory currents in said tuned circuit.

5. In a device of the character of claim 3, means for electrically shielding said electron gun from said anodes.

6. In a device of the character of claim 4, means for electrically shielding said electron emissive means from said anodes.

7. An electronic oscillator comprising an evacuated envelope, a pair of hollow anodes having adjacently disposed open ends, means disposed within each of said hollow anodes for emitting and projecting electrons into the adjacently disposed hollow anodes, means for driving said electrons through said hollow anodes in curved paths of decreasing radii, and a tuned circuit connected to said anodes and arranged to subtract energy from said electrons to thereby establish and maintain oscillatory currents in said tuned circuit.

8. An electronic oscillator comprising an evacuated envelope, a pair of hollow anodes having adjacently disposed open ends, means disposed within each of said hollow anodes for emitting and projecting electrons into the adjacently disposed hollow anodes, means for driving said electrons through said hollow anodes in curved paths of decreasing radii, a resonant transmission line connected to said anodes to subtract energy from said electrons and thereby establish oscillatory currents in said line, and a dipole antenna connected to said transmission line remote from said anodes.

9. In a device of the character of claim 1, means to prevent the emission of electrons whose motions would be out of phase with respect to the electrons delivering energy to said tuned circuit.

10. In a device of the character of claim 7, means to prevent the emission of electrons whose motions would be out of phase with respect to the electrons delivering energy to said tuned circuit.

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