June 8, 1954

P. GUÉNARD ET AL
ELECTRIC DISCHARGE DEVICE FOR
HIGH-FREQUENCY OSCILLATIONS

2,680,811

Filed Dec. 20, 1950

3 Sheets-Sheet 1

FIG. 1.

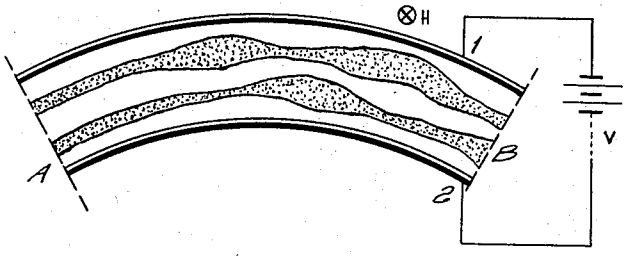
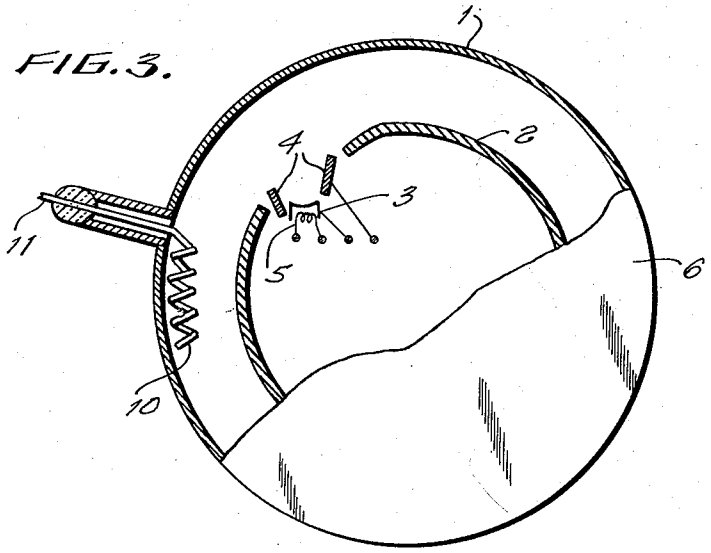


FIG. 3.



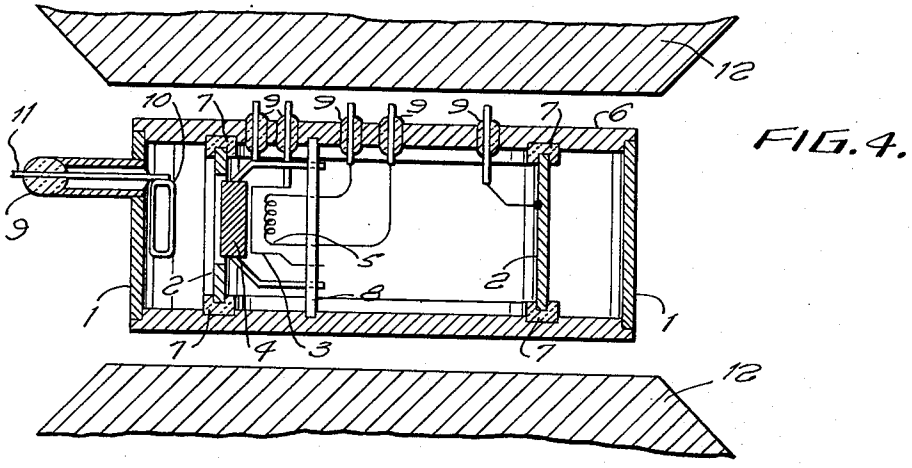


FIG. 4.

June 8, 1954 P. GUÉNARD ET AL 2,680,811

ELECTRIC DISCHARGE DEVICE FOR HIGH-FREQUENCY OSCILLATIONS

Filed Dec. 20, 1950 3 Sheets-Sheet 2

FIG. 2.

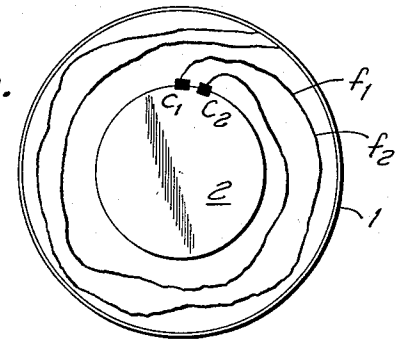


FIG. 5.

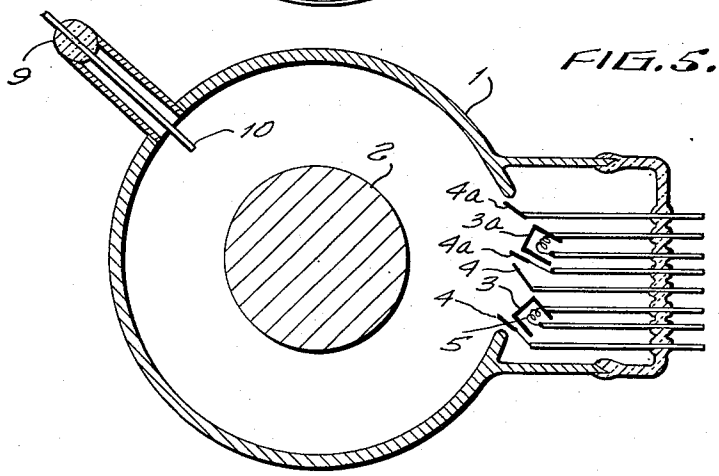
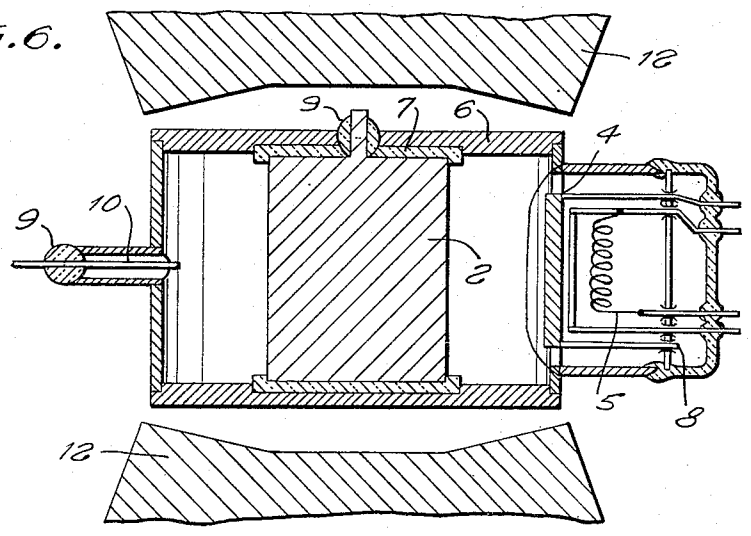


FIG. 6.



June 8, 1954

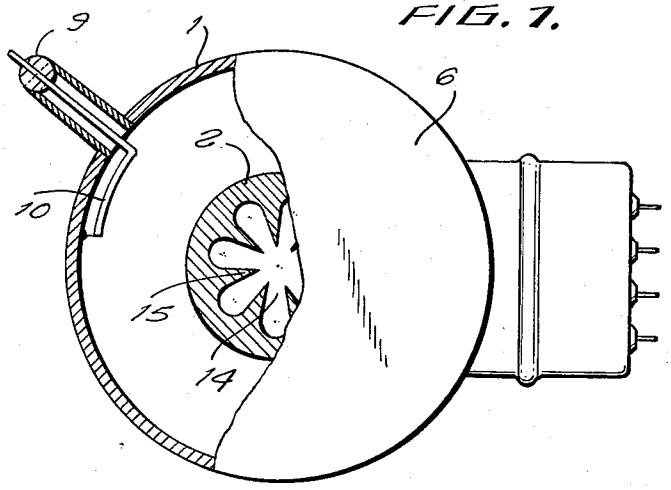
P. GUÉNARD ET AL
ELECTRIC DISCHARGE DEVICE FOR
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Filed Dec. 20, 1950

3 Sheets-Sheet 3

FIG. 7.



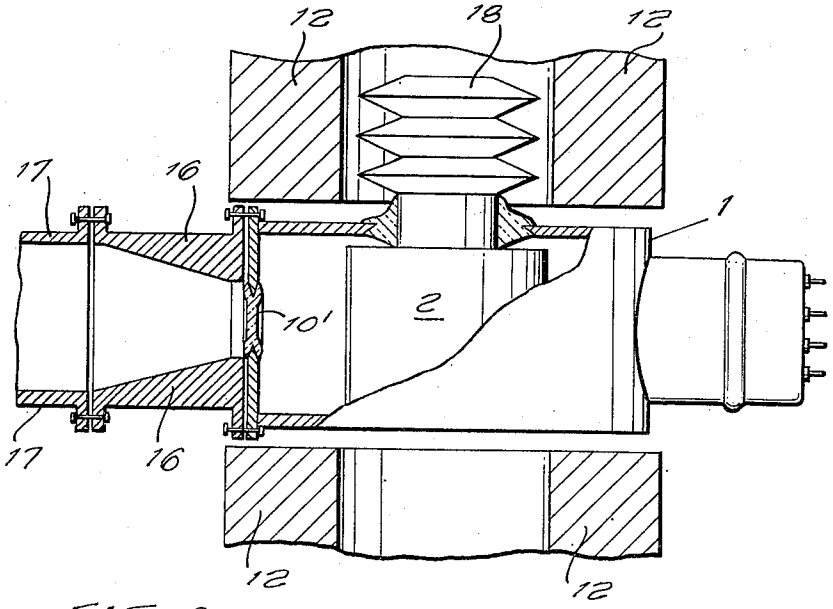


FIG. 8.

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UNITED STATES PATENT OFFICE

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ELECTRIC DISCHARGE DEVICE FOR HIGH-FREQUENCY OSCILLATIONS

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Application December 20, 1950, Serial No. 201,712

Claims priority, application France December 23, 1949

10 Claims. (Cl. 250—36)

1

In the co-pending application of Warnecke et al., Serial No. 144,502 filed February 16, 1950, for "Ultra High Frequency Amplifying Tube," there is described an electronic tube in which several electronic streams of different velocities, forming part of one or several beams and having been subjected to a previous density modulation, propagate in an interaction space comprised between two conductors between which there exists an electric field perpendicular to the propagation direction of the streams, a magnetic field being in addition applied in a direction perpendicular both to said electric field and to said propagation direction of the streams. It was shown that in the foregoing conditions the alternating energy transmitted by electrons is submitted to an amplification and the use of this tube was proposed as amplifier of which the manufacture is relatively simple as it does not comprise an internal circuit between the incoming and outgoing coupling circuits. There were also described the forms of semi-cylindrical embodiments, said forms constituting one of the means for obtaining in the interaction space a variable electric field transverse to the direction of the propagation of the streams, this variation being a means of conferring different velocities to the different streams. The present invention, relies on the fact that if an entirely cylindrical and not a semi-cylindrical form is given to the interaction space and if the electrons are allowed to circulate in a closed circuit, the tube is capable of functioning as an oscillator with great efficiency, susceptible of furnishing a frequency easily variable by the control of exterior voltages. It is of very simple construction seeing that it comprises only cylindrical elements easily machined and not complicated by internal circuits, cavities, slots etc., the effecting of which with the necessary precision is difficult.

The present invention will be better understood with the aid of the annexed drawings of which Figs. 1 and 2 represent schematics intended to aid in the understanding of the mechanism and conditions of the production of oscillations whereas Figs. 3 to 8 show some constructive examples of embodiment.

Fig. 1, intended for explaining the functioning of the tube, represents schematically a part of the device. A fixed potential difference is applied between electrodes 1 and 2; the positive electrode can be either the internal or the external electrode. A magnetic field H uniform or not, is applied perpendicularly to the plane of the drawing.

2

In the space between the electrodes there are injected two beams f_1 and f_2 provided for example by two cathodes C_1 and C_2 (Fig. 2), said beams being supposed to travel in the direction from A towards B. It is known that if one of the beams is modulated in the plane A in its form and density, it induces in the second beam a modulation of form and density and that, for suitable velocity differences of beams there is an amplification of the modulation. From the viewpoint of the alternating electric field this means that the electric field in plane B is greater than the electric field in plane A.

If it is now assumed, as indicated in Fig. 2 that the electrodes limit an annular space, and that the relation of the electric and magnetic fields is such that the beam path follows said space circularly, the applied field after a complete turn superposes onto the initial modulation a modulation which can be in phase if the field frequency is suitable. There is then an auto-maintenance of the modulation and as a consequence the device furnishes high frequency energy to pre-determined frequencies.

It is understood that the necessary initial modulation for setting up the system is produced as in each auto-oscillator, during the application of a voltage to the tube following the current fluctuations at the starting period.

If it is assumed that the electrons in the absence of high frequency, move in parallel to the electrodes in a region of which the potential is V in relation to the anode, it is seen that the alternating power furnished is of the value of VI, I being the continuous intensity of the beam; in fact when the high frequency field operates, the electrons approach the anode as shown in Fig. 2, in keeping a constant average longitudinal velocity. The oscillator efficiency can therefore be considerable if $-V$ is close enough to the potential of electrode 2. This is an advantage over two beam amplifiers without crossed fields arranged as oscillators; it is known that such tubes only operate if the beams have only slightly different velocities and that only the energy corresponding to the differences of velocities can be transformed into alternating energy.

Over oscillating tubes such as magnetrons and travelling wave tubes based on interaction, in crossed magnetic and electrostatic fields of a magnetic beam and a low velocity electromagnetic wave, the present invention possesses the advantage heretofore mentioned of not comprising cavities, multiple slots, etc., constantly guiding the wave, the manufacture of which with the requisite

precision is difficult. Therefore the manufacture of the tube according to the present invention is simplified.

On the other hand, the frequency of the oscillator depending essentially on the space charge and the velocity of the electrons, there are no elements such as cavities for fixing the oscillation frequency. The oscillator according to the present invention is therefore utilisable on a wide band, the frequency variations being obtained on varying the cathode and cylindrical electrode voltages and the magnetic field.

Figs. 3 and 4 show a first example of an oscillator in which the electronic streams are contained in one beam only. The copper external electrode 1 at zero potential, forms, with two circular covers 6, a vacuum-tight element. The interior electrode 2 maintained by insulators 7 is at negative potential. The device functions with a single electronic beam emitted by a cathode 3 and focussed by electrodes 4, seals 9 accommodating leads for assuring the supply of the current to the filament heater 5 of cathode 3 and to electrodes 2, 3, 4 fixed on bars 8. The extraction of energy is effected by means of a few coils of a flat helix 10. The output is effected on a coaxial line 11. The magnetic field is created by pole pieces 12. The ratio E/B of this tube is variable in the radial sense due to the cylindrical form of the electrodes.

In the second example of the oscillator, represented in Figs. 5 and 6, two beams are utilised. The internal electrode 2 is at positive potential, its current feed is assured by leads accommodated in the seals 9. The cathodes 3 and 3a are placed at the exterior. The beams are focussed by "wehnelts" 4 and 4a. The high frequency energy is taken by 10. The form of pole pieces 12 allow the obtaining of a non-uniform magnetic field. The ratio E/B here varies considerably.

Fig. 7 shows a third example, analogous to the preceding example and utilizing the same reference numbers, with the differences that the energy is taken by a loop 10 parallel to the plane of the beam, and that the internal electrode 2 at a positive potential is recessed at 14 and is provided with fins 15 for assuring cooling under the action of air currents.

In a fourth example of embodiment according to Fig. 8, the energy is taken by a slot 10' and transmitted by "horn" 16 to a guide 17. There is provided a group of fins assuring the cooling of the anode 2 placed at the interior of the device. The polar pieces 12 are recessed at their centre in such a way that the magnetic field traverses only the useful interaction space and that the block 18 can engage in the available recesses in the pole pieces.

We claim:

1. An electronic tube comprising two spaced concentric cylindrical electrodes having smooth surfaces defining a circular electron orbit therebetween, a pair of end plates connected to said concentric electrodes and defining therewith a vacuum-tight envelope enclosing said orbit, insulating means electrically separating said concentric electrodes from each other, electron emissive means in said envelope positioned adjacent said orbit and comprising an electron optical system having an optical axis substantially tangential to a cylinder coaxial with said concentric electrodes, leads through said envelope connected to said electron emissive means and electron optical system for applying potentials thereto to determine the velocity of electrons in said orbit, a lead through said envelope connected to the inner one of said concentric electrodes for establishing a radial electrical field of predetermined magnitude across said orbit, a magnetic source adjacent said tube for creating an axial field of predetermined magnitude across said orbit, and means positioned in said orbit for extracting from said tube the oscillatory energy generated when the ratio of the magnitudes of said radial electrical and axial magnetic fields is substantially equal to the velocity determined by said potentials.

2. A tube according to claim 1, wherein the exterior one of said electrodes is constituted by at least part of a first cylindrical circular surface, said end plates being connected to said surface to constitute said vacuum-tight envelope and having the shape of cross-sections of said cylindrical surface, said insulating means supporting the interior one of said electrodes, said interior electrode being constituted by at least part of a second circular cylindrical surface coaxial with said first surface, and seals in the walls of said envelope enclosing leads connected to said electron emissive means, to said interior electrode and to said means for extracting energy from the tube.

3. A tube according to claim 2 wherein said electron emissive means comprise a single cathode and a focussing electrode adjacent thereto for concentrating the emitted beam into a single beam containing a plurality of electronic streams travelling at different velocities.

4. A tube according to claim 3 wherein the interior one of said electrodes is in the shape of a cylindrical surface bounded by two generating lines, said electron emissive means being positioned inside said cylindrical surface and having its optical axis directed into said annular space and a seal in said exterior electrode enclosing a probe connected to the interior conductor of a coaxial transmission line for extracting energy from the tube.

5. A tube according to claim 2 wherein said electron emissive means comprise at least two cathodes for emitting electronic beams at velocities different from each other.

6. A tube according to claim 5 wherein the exterior one of said electrodes is in the shape of a cylindrical surface bounded by two generating lines defining a circumferential space therebetween, said space establishing a communication between said orbit and a contiguous vacuum-tight space, the walls of which are connected to said exterior electrode, at least part of said walls being made of insulating material, and said electron emissive means comprising at least two emissive cathodes located inside said contiguous space for emitting individual electron beams into said orbit at velocities different from each other.

7. A tube according to claim 6 wherein the interior electrode is recessed and provided with internal cooling fins.

8. A tube according to claim 6 wherein the magnetic source comprises a pair of poles having surfaces facing said end plates and coaxial with said electrodes, said surfaces being substantially concave thereby to create a non-uniform magnetic field.

9. A tube according to claim 6 wherein said exterior electrode includes a slot, an insulating joint positioned in said slot, thereby to enable the extraction of energy from the tube, and a horn connecting said slot to an external wave guide.

10. A tube according to claim 6 wherein the magnetic source comprises a pair of poles having surfaces facing said end plates and coaxial with

said electrodes, said surfaces being recessed at their centers to provide an annular magnetic field through said orbit, said tube further comprising a finned block connected to said interior electrode and extending therefrom inside the recessed portion of at least one of said poles.

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