

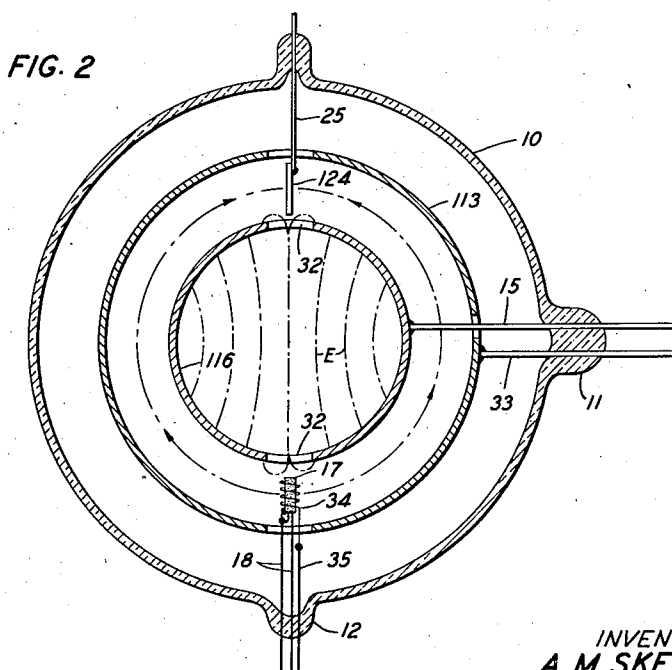
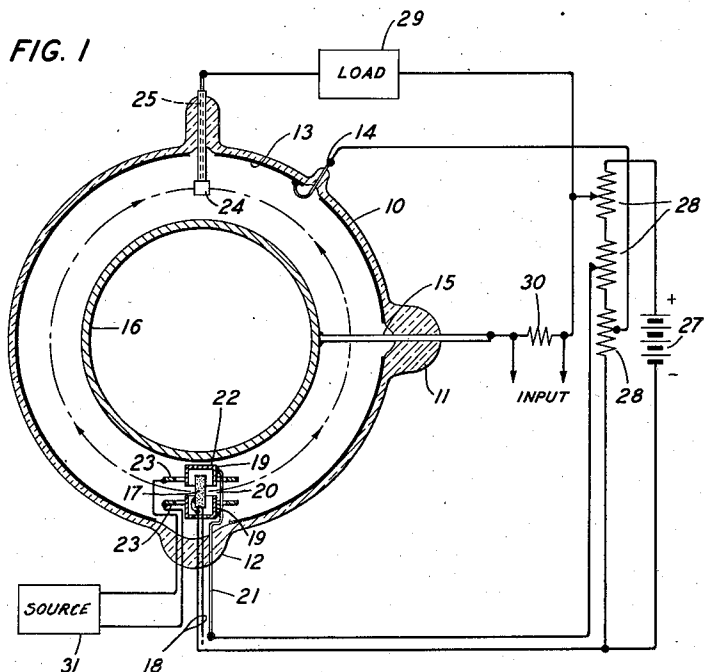
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ELECTRON DISCHARGE APPARATUS

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ELECTRON DISCHARGE APPARATUS

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This invention relates to electron discharge apparatus and more particularly to amplifiers and oscillation generators of the electron beam type.

One object of this invention is to simplify the construction of electron discharge devices of the beam type and especially of such devices suitable for operation at ultra-high frequencies.

Another object of this invention is to reduce the stringency of dimensional design requirements in electron discharge devices intended for operation at ultra-high frequencies, for example frequencies corresponding to wavelengths in the centimeter range or lower.

A further object of this invention is to increase the effective segregation of the input and output gaps in a two-gap beam type, ultra-high frequency oscillation generator whereby undesired coupling between these gaps is minimized.

In one illustrative embodiment of this invention, an electron discharge device comprises a cathode, a target electrode or anode aligned with said cathode, and an electrode system for concentrating electrons emanating from the cathode into a beam normally focussed upon the target electrode or anode.

In accordance with one feature of this invention, the electrode system comprises a pair of concentric spherical electrodes between which the cathode and target electrode are mounted, the target electrode and cathode being disposed adjacent opposite ends of a diameter of the outer spherical electrode, and the spherical electrodes being biased at such potentials as to concentrate electrons emanating from the cathode into a hollow spherical beam focussed upon the target electrode. Means are provided for altering the focus of the beam in accordance with a signal whereby the beam current to the target electrode also is varied in accordance with the signal. In one specific construction, one or more deflector plates adjacent the cathode are utilized to alter the electron trajectories and, thus, to vary the beam focus. In another construction, the inner spherical electrode may be utilized for this purpose.

In accordance with another feature of this invention, the inner spherical electrode is constructed to constitute a cavity resonator and is provided with diametrically opposite apertures adjacent the cathode and the target electrode

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and the outer spherical electrode is made of such diameter that standing waves, radial with respect to the two electrodes, are established in the vicinity of the cathode when the resonator is energized. Such waves result in deflection of the beam adjacent the cathode and consequent sweeping or deflection of the beam along the target electrode, radially with respect to the spherical electrodes. Consequently, waves of the E_0 type are established in the resonator and oscillations are generated and sustained.

The invention and the above-noted and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing, in which:

Fig. 1 is in part a sectional view of an electron discharge device and in part a circuit diagram of apparatus illustrative of one embodiment of this invention and particularly suitable for use as an amplifier; and

Fig. 2, which is similar to Fig. 1, illustrates an embodiment of this invention particularly suitable for the generation of ultra-high frequency oscillations.

Referring now to the drawing, the electron discharge device illustrated in Fig. 1 comprises a highly evacuated enclosing vessel of insulating, e. g. vitreous, material, having a spherical portion 10 and a pair of stems 11 and 12. The inner surface of the spherical portion 10 has thereon an electrically conductive coating 13, for example a deposit of colloidal graphite known commercially as "Aquadag," to which electrical connection may be established by way of a leading-in conductor 14. Supported from the stem 11 by a rigid leading-in conductor 15 is an inner spherical electrode 16 concentric with the coating or electrode 13.

A linear cathode 17, for example of the indirectly heated equipotential type, is supported from the stem 12 by suitable leading-in conductors 18 and extends radially with respect to the electrodes 13 and 16. The cathode 17 is encompassed by a cylindrical accelerating electrode 19 coaxial therewith, having an annular window 20 therein, and supported from the stem 12 by a leading-in conductor 21. Advantageously, the inner end of the accelerating electrode 19 is closed, as by a disc 22, in order to prevent flow of

electrons directly from the cathode to the inner spherical electrode 16. A pair of parallel deflector electrodes 23, for example discs coaxial with the accelerating electrode, are mounted adjacent the opposite extremities of the window 20 as shown.

Mounted diametrically opposite the cathode 17 is a target electrode or anode 24, which may be supported by a leading-in conductor 25 sealed in the spherical portion 10 of the enclosing vessel.

It has been found that if the relative potentials of the electrodes are properly correlated, the electrons emanating from the cathode can be concentrated into a spherical beam substantially concentric with the two spherical electrodes 13 and 16 and that the exact configuration of the beam is dependent primarily upon the relative potentials of the two spherical electrodes. More specifically, it has been found that the beam can be focussed sharply upon the target or collector electrode 24 and that the focus can be varied markedly by relatively small changes in the potential of the inner spherical electrode 16, whereby the beam current to the target electrode or anode 24 is varied accordingly.

In one illustrative device, as illustrated in Fig. 1, the cathode 17 is maintained at a negative potential with respect to the outer spherical electrode 13, the inner spherical electrode 16 and target electrode 24 are biased at a positive potential with respect to the electrode 13 and the accelerating electrode 19 is biased at a somewhat lower positive potential with respect to the electrode 13, as by a source 27 and associated potentiometer resistances 28. The inner deflector electrode 23, that is the upper deflector electrode in Fig. 1, may be biased at a positive potential, for example the same potential as the inner spherical electrode 16, and the other deflector electrode may have its bias adjusted to produce maximum current to the target electrode. The biasing potentials for the deflector electrodes may be obtained from a suitable source 31. A load 29 may be connected in circuit with the target electrode 24 and a resistor 30 across which a signal potential may be impressed is connected in circuit with the inner electrode 16 as shown.

Because of the positive potential of the electrode 19, with respect to the cathode, it will be appreciated that the electrons emanating from the cathode 17 will be accelerated radially outwardly in all directions from the cathode and issue from the window 20. They are then subjected to a resultant field determined by the potentials of the inner and outer spherical electrodes and, in the vicinity of the window 20, also by the potentials of the deflector electrodes. The paths followed by the electrons, as is obvious, will be dependent upon the resultant field noted above and the velocity with which the electrons issue from the window 20. As will be seen, if the centrifugal and centripetal forces effective upon the electrons are in substantial balance, electrons will be directed along circular paths substantially concentric with the spherical electrodes and will impinge upon the anode or target electrode. If this balance of forces is disturbed, as by the application of a signal potential across the input resistor 30, the electron trajectories will be altered and a portion or all of the electrons will fail to reach the anode, flowing to either the inner or the outer spherical electrode, depending upon the polarity of the input signal. Thus, the current to the anode 24 is variable in accordance with the input signal.

Of course, the specific amplitudes of the potentials applied to the several electrodes for optimum operation will be dependent upon the particular construction of the discharge device. However, it has been determined that a maximum target current can be obtained by correlating the electrode potentials and that the target current can be varied by varying the potential of the inner spherical electrode. For example, in a particular construction wherein the inner electrode 16 had a radius of 2.2 centimeters and the outer electrode 13 had a radius of 5 centimeters, a maximum target current was obtained for the following voltages on the several electrodes:

	Volts
Spherical electrode 13.....	0
Spherical electrode 16.....	+130
Accelerating electrode 19.....	+36
Cathode 17.....	-54
Target electrode 24.....	+130
Upper deflector electrode 23.....	+132
Lower deflector electrode 23.....	+81

For such particular device, the current to the target electrode varied from the maximum to about 80 per cent of maximum when the voltage of the electrode 16 was reduced to 120 volts and fell abruptly to substantially zero when this voltage was reduced to about 100 volts. Thus, it will be appreciated that large variations in target current with relatively small proportional changes in potential of the inner spherical electrodes are realizable.

Although in the embodiment described above, the target current is controlled by varying the potential of the inner spherical electrode, it may be controlled alternatively by otherwise disturbing the balance requisite for focussing of the spherical electron beam upon the target electrode. For example, the direction of the injection of the electrons into the radial field between the two spherical electrodes may be varied by impressing a suitable varying potential between the deflector electrodes 23, as by way of the connections therefrom to the source 31, whereby the electron trajectories and, consequently, the target current are varied. Also, as another example, the velocity with which the electrons are injected into the field between the spherical electrodes may be varied as by varying the potential of the accelerating electrode 19 or of a control electrode or grid, not shown, adjacent the cathode, whereby the electron trajectories and the target current are modified accordingly. As a further example, the electron current may be modulated by a control electrode or grid adjacent the cathode and biased negatively with respect thereto.

The device illustrated in Fig. 2 is generally similar to that shown in Fig. 1 and described hereinabove but is adapted particularly for utilization as an ultra-high frequency oscillation generator. The inner spherical electrode 116 is provided with diametrically opposite apertures 32 adjacent the cathode 17 and the radially extending, wire or rod target electrode or anode 124 and is designed to constitute a cavity resonator at the intended operating frequency of the device. The outer spherical electrode 113 is mounted concentrically with the electrode 116 as by a rigid leading-in conductor 33 sealed in the stem 11. The cathode 17 is encompassed by a control electrode or grid 34 coaxial therewith and supported from the stem 12 by a leading-in conductor 35.

As in the device illustrated in Fig. 1 and described hereinabove, in the device shown in Fig.

2 the potentials of the several electrodes are correlated so that normally the electrons emanating from the cathode 17 are concentrated into a spherical beam focussed upon the target electrode or anode 124, advantageously upon an intermediate area thereof. Because of the coupling of the region immediately adjacent the cathode 17 and grid 34 and the region immediately adjacent the target electrode or anode 124, by way of the cavity resonator 116, the device is inherently unstable and, when the electrode potentials are applied, energy is fed back from the anode region to the cathode region by the cavity resonator. The energy fed back to the cathode region is reflected by the other spherical electrode 113 and standing waves are established along the grid 34, i. e. in the direction of the longitudinal axis of the grid, whereby oscillating potential gradients are produced along the grid in this direction. Consequently, the electron trajectories are altered and the spherical beam is deflected accordingly along the target electrode or anode 124. As a result, waves of the E_0 variety, the general configuration of the typical lines of which is indicated by the dotted lines E in Fig. 2, are built up within the cavity resonator and oscillations at the natural frequency of the resonator are generated and sustained. Oscillatory energy may be abstracted from the field within the resonator 116 by a suitable probe or loop, not shown, projecting thereinto. For example, the target electrode 124 may be extended to project into the interior of the resonator, and utilized as the output electrode.

It will be noted that by virtue of the interposition of the resonator 116 between the cathode and anode regions, undesired coupling between these regions is minimized. Further, the generation of oscillations involves only a suitable phase relation between the energy at the two regions and is substantially independent of transit time factors so that dimensional limitations due to such factors are eliminated and the construction of devices operable at ultra-high frequencies, for example frequencies corresponding to wavelengths in the centimeter range or lower, is simplified and facilitated. Also, as will be appreciated readily, the construction enables effective utilization of the inherently high Q of spherical cavity resonators. Moreover, it will be appreciated that the electrons constituting the beam are spread out so that deleterious effects due to mutual interaction of the electrons are minimized.

Although specific embodiments of the invention have been shown and described, it will be understood that they are but illustrative and that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. Electron discharge apparatus comprising a source of electrons, an electron receiving electrode, and a pair of concentric spherical electrodes, said source and said electron receiving electrode being mounted at substantially diametrically opposite regions between said spherical electrodes.

2. Electron discharge apparatus comprising a cathode, means including an electrode adjacent said cathode for accelerating electrons emanating from said cathode in all directions normal to an axis of said cathode, means for directing the accelerated electrons along similar curved paths lying in a spherical boundary, said means includ-

ing a pair of concentric spherical electrodes and said cathode being mounted between said spherical electrodes, and target electrode means positioned to receive the electrons directed along said paths.

3. Electron discharge apparatus comprising a cathode, a target electrode, means for concentrating electrons emanating from said cathode into a hollow substantially spherical beam focussed upon said target electrode, said means including a pair of concentric spherical electrodes and said cathode and target electrode being mounted at diametrically opposite regions between said spherical electrodes, and means including an electrode adjacent said cathode for varying the trajectory of electrons in said beam to vary the beam current to said target electrode.

4. Electron discharge apparatus in accordance with claim 3 comprising an accelerating electrode encompassing said cathode and having an annular window therein coaxial with the diameter of alignment of said cathode and said target electrode.

5. Electron discharge apparatus comprising a pair of concentric spherical electrodes, a cathode between said electrodes and extending along a radius thereof, a pair of annular deflector electrodes encompassing and coaxial with said cathode and extending normal to said radius, and a target electrode between said spherical electrodes and diametrically opposite said cathode.

6. Electron discharge apparatus comprising an electrode system including a pair of concentric spherical electrodes, a cathode mounted between said electrodes, a target electrode mounted between said spherical electrodes at a region angularly displaced from said cathode, means including a source of potential connected to said spherical electrodes and said cathode for biasing the electrodes of said system to concentrate electrons emanating from said cathode into a hollow substantially spherical beam concentric with said spherical electrodes and focussed upon said target electrode, and means connected between said cathode and one of the electrodes of said system for varying the potential of said one electrode to vary the beam current to said target electrode.

7. Electron discharge apparatus comprising a substantially spherical cavity resonator having a pair of apertures at spaced portions thereof, a cathode outside of said resonator and adjacent one of said apertures, a target electrode adjacent the other of said apertures and outside of said resonator, and means including an electrode in juxtaposition to the outer surface of said resonator for directing electrons emanating from said cathode to said target electrode along curved paths outside of and substantially concentric with said resonator.

8. Electron discharge apparatus comprising a substantially spherical cavity resonator having a pair of apertures at diametrically opposite portions thereof, a cathode outside of said resonator and adjacent one of said apertures, a target electrode adjacent the other of said apertures and outside of said resonator, and means for concentrating electrons emanating from said cathode into a hollow substantially spherical beam substantially concentric with said resonator, said means including a spherical electrode outside of and concentric with said cavity resonator.

9. Electron discharge apparatus comprising a

spherical cavity resonator having a pair of apertures at diametrically opposite portions thereof, a cathode and a target electrode outside of said resonator, extending radially with respect hereto and each opposite a respective one of said apertures, a cylindrical grid encompassing said cathode and coaxial therewith, and a spherical electrode outside of and concentric with said resonator, said cathode, target electrode and grid being inside of said spherical electrode.

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