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ELECTRON DISCHARGE APPARATUS

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FIG. 1

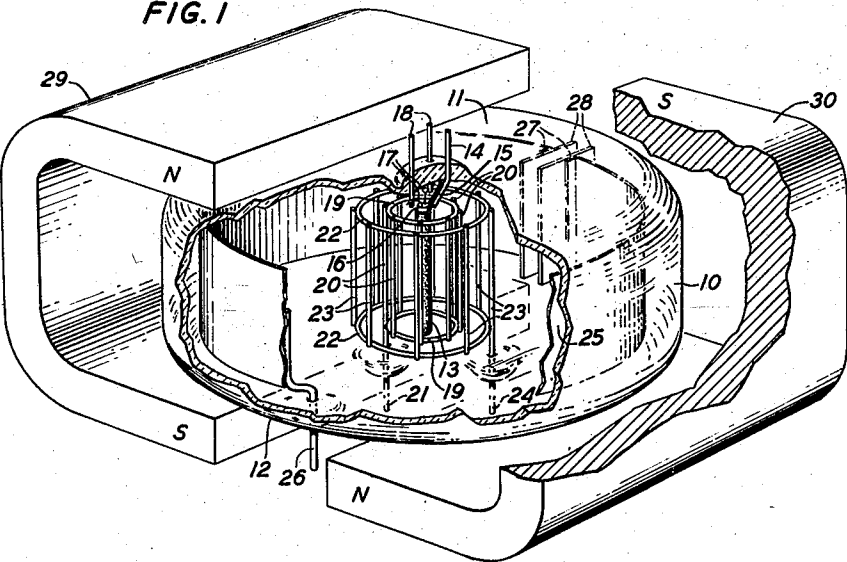


FIG. 2

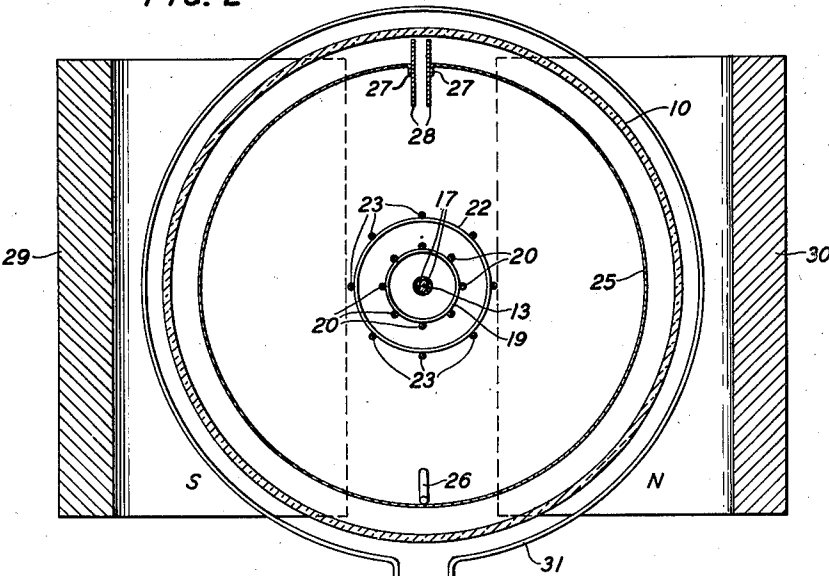
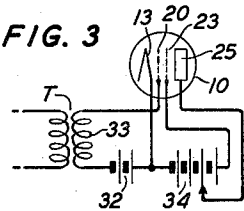


FIG. 3



TO UTILIZATION
CIRCUIT

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ELECTRON DISCHARGE APPARATUS

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12 Claims. (Cl. 250—36)

This invention relates to electron discharge apparatus and more particularly to such apparatus especially suitable for the generation of ultra-high frequency oscillations.

One object of this invention is to enable the generation of oscillations of extremely short wave-lengths.

Another object of this invention is to simplify ultra-high frequency electron discharge apparatus.

A further object of this invention is to facilitate the production of a negative resistance in the plate circuit of an electron discharge device, enabling the device to oscillate.

In one illustrative embodiment of this invention, an electron discharge device comprises a cathode, a plate electrode surrounding the cathode and a plurality of successively arranged grid electrodes between the cathode and the plate electrode. The inner surface of the latter may be treated or coated to facilitate copious emission of secondary electrons therefrom. The plate electrode is operated at a positive potential with respect to the cathode and the outer grid electrode is operated at a positive potential higher than that upon the plate electrode. The potentials on the various electrodes preferably are so related that the device operates upon the negative slope portion of the plate voltage-plate current characteristic and, more particularly, about a point in this characteristic corresponding to such conditions that the secondary electron current from the plate electrode to the outer grid is equal to the primary electron current to the plate electrode and the plate electrode current decreases as the potential of this electrode is increased.

In accordance with one feature of this invention, the plate electrode is provided with a substantially cylindrical portion forming an inductance, and with other portions forming a capacitance whereby a tuned circuit is completed within the enclosing vessel of the electron discharge device.

In accordance with another feature of this invention, means are provided for producing magnetic fields of opposite polarity or direction adjacent spaced portions of the plate electrode. The current circulating in the plate electrode produces magnetic fields which augment the field adjacent one portion of the plate electrode and oppose the field adjacent another portion of the plate electrode. Consequently, the secondary electron current from one portion of the plate electrode is decreased and the secondary electron current from another portion of this electrode is

increased thereby supplying a negative resistance to the tuned circuit so that oscillations will be produced therein.

The invention and the foregoing 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 a view in perspective of electron discharge apparatus illustrative of one embodiment of this invention, a portion of one of the magnets and of the enclosing vessel and plate electrode being broken away to show the electrodes more clearly;

Fig. 2 is a top view in cross-section of the apparatus illustrated in Fig. 1 and showing an external conductor for coupling a utilization circuit to the oscillating circuit; and

Fig. 3 is a circuit diagram showing the external connections between the electrodes of the electron discharge device illustrated in Figs. 1 and 2.

Referring now to the drawing, the electron discharge device there shown comprises an evacuated enclosing vessel 10, which preferably is of relatively small height, having opposite substantially plane end walls 11 and 12. Mounted within the vessel 10 is a cathode, which preferably is linear and disposed in the axis of the vessel. The cathode may be of the equipotential or heater type and comprise a cylindrical metallic sleeve 13, having a coating of thermionic material upon its outer surface, supported by a rigid conductor 14 sealed in the end wall 11 and affixed to an integral extension 15 on the sleeve 13. A heater element 16 including, for example, a filament 17 is enclosed by the cathode sleeve 13, the ends of the filament being connected to suitable leading-in conductors 18 sealed in the end wall 11 of the enclosing vessel.

The cathode is encircled by a cylindrical inner grid coaxial therewith which may comprise a pair of annular conductive end members 19 and a plurality of equally spaced metallic rods or wires 20 disposed parallel to one another and to the cathode and affixed to the annuli 19. One of the rods or wires 20 may have an integral extension 21 sealed in the base or end wall 12 of the enclosing vessel.

Disposed about the grid above described and coaxial therewith is a second grid which may comprise annular conductive end members 22 and a plurality of equally spaced metallic rods or wires 23 affixed to the end members 22 and arranged parallel to one another and to the cathode. Preferably the wires or rods 23 are mounted

in radial alignment with the corresponding wires or rods 20 of the inner grid, as shown clearly in Fig. 2. The outer grid may be supported by an integral extension 24 of one of the rods or wires 23, sealed in the end wall or base 12 of the enclosing vessel.

The outer grid 23 is encompassed in turn by a plate electrode including a split substantially cylindrical portion 25 coaxial with the cathode 13 and supported by a metallic rod or wire 26 sealed in the base or end wall 12 of the enclosing vessel and connected to the plate electrode at the midpoint thereof. The inner surface of the cylindrical portion 25 preferably is coated with a material having good secondary electron emitting properties. The plate electrode is provided also with a pair of parallel conductive plates 27 affixed, for example, to flanges 28 on the cylindrical portion 25. The plates 27 form a condenser and the cylindrical portion 25 forms an inductance in series with the condenser and constitutes therewith the oscillating circuit of the device. An external utilization circuit may be coupled to the oscillating circuit as by a looped conductor 31 encircling the vessel 10.

Mounted about the enclosing vessel are two horseshoe magnets 29 and 30 the poles of which preferably are located in proximity to the cylindrical portion 25 of the plate electrode so that concentrated fields obtain in the region between the inner surface of the plate electrode and the outer grid. The two magnets are so constructed that the fields thereof are of substantially equal intensity and have their poles arranged oppositely so that the fields are opposite in direction. That is to say, the north pole of each magnet is opposite the south pole of the other magnet so that, as indicated, for example, in Fig. 1, the field of the magnet 29 is immediately adjacent the left-hand portion or half of the plate electrode and downward in direction whereas the field of the magnet 30 is immediately adjacent the right-hand portion or half of the plate electrode and upward in direction.

As shown in Fig. 3, the inner grid may be biased negatively with respect to the cathode, as by a battery 32, through a coil 33, which may be the secondary winding of an input transformer T. The outer grid and the plate electrode may be maintained at positive potentials with respect to the cathode, as by a battery 34, the potential applied to the outer grid being greater than that applied to the plate electrode and preferably of the order of several hundred volts.

During operation of the device, primary electrons emanating from the cathode 13 are attracted toward the outer grid 23 and the plate electrode 25. Some of these electrons, because of their high velocities, will pass between the wires or rods 23 of the outer grid and impinge upon the plate electrode, as a result of which secondary electrons will be released from the plate electrode. Some of these electrons thus produced will flow to the outer grid because of its higher potential while others will return to the plate electrode. Preferably the fields produced by the magnets 29 and 30 and the potentials applied to the outer grid and the plate electrode are such that for steady state conditions the primary electron current to the plate electrode and the secondary electron current from the plate electrode to the outer grid are substantially equal and the resultant plate electrode current when varied decreases as the potential of this electrode is increased. Inasmuch as the fields of the magnets

29 and 30 are of equal intensity, as described heretofore, the secondary current to the outer grid from the left-hand half and the right-hand half (in Figs. 1 and 2) of the plate electrode will be of substantially equal magnitude.

When the steady state condition is disturbed, as occurs actually when the potentials are applied to the electrodes of the device, a current circulates in the circuit composed of the cylindrical portion 25 of the plate electrode and the condenser plates 27. This current produces magnetic fields which oppose the field of one of the magnets 29 and 30 and aid the field of the other of the magnets. At that portion or half of the plate electrode wherein the circulating current produces a field aiding the field of the associated magnet, fewer secondary electrons flow to the outer grid so that in effect the resultant current in this portion is increased. Conversely, at that portion of the plate electrode wherein the circulating current opposes the field of the associated magnet, more secondary electrons leave this portion and flow to the outer grid so that in effect the resultant current in this portion is decreased. Consequently, a negative resistance is supplied to the circuit composed of the cylindrical portion 25 of the plate electrode and the condenser plates 27 as a result of which an oscillating current is produced in this circuit. A similar oscillating current will obtain in a utilization circuit coupled to the internal circuit by the conductor 31. The oscillating current may be modulated through the agency of the inner grid 20.

Inasmuch as the cylindrical portion 25 and condenser plates 27 constituting the oscillating circuit may be made of small dimensions, the impedances of this circuit may be correspondingly small so that the internal circuit may be resonant and oscillable at extremely high frequencies.

Although a specific embodiment of the invention has been shown and described, it will be understood, of course, that various modifications may be made therein without departing from the scope and spirit of this invention as defined in the appended claims. For example, although a coil has been shown for inductively coupling a utilization circuit to the oscillating circuit, capacitive coupling means may be employed. Also, a dielectric medium, such as mica, may be interposed between the condenser plates 27.

What is claimed is:

1. Electron discharge apparatus comprising a cathode and an output electrode, said output electrode having a cylindrical electron receiving portion encompassing said cathode and defining an inductance, and having also spaced portions forming a capacitance in circuit with said inductance.

2. Electron discharge apparatus comprising a cathode, a grid, a plate electrode encompassing said cathode and grid and having a cylindrical portion coaxial with said cathode, said cylindrical portion having a slot therein, and a pair of plate members mounted on said portion adjacent said slot and spaced to form a condenser.

3. Electron discharge apparatus comprising a cathode, a grid encompassing said cathode and coaxial therewith, a plate electrode encompassing said cathode and grid, said plate electrode having a split cylindrical portion coaxial with said cathode and defining an inductance, the inner surface of said portion being adapted to emit secondary electrons, and a pair of spaced plate members mounted on said cylindrical portion and

forming a condenser in series with said inductance.

4. Electron discharge apparatus comprising a cathode, a grid, a plate electrode having a portion defining an inductance and having the surface thereof toward said cathode adapted to emit secondary electrons, means forming a condenser in circuit with said inductance, means applying positive potentials to said grid and plate electrode, the potential on said grid being greater than that upon said plate electrode, and means for producing spaced magnetic fields adjacent said surface, the field adjacent one portion of said surface being opposite in direction to the field adjacent another portion of said surface.

5. Electron discharge apparatus in accordance with the next preceding claim wherein said potentials and said fields are of such magnitudes that for steady state conditions the primary electron current to said plate electrode from said cathode and the secondary electron current to said grid from said plate electrode are substantially equal.

6. Electron discharge apparatus in accordance with the second preceding claim wherein said field producing means comprises two magnets having their poles adjacent opposite edges of said plate electrode, the north pole of each magnet being in juxtaposition to the south pole of the other magnet.

7. Electron discharge apparatus comprising a cathode, a grid encompassing said cathode, a plate electrode including a cylindrical portion encompassing said grid and having its inner surface adapted to emit secondary electrons, said cylindrical portion having a dividing slot therein, plate members mounted on said portion adjacent said slot and forming a condenser, means for maintaining said grid and plate electrode positive with respect to said cathode, means for producing a magnetic field in one direction adjacent said cylindrical portion and to one side of said slot, and means for producing a magnetic field in the opposite direction adjacent said cylindrical portion and to the other side of said slot.

8. Electron discharge apparatus in accordance with the next preceding claim in which said field producing means comprises a pair of magnets having their poles adjacent opposite edges of said plate electrode.

9. Electron discharge apparatus comprising a

cathode, a grid encompassing said cathode, a plate electrode having a cylindrical portion coaxial with said cathode and defining an inductance, the inner surface of said portion being adapted to emit secondary electrons, means defining a capacitance in series with said inductance, means maintaining said grid and said plate electrode at positive potentials with respect to said cathode, and means for producing substantially equal magnetic fields adjacent and parallel to opposite halves of said portion, the fields adjacent said halves being opposite in direction.

10. Electron discharge apparatus comprising a cathode, a grid, a tuned circuit consisting of an electrode in cooperative relation to said cathode and said grid, said electrode being adapted to emit secondary electrons when primary electrons from said cathode impinge thereon, and means for differentially controlling the secondary electrons emitted from spaced portions of said electrode.

11. Electron discharge apparatus comprising a cathode, a grid, a plate electrode having a cylindrical portion encompassing said cathode and said grid and defining an inductance, means defining a capacitance in circuit with said inductance and forming a tuned circuit therewith, the inner surface of said cylindrical portion being adapted to emit secondary electrons, and means for differentially controlling the secondary electrons emanating from opposite halves of said cylindrical portion.

12. Electron discharge apparatus comprising an enclosing vessel housing a cathode, a grid encompassing said cathode, a plate electrode having a cylindrical portion coaxial with said cathode adapted to emit secondary electrons, and means defining a condenser in circuit with said cylindrical portion and defining an oscillable circuit therewith, means for applying a positive potential to said plate electrode and a higher positive potential to said grid, a permanent magnet having its poles adjacent opposite edges of substantially one half of said cylindrical portion, and a second permanent magnet having its poles adjacent opposite edges of the other half of said cylindrical portion, said magnets being of substantially the same strength and the field of one being opposite in direction to that of the other.

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