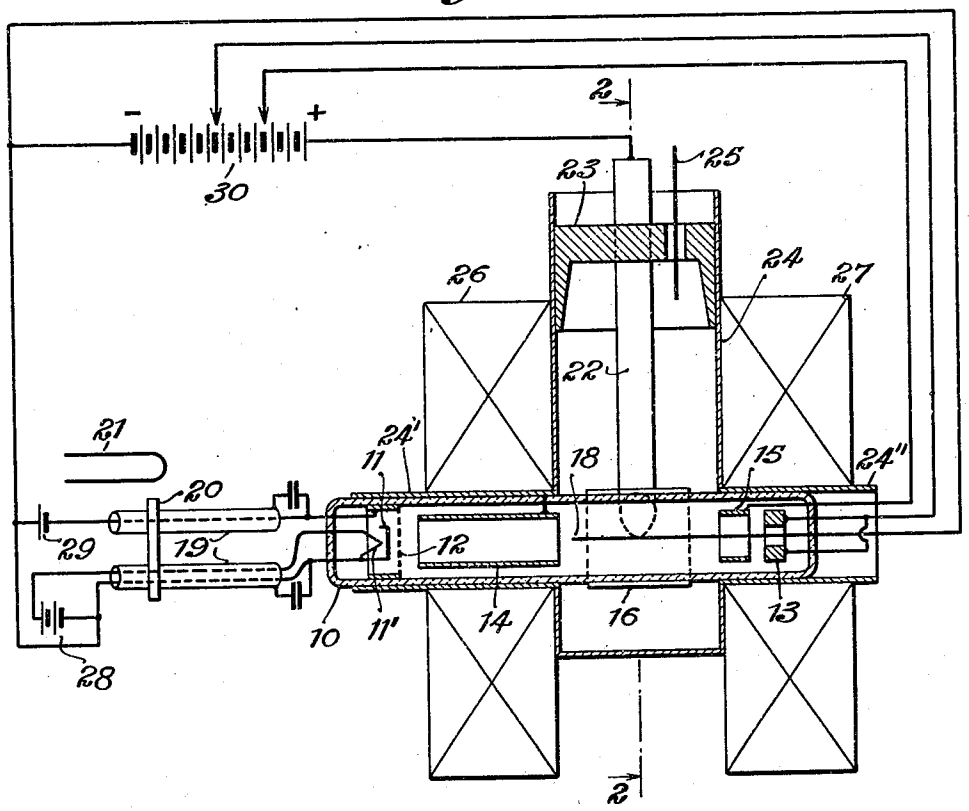
Sept. 21, 1943. L. S. NERGAARD 2,329,777

ELECTRON DISCHARGE DEVICE

Filed Oct. 30, 1941

Fig. 1.



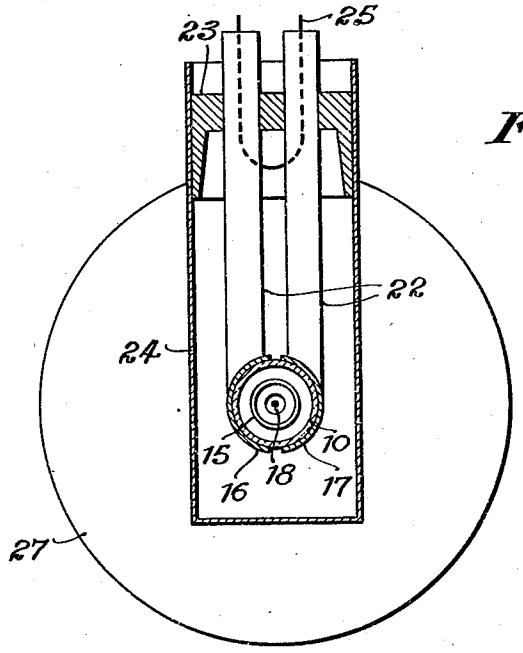


Fig. 2.

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ELECTRON DISCHARGE DEVICE

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12 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices, more particularly to such devices useful at ultra high frequencies.

It is desirable to have an output system having low impedance suitable for operation with broad band circuits in the ultra high frequency field and to have an electron discharge device which may be incorporated in such a system. It is further desirable to eliminate high frequency losses normally encountered in bringing high frequency leads through the envelope of the electron discharge device. Another desirable feature is to be able to electrically and physically separate the output electrodes from the current collector so that the power dissipating ability of the output electrodes imposes no limitation on the power output.

It is, therefore, an object of my invention to provide an improved electron discharge device suitable for use at high frequencies and capable of use with output systems having a low output impedance and suitable for operation with broad band circuits.

It is another object of my invention to provide an electron discharge device suitable for use at high frequencies and which avoids the use of high frequency leads extending through the tube envelope, thus reducing high frequency losses.

Another object of my invention is to separate the current collector and output electrodes so that the power dissipating ability of the electrodes imposes no limitation on the power output. These and other objects will appear hereinafter.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a schematic longitudinal section of an electron discharge device and associated circuit made according to my invention and Figure 2 is a section taken along the line 2—2 of Figure 1.

Briefly in an electron discharge device made according to my invention, an elongated envelope contains at one end a cathode and modulating electrode for projecting a beam of electrons axially of the envelope and a collector electrode is mounted in the other end of the envelope. Adjacent the modulating grid is a screen and accelerating electrode and adjacent the collector is a further screen and accelerating electrode. Positioned between the collector and modulating electrode and outside of the envelope are anode segments having gaps lying parallel to the longitudinal axis of the envelope and the electron stream. The anode segments are connected to a parallel transmission line, the anode segments and line being shielded within a shielding compartment, the line being tuned by proper tuning means and energy being extracted by means of a loop coupled to the transmission line. Magnetic means are provided which cooperate with the other electrodes to determine the path of the electrons in the tube. Positioned centrally of the anode segments is an electrode for causing electrons passing through the envelope adjacent the anode segments to describe paths close to the envelope wall and the gaps between the anode segments.

Referring to the drawing, the elongated envelope 10 has positioned at one end, the indirectly heated cathode 11 provided with heater 11', and grid 12 for modulating the electron stream when an R. F. potential is applied between the cathode and grid. Mounted at the other end of the envelope is a collector 13. The output electrodes comprise the anode segments 16—17 positioned on opposite sides of the electron stream between the cathode and collector and on the outside of the envelope. Adjacent the grid is a cylindrical electrode 14 operated at a sufficiently high voltage to prevent formation of a virtual cathode and consequent reflection of electrons within the cylinder. The cylinder is long enough to prevent coupling between the grid 12 and the output electrodes 16 and 17. Adjacent the collector is an electrode 15 which serves as a screen and suppressor for the electrode 13 which collects the electrons. The collector is operated at a voltage just sufficient to collect all the electrons, hence the collector can be operated at a lower potential than the output electrodes.

A rod eletetrode 18 extends through the collector 13 and suppressor 15, axially of the anode segments 16 and 17. This electrode is operated at approximately cathode potential and during operation of the tube reduces the axial or longitudinal velocity of the electrons and provides a radial electric field so that the electrons perform a large number of spiral orbits in the electric field of the output electrodes.

The magnetic field is provided by means of the electromagnets 26 and 27 and the field is adjusted to such a value that the time for each orbit of the electrons in passing through the output electrodes is equal to a period of the R. F. grid voltage. The potential of the output electrodes is so adjusted that the orbits bring the electrons almost out to the wall of the envelope

of the tube. The electromagnets also serve to keep the beam focused in passing through the shield 14.

The input circuit may be provided by transmission line 19 shorted by the tuning bar 20, the input voltage being coupled into the transmission line by means of the coupling loop 21. The anode segments 16—17 are connected to the output transmission line comprising a pair of conductors 22 extending in a plane normal to the longitudinal axis of the tube envelope and shorted by means of the tuning member or disk 23, slidable on the conductors 22. The output circuit and output electrodes are enclosed within the shielding member 24 which shields the output from the input circuit and prevents undesired radiation. The shorting disc 23 serves to close the shielding compartment. The shielding compartment is provided with extensions 24' and 24'', which enclose the cathode, grid and accelerator and the suppressor and collector positioned in opposite ends of the tube envelope. The output transmission line circuit may be coupled to output coupling loop 25 extending through the shorting member or disc into the shielded space.

Suitable sources of voltage 28 provided for the cathode heater, 29 for providing a proper bias on the grid, and 30 for supplying various voltages on the other electrodes are also provided. Suitable connections are made for applying a higher voltage to the output electrode segments 16 and 17 and the shielding casing 24, and lower voltages to the suppressor 15 and collector 13. The rod 18 is connected to the cathode so as to have cathode potential applied thereto during operation of the device.

Briefly the operation of the device is as follows: an R. F. signal is applied to the transmission line 19, which causes an R. F. voltage to appear on the grid 12, which modulates the electron stream from the cathode 11. This modulated stream traverses the shielding electrode 14 and enters the space of the output electrode segments 16—17. In this space the electrons are slowed down by rod 18 and directed outwardly by the radial electrostatic field between rod 18 and the segments. The axial magnetic field causes the electrons to perform spiral orbits, as in a magnetron, and give up energy to the output electrodes each time they cross the gaps or the gap field between the output electrode segments. The effective current from which the output electrodes obtain power is thus the product of the beam current and the number of spirals. Since this effective current is large the tube is capable of driving a low impedance load such as encountered in wide band transmission. After giving up their energy, electrons are collected by the collector 13.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact form illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device having means for generating a modulated stream of electrons and an electrode for receiving the electrons in said stream, output electrode means comprising a plurality of segments surrounding the path of the stream and separated by gaps extending along the longitudinal axis of said stream, means for causing electrons of said stream to follow spiral orbital paths within the output electrode means a plurality of times past the gaps between said plurality of segments and then toward said collector, said last means comprising electromagnetic means for producing a magnetic field parallel to the longitudinal axis of said device and a rod positioned within and coaxial of said electrode segments and adapted to be maintained at substantially cathode potential during operation of said electron discharge device, and an output means comprising a conductor connected to one of said segments and another conductor connected to another of said segments, and means electrically joining the conductors remote from said segments.

2. An electron discharge device having means for generating a modulated beam of electrons and a collector for receiving the electrons in said beam, output electrode means comprising a plurality of electrode segments surrounding the path of the beam and separated by gaps extending along the longitudinal axis of said beam, means for causing electrons of said beam to follow spiral orbital paths within the output electrode means past the gaps between said plurality of segments and then toward said collector, and an output means comprising a conductor connected to one of said segments and another conductor connected to another of said segments, and a shielding system surrounding said plurality of segments and said output means and means electrically joining the conductors remote from said segments and positioned within said shield.

3. An electron discharge device having means for generating a modulated beam of electrons and a collector for receiving the electrons in said beam, output electrode means comprising a plurality of electrode segments surrounding the path of the beam and separated by gaps extending along the longitudinal axis of said beam, means for causing electrons of said beam to follow spiral orbital paths within the output electrode means a plurality of times past the gaps between said plurality of segments and then toward said collector, and an output means comprising a conductor connected to one of said segments and another conductor connected to another of said segments, and a shielding system surrounding said plurality of segments and said output means, and conducting means slidable within said shielding system and electrically shorting said conductors and closing the shielding system around said output means.

4. An electron discharge device having an elongated envelope and containing means for directing a modulated beam of electrons longitudinally of said envelope, and a collector for collecting said electrons, output electrode means comprising a plurality of electrode segments surrounding and closely adjacent the outside of said envelope, said segments being separated by gaps extending along the longitudinal axis of said beam and means for causing electrons from the cathode to follow orbital paths within the space surrounded by said electrode segments.

5. An electron discharge device having an elongated envelope and containing means for directing a modulated beam of electrons longitudinally of said envelope, and a collector for collecting

said electrons, output electrode means comprising a plurality of electrode segments surrounding and closely adjacent the outside of said envelope, said segments being separated by gaps and means for causing electrons from the cathode to follow orbital paths within the space surrounded by said electrode segments, said last means comprising electromagnetic means for producing a magnetic field parallel to the longitudinal axis of said envelope, and a rod positioned axially of said electrode segments and adapted to be maintained at substantially cathode potential during operation of said electron discharge device.

6. An electron discharge device having an elongated envelope and containing means for directing a modulated beam of electrons longitudinally of said envelope, and a collector for collecting said electrons, output electrode means comprising a plurality of electrode segments surrounding and closely adjacent the outside of said envelope, said segments being separated by gaps and means for causing electrons from the cathode to follow orbital paths within the space surrounded by said electrode segments, said last means comprising electromagnetic means for producing a magnetic field parallel to the longitudinal axis of said envelope, and a rod positioned axially of said electrode segments and adapted to be maintained at substantially cathode potential during operation of said electron discharge device, and conducting members connected to different ones of said electrode segments, and means electrically connecting said conducting members remote from said electrode segments to provide an output transmission line.

7. An electron discharge device having an elongated envelope and containing means for directing a modulated beam of electrons longitudinally of said envelope, and a collector for collecting said electrons, output electrode means comprising a plurality of electrode segments surrounding and closely adjacent the outside of said envelope, said segments being separated by gaps and means for causing electrons from the cathode to follow orbital paths within the space surrounded by said electrode segments, said last means comprising electromagnetic means for producing a magnetic field parallel to the longitudinal axis of said envelope, and a rod positioned axially of said electrode segments and adapted to be maintained at substantially cathode potential during operation of said electron discharge device, and conducting members connected to different ones of said electrode segments, and means electrically connecting said conducting members remote from said electrode segments to provide an output transmission line, and shielding means surrounding said electrode segments and said conducting members connected thereto for preventing radiation from said transmission line and coupling means associated with said transmission line.

8. An electron discharge device having an elongated envelope and having at one end a cathode and a grid for supplying a modulated beam of electrons longitudinally of said envelope, and a collector at the other end of said envelope for collecting said electrons, output electrode means comprising a plurality of electrode segments surrounding and closely adjacent the outside of said envelope, said segments being separated by gaps, and a shielding electrode positioned adjacent the grid for shielding said cathode and grid from said electrode segments, and a second shielding electrode positioned between the collector and said electrode segments, and means for causing electrons from the cathode to follow orbital paths within the space surrounded by said electrode segments, said last means comprising electromagnetic means for producing a magnetic field parallel to the longitudinal axis of said envelope, and a rod positioned axially of said electrode segments and adapted to be maintained at substantially cathode potential during operation of said electron discharge device, and an output means connected to said electrode segments, and shielding means surrounding said electrode segments and output means for preventing undesired radiation from said output means.

9. An electron discharge device having an elongated envelope containing a cathode and control grid at one end of said envelope for providing a stream of electrons longitudinally of said envelope, and a collector at the other end of said envelope, a tubular electrode positioned adjacent the control grid, and a second tubular electrode positioned adjacent the collector, an output electrode system surrounding said envelope between said tubular electrodes and including a plurality of anode segments separated by gaps extending along the longitudinal axis of said envelope, and a rod-like electrode extending axially of the envelope within the space surrounded by said anode segments and adapted to be maintained at cathode potential during operation of said electron discharge device, and means for providing a magnetic field parallel to and surrounding the rod-like electrode and an output means connected to said electrode segments.

10. An electron discharge device having an elongated envelope containing means at one end of said envelope for providing a stream of electrons longitudinally of said envelope, a control grid adjacent said means and a collector at the other end of said envelope, a tubular electrode positioned adjacent the control grid, and a second tubular electrode positioned adjacent the collector, an output electrode system surrounding said envelope between said tubular electrodes and including a plurality of anode segments separated by gaps extending along the longitudinal axis of said envelope, and a rod-like electrode extending axially of the envelope within the space surrounded by said anode segments and adapted to be maintained at cathode potential during operation of said electron discharge device, and electromagnetic means surrounding said envelope for producing a magnetic field longitudinally of said envelope.

11. An electron discharge device having an elongated envelope containing means at one end of said envelope for supplying a stream of electrons longitudinally of said envelope, a control grid adjacent said means and a collector at the other end of said envelope, a first tubular electrode positioned adjacent the control grid, and a second tubular electrode positioned adjacent the collector, an output electrode system surrounding said envelope between said tubular electrodes and including a plurality of anode segments separated by gaps extending along the longitudinal axis of said envelope, and a rod-like electrode extending axially of the envelope within the space surrounded by said anode segments and adapted to be maintained at cathode potential during operation of said electron discharge device, and an output means connected to said electrode segments, and electromagnetic means for producing a magnetic field longitu-

dinally of said envelope, and a shielding structure surrounding said anode segments and said output means for preventing undesired radiation therefrom, and having extensions surrounding the envelope around the electron supplying means and first tubular electrode and around said collector and second tubular electrode.

12. An electron discharge device having an elongated envelope containing at one end a cathode and grid for supplying a modulated beam of electrons longitudinally of said envelope, and a collector at the other end of the envelope for collecting the electrons, output electrode means comprising a plurality of electrode segments surrounding the path of the electron stream between said grid and collector, and a shielding electrode positioned adjacent the grid for shielding said cathode and grid from said electrode segments, and a second shielding electrode positioned between the collector and said electrode segments, and means for causing electrons from the cathode to follow orbital paths within the space surrounded by said electrode segments, said last means comprising electromagnetic means for producing a magnetic field parallel to the longitudinal axis of the envelope and a rod positioned axially of the longitudinal axis and adapted to be maintained at substantially cathode potential during operation of said electron discharge device, and an output means connected to said electrode segments and shielding means surrounding said electrode segments and output means for preventing undesired radiation from said output circuit and extensions on said shielding means surrounding said cathode and grid and first shielding electrode and surrounding said second shielding electrode and said collector.

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