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ELECTRON DISCHARGE TUBE

Original Filed June 1, 1931

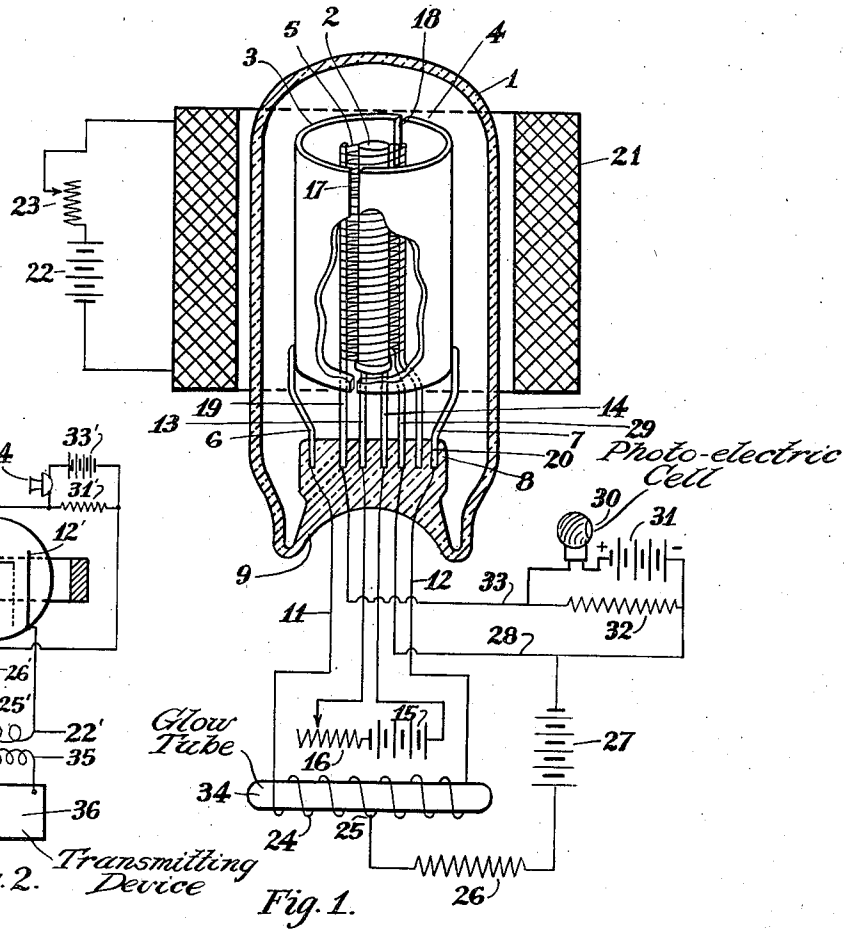


Fig. 1.

Fig. 2.

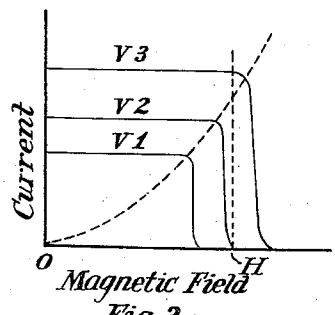


Fig. 3.

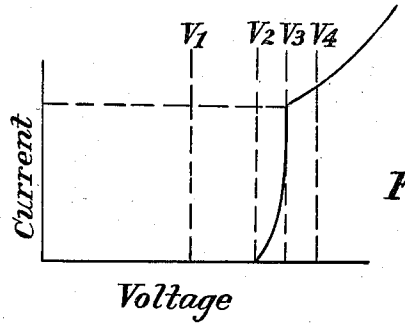


Fig. 4.

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ELECTRON DISCHARGE TUBE

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9 Claims. (Cl. 179—171.5)

This invention relates to an electron discharge device.

Among the objects of the invention is the production of a device that is capable of producing electrical oscillations and to provide means whereby the output of said device may be modulated in a simple manner.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawing wherein—

Fig. 1 is a view of my tube partly in section with one circuit with which it may be used shown in diagrammatic form;

Fig. 2 is a diagrammatic showing of another circuit with which my new tube may be used; and

Figs. 3 and 4 are diagrams showing the electrical characteristics of my tube.

Fig. 1 illustrates one form of device embodying my invention comprising an evacuated tube 1 containing an indirectly heated cathode 2, two semi-cylindrical anodes 3 and 4 and a control grid 5. The cathode, control grid and the two anodes are arranged in concentric relation, the cathode and grid being substantially equidistant from each anode at all points along its length. This arrangement is the preferred one.

The tube 1 is evacuated and the parts therein are deprived of occluded gases to such an extent that an electron discharge independent of gas ionization occurs therein. However, a slight amount of gas will improve the operation by reducing the space charge due to a slight amount of ionization. The total amount of gas must not be great enough to cause any considerable conduction due to ionization.

The anodes 3 and 4 are formed of semi-cylindrical plates, and are carried by the anode supporting wires 6 and 7 sealed in a press 8 formed on the outer end of the re-entrant stem 9 of the tube 1. These semi-cylindrical plates are maintained a slight distance apart so that small spaces 17 and 18 exist between the adjacent longitudinal edges of said plates.

The cathode 2 is of the indirectly heated type, and comprises an outer metal cylinder coated with some material, such as, for example, barium or strontium oxide in order to increase the electron emissivity of the outer surface thereof. The interior of the cathode is provided with a heating filament fed from two heater leads 13 and 14 sealed in the press 8. The filament is supplied with heating current from a source of current, such as, for example, a battery 15. The amount of heating current is regulated by an adjustable resistance 16.

The control grid is formed by a continuous helix of fine wire wound on the two grid standards 19 and 20 which are also sealed in the press 8. A coil 21 surrounds the tube and produces a magnetic field within the tube when energized by the battery 22 through the adjustable resistance 23.

The anode 3 is connected through lead 11 to one end of a coil 24, the anode 4 being connected to the other end of said coil through lead 12. An intermediate point on the coil 22, such as the mid-point 25 is connected through the resistance 26, battery 27, and lead 28 to the cathode lead 29, which is welded to the cathode 2.

A varying or modulating potential is connected between the grid and the cathode 2. This modulating potential may be generated, for example, by a photo-cell 30 connected in series with a battery 31 across a resistance 32. One end of this resistance 32 is connected to a conductor 33 which leads to the grid standard 19. The other end of the resistance 32 is connected to the cathode through the lead 28. A varying amount of light falling on the photo-cell 30 will cause a varying potential to be impressed on the grid.

When a field of the requisite value is set up by the coil 21, the tube will oscillate and the oscillations produced will be modulated in accordance with the varying potential which may be impressed on the grid. These oscillations may be used to produce an electrodeless discharge in a gas or vapor-filled tube 34 by surrounding said tube by the coil 24.

According to my present understanding of the operation of the tube, the following phenomena occur in said tube. When the cathode 2 is raised to a sufficiently high temperature, a large number of electrons will be emitted from its surface. When a potential such as that of the battery 27 is impressed between an anode and the cathode and the coil 21 is deenergized, the electrons will travel in substantially radial lines from the cathode to the anode. When a magnetic field is created in the tube at right angles to the electrostatic field created by the potential between the cathode and anode, the electrons will be deviated from a straight radial path and will travel in curved paths which decrease in radius with increased magnetic fields. Thus at a certain value of magnetic field, all of the electrons will miss the anode entirely

and will fall back onto the cathode. Fig. 3 represents by three curves the relation between anode current and magnetic field at three different constant anode voltages designated by V_1, V_2, and V_3. The dotted line drawn from zero through the knees of the curves V_1, V_2, and V_3 is substantially the form of a parabola.

Fig. 4 represents the relation between the anode current and the anode voltage at a constant value of field. This value in Fig. 4 is taken as the value H of Fig. 3.

The voltage impressed between the cathode and each of the anodes 3 and 4 by the battery 27 may be represented by V_1. When the magnetic field is adjusted to the point indicated by H, the tube will start to oscillate. It will be noted that the value of field is such as to substantially cut off the flow of the electrons to both anodes. However, even under these conditions at each anode there will be a tendency for a small number of electrons to flow intermittently to the anode. When a slight discharge of this type takes place at one of the anodes, for example anode 3, a small current will flow in that anode circuit. This increase in current flow will produce a back electromotive force in the half of the coil 24 between 25 and 11, which will oppose the flow of current in that anode circuit. A similar electromotive force will be generated in the other half of coil 24 due to the inductive relationship between both halves of the coil. This latter electromotive force will be sufficient to raise the effective voltage as applied to the anode 4 from V_2 to a value which may be represented by V_4 on the curves shown in Figs. 3 and 4, and will cause a corresponding increase in current to anode 4. This current increase will produce a comparatively large back electromotive force in its half of the coil 24 which will lower the voltage as applied to anode 4 to a point which may be represented by V_1 on the curves on Figs. 3 and 4. An electromotive force will also be induced in the other half of the coil 24, and will raise the voltage as applied to the anode 3 to a point which may be represented by V_3 on each of said curves. A corresponding decrease in current to anode 4 and an increase in current to anode 3 will result. This will be repeated and oscillations will be set up in the tube. The frequency of these oscillations is determined by the inductance of the coil 24 and the capacity between the anodes 3 and 4.

I have found that the oscillations so produced may be modulated by varying the space charge between the cathode 2 and the anodes 3 and 4, which may be accomplished, for example, by means of the grid 5. The effect of a potential impressed on the grid, acting in the same direction as the potential between the cathode and an anode, is to raise the height of the curves shown in Fig. 3. However, the value of the field at which the current is cut off in each case is increased only very slightly. The potential on the grid neutralizes part of the space charge whereby fewer electrons are repelled back to the cathode, causing a larger number to reach the anode. This manifests itself as an increased current to the anode. The action of the potential on the grid in opposition to the potential on the anode produces an increase in the space charge which results in a decrease in the current to the anode. On applying a varying potential to the grid 5, the current impulses in each anode rise to either higher or lower maximums during each oscillatory cycle, in accordance with the variation in potential on the grid. The minimum value to which the current to each anode drops during each impulse is not affected by variation in space charge to an appreciable amount. Thus the amplitude of the oscillations produced by such a tube will vary in accordance with the variations in potential on the grid. By varying the potential on the grid or the space charge in accordance with some desired modulation, the oscillations produced by the tube will be correspondingly modulated. By applying a sufficiently large potential to the grid 5, it would be possible to stop the tube from oscillating. However, in the example which I have shown, the potentials applied to the grid are not large enough to produce such a result.

In Fig. 1 the photo-cell, varying its resistance in accordance with the amount of light which falls on it, varies the current flowing from the battery 31 through the resistance 32 in a like manner. The current flowing through resistance 32 causes a voltage drop therein which, due to the arrangement of the connections, is impressed on the grid. Thus the oscillations generated by the arrangement will be modulated in accordance with the amount of light falling on the photo-cell 30. These oscillations are impressed on the tube 34 by means of the coil 24. An electrodeless discharge will be induced in the tube 34 which will cause a light to be emitted, the intensity of said light varying in accordance with the amplitude of said oscillations. Thus the intensity of the light emitted from the tube 34 will vary in accordance with the amount of light falling on the photo-cell 30.

Although I have shown my device as being a light-responsive system, any desired type of modulation may be impressed on the grid of the tube. In Fig. 2, for example, I have shown a system for the purpose of modulating a high frequency current in accordance with the variations of sound which it may be desired to transmit.

In Fig. 2, the two anodes 11' and 12' are connected to the opposite ends of a coil 22'. The cathode 15' is connected through a battery 26' and resistance 25' to a mid-point 24' on the coil 22'. The grid 16' is connected to the cathode 15' through the risistance 31'. A coil 17' is provided to produce the longitudinal magnetic field. Instead of using a photo-electric cell as the controlling member, as in Fig. 1, some other device such as a microphone 34' may be used. This is connected across the resistance 31' in series with the battery 33'.

Also instead of utilizing the oscillations produced in the coil 22' for the purpose of energizing a glow tube, these oscillations may be impressed upon some transmitting circuit, which may be utilized for the purpose of radio transmission or for any of the well-known systems which utilize modulated high-frequency currents for the purpose of transmitting audible sounds. For this purpose the coil 22' may be inductively coupled to a coil 35 which may be connected to the input of such a system as specified above, such system being indicated at 36.

The invention is not limited to the particular details of construction, materials or processes described above, as many equivalents must suggest themselves to those skilled in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

Having described my invention, I claim:

1. An electron discharge device comprising an

evacuated envelope, two anodes within said envelope, a cathode intermediate said anodes, a control electrode interposed between said cathode and both of said anodes, means for producing a magnetic field in the space between said cathode and anodes, an inductively wound coil, said anodes being connected to opposite ends of said coil, said cathode being connected to a point intermediate the ends of said coil, a glow tube adapted to be energized by said coil, and means, including a light-responsive device, for impressing a varying potential upon said control electrode.

2. An electron discharge device comprising an evacuated envelope, two anodes within said envelope, a cathode intermediate said anodes, a control electrode interposed between said cathode and both of said anodes, means for producing a magnetic field in the space between said cathode and anodes, an inductively-wound coil, said cathode being connected to a point intermediate the ends of said coil, a discharge lamp adapted to be energized by said coil, and means for impressing a varying potential upon said control electrode.

3. An oscillation generator comprising an evacuated envelope containing an anode, a cathode adjacent said anode, and means for producing a magnetic field in the space between said cathode and anode, a control electrode interposed between said anode and said cathode for modulating the oscillations generated by said oscillation generator, an inductively-wound coil, a discharge lamp adapted to be energized by said coil, and means for impressing a varying potential upon said control electrode.

4. Apparatus for generating electrical oscillations comprising a split-anode magnetron including means for establishing a magnetic field, a cylindrical anode divided into at least two parts by at least one axial plane and mounted with its axis extending in the direction of said magnetic field, a thermionic cathode lying approximately along said axis, and a grid-like electrode mounted between the cathode and the anode and connected to said cathode.

5. Apparatus for generating electrical oscillations comprising a split-anode magnetron including means for establishing a magnetic field, a cylindrical anode divided into a plurality of symmetrically arranged parts and mounted with its axis extending in the direction of said magnetic field, a thermionic cathode lying approximately along said axis, a grid-like electrode between the anode and cathode and comprising a plurality of wires parallel to and symmetrically arranged with respect to said cathode, and means connecting said grid-like electrode with said cathode.

6. In a modulating system comprising a circuit having high frequency currents flowing therein, and, an electron discharge device having an electrode adjacent its cathode connected to said circuit for varying the flow of currents in said circuit, the method of varying the amplitude of current flowing in said circuit which includes varying the voltage on said electrode adjacent the cathode of said device, in accordance with variations to be imparted to the high frequency currents flowing in said circuit, and, subjecting the electron stream within said device to a unidirectional magnetic field.

7. In a modulating system comprising a circuit having high frequency currents flowing therein, and, an electron discharge device having an electrode adjacent its cathode connected to a point on said tuned circuit for varying the flow of currents in said circuit, the method of varying the amplitude of current flowing in said circuit which includes varying the voltage on said electrode adjacent the cathode of said device, in accordance with modulating potentials to be impressed on the high frequency currents flowing in said circuit, and simultaneously subjecting the electron stream in said device to a unidirectional magnetic field of substantially constant strength perpendicular to the path of said electron stream.

8. A modulating system comprising a circuit having high frequency currents flowing therein, an electron discharge device having an electrode adjacent its cathode connected to said circuit for varying the flow of currents in said circuit, means for varying the amplitude of current flowing in said circuit, including means for varying the voltage on said electrode adjacent the cathode of said device in accordance with variations to be imparted to the high frequency currents flowing in said circuit, and means for subjecting the electron stream within said device to a unidirectional magnetic field.

9. A modulating system comprising a circuit having high frequency currents flowing therein, an electron discharge device having an electrode adjacent its cathode connected to a point on said tuned circuit for varying the flow of currents in said circuit, means for varying the amplitude of current flowing in said circuit, including means for varying the voltage on said electrode adjacent the cathode of said device in accordance with modulating potentials to be impressed on the high frequency currents flowing in said circuit, and means for simultaneously subjecting the electron stream in said device to a unidirectional magnetic field of substantially constant strength perpendicular to the path of said electron stream.

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