July 8, 1941. C. V. LITTON 2,248,712

MAGNETIC CONTROL VACUUM TUBE

Filed March 20, 1940

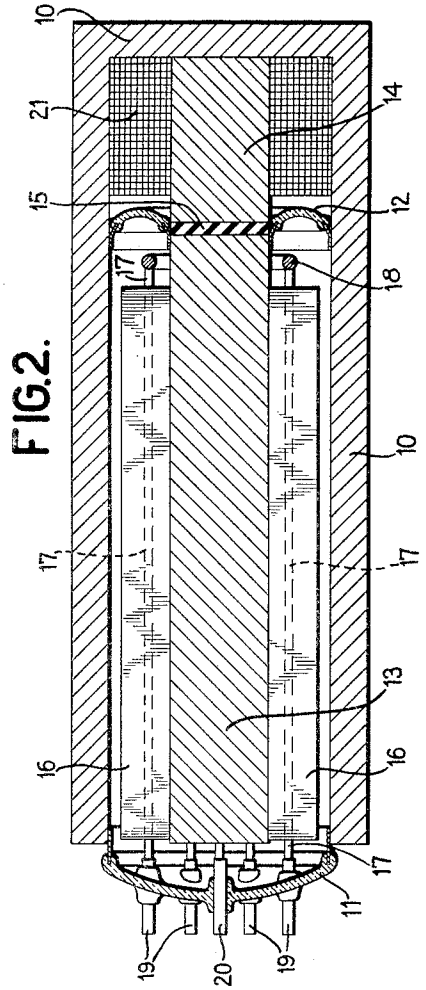


FIG.2.

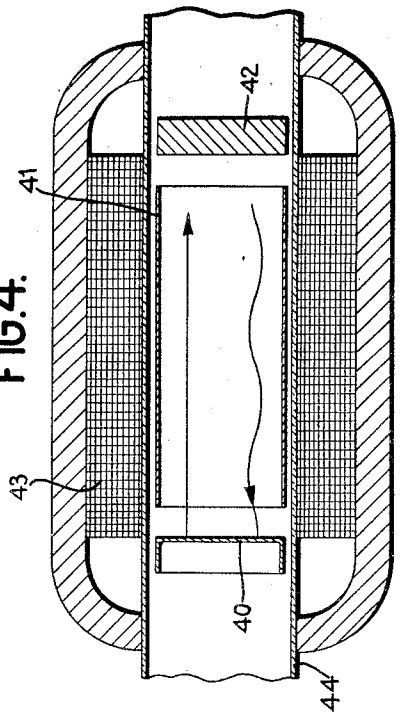


FIG.4.

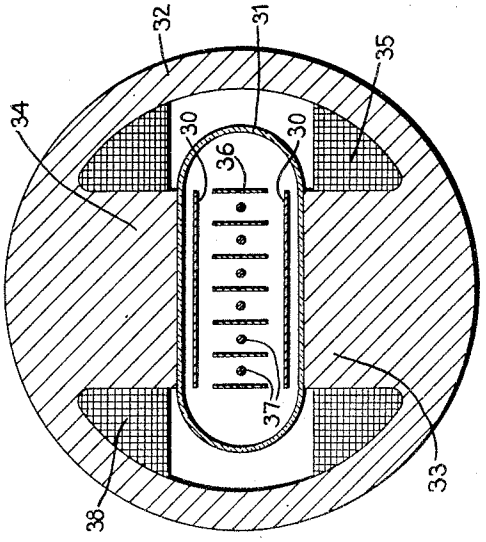


FIG.3.

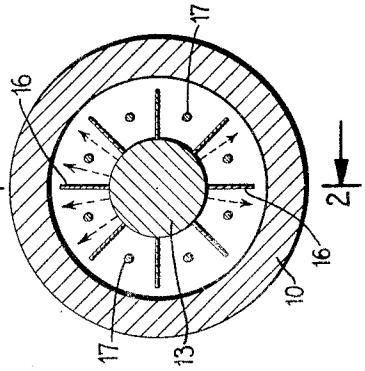


FIG.1.

INVENTOR.
CHARLES V. LITTON

BY R. C. Hopgood

ATTORNEY.

Patented July 8, 1941 2,248,712

UNITED STATES PATENT OFFICE

2,248,712

MAGNETIC CONTROL VACUUM TUBE

Charles V. Litton, Redwood City, Calif., assignor to Mackay Radio and Telegraph Company, New York, N. Y., a corporation of Delaware

Application March 20, 1940, Serial No. 324,925

5 Claims. (Cl. 250—27.5)

This invention relates to vacuum tube structures and more particularly to vacuum tubes wherein losses due to electrons reaching the control grid are minimized.

In known vacuum tube structures the electrons emitted from a cathode are attracted to a positively biased plate or anode electrode and are controlled during this passage by a control potential applied to the grid electrode. In operation the grid may be subjected to positive potentials during certain portions of a cycle. This tends to direct the electrons to the grid, giving rise to grid current and consequent lowering of efficiency. For this reason the grid swing of an oscillator, for example, may be limited below a fixed positive value.

According to my invention I provide a magnetic field which tends to cause electrons to be confined to a narrow spiral path and to thus be prevented from contacting the control grid. Thus, the tube if used as an oscillator may operate with high maximum positive grid swing.

According to another feature of my invention electrons passing longitudinally between a pair of electrodes under control of a further electrode may be prevented from spreading by providing a magnetic field along the path of travel of the electron.

It is a principal object of my invention to provide a vacuum tube in which the operating efficiency is improved by use of an added magnetic field.

It is a further object of my invention to provide a vacuum tube having a control electrode outside the normal path of travel of the electron stream and means for producing a magnetic field with the line of force in the direction of travel of electrons between cathode and anode.

A better understanding of my invention, as well as other features and objects thereof will be apparent to those skilled in the art from a review of the particular description of my invention made in connection with the accompanying drawing, in which

Figs. 1 and 2 illustrate transverse and longitudinal cross sections, respectively, of a tube embodying the principles of my invention.

Fig. 3 illustrates a transverse section of a modified form of a tube embodying features of my invention, and

Fig. 4 is a longitudinal cross-section of a further modified vacuum tube embodying further features of my invention.

Turning to Figs. 1 and 2, 10 represents an anode made of magnetic material and forming a portion of the envelope of the tube, the envelope being completed by a glass member 11 sealed to the anode, and glass sealing ring 12 forming a seal between anode 10 and the central control electrode support 13. Support member 13 is also made of magnetic material and is maintained centrally of said anode by a projecting portion 14 of magnetic material insulated from said control electrode support by an insulating disc 15.

Radially mounted on member 13 are a plurality of control electrode members 16. These members may be in the form of sheets or plates or may be of wire mesh. A filamentary cathode comprising wires 17 connected at one end to a ring element 18 and at the other end to terminals 19 completes the tube element assembly. A control electrode lead 20 serves for supplying bias and control potential to control electrode assembly 13, 16. On projecting member 14 is provided a magnetizing winding 21, which serves to magnetize electrode members 10 and 13 to produce a magnetic field between these members. The lines of magnetic force then extend radially from member 13 to anode 10, as indicated by dotted lines in Fig. 1.

In operation filaments 17 are brought to electron emissivity and the electrons emitted are attracted toward anode 10 as an average velocity dependent upon the positive bias of the anode. A control potential is supplied to grids 16 to vary the electron flow in accordance therewith. This control potential may render grid 16 positive during certain portions of cycles of operation tending to divert the electrons from their normal path to said anode toward the grid elements. This diversion is prevented, or at least substantially controlled by the effect of the magnetic field existing between members 10 and 13. When an electron attempts to move across a magnetic field, it finds a force acting upon it which tends to cause it to follow a curved path.

The radius R of curvature for the motion of the electron is expressed in the following equation

$$R=3.37\sqrt{\frac{Ev}{H}}$$

in which Ev is the measure of the electron's kinetic energy in electron volts in the plane of curvature, and H is the magnetic field strength at the point in question. The electrons are accelerated in the same direction as the magnetic field, so the initial component in a direction perpendicular to the field is quite small. For this reason the comparatively weak magnetic field is

able to keep them within the confines of a very small radius circle. As the electrons travel away from the cathode they tend to disperse due to their mutual repulsion, causing a larger component of movement perpendicular to the magnetic field. The electrons then travel in the path of a helical spiral, which may be controlled in diameter by the magnetic field strength so that the electrons do not reach the grid.

This general principle of control by the magnetic field applies to other forms of tubes as well as that illustrated in Figs. 1 and 2.

In Fig. 3 is illustrated another form of tube using a magnetic field to control the path of travel of the electrons to the anode. In this tube the magnetic members are entirely outside the tube envelope. The anodes 30, grid or control electrode member 36 and cathode filaments 37 are arranged within an envelope 31, which may be of any desired material, glass, for example. About the tube envelope is provided a magnetic system comprising a ring of magnetic material 32 on which are formed inwardly projecting pole pieces 33, 34. Magnetic windings 35, 38 are provided on pole pieces 33, 34 to produce a magnetic field across the tube envelope 31 in line with the initial electron path between filaments 37 and anodes 30.

Fig. 4 is a fragmentary view showing still another form of vacuum tube using a magnetic field to control the path of an electron. In this embodiment, electrons emitted from a cathode 40, which may be an indirectly heated cathode, pass longitudinally through a cylindrical control electrode 41, to an anode electrode 42. Although the electrons are initially moving at a high velocity toward anode 42 they must traverse a relatively long distance through the control electrode 41 before reaching the anode. Accordingly, they tend to disperse and unless some provisions are made to prevent it many will be attracted to control electrode 41 during its positive swings and will never reach the anode 42.

To prevent the electrons from reaching control electrode 41, magnetic coil winding 43 is provided about the tube envelopes 44. The magnetic field within this coil will be longitudinal thereof and consequently parallel with the normal desired path of electron flow. Because of this the electrons may be caused to follow a spiral path under control of the magnetic field and be diverted away from contact with control electrode 41. If desired a shell of magnetic material 45 may be provided about coil 43 to strengthen the magnetic field through the coil.

Although I have described a few particular embodiments of my invention it should be distinctly understood that these examples serve merely as illustrations of my invention and not as limitations thereof. Many modifications within the scope of my invention will be readily apparent to those skilled in the art. What I consider to be my invention is embodied in the accompanying claims.

What I claim is:

1. A radial-type vacuum tube comprising an envelope, hollow cylindrical anode means, an electron emissive cathode within said cylindrical anode means, said anode receiving the electrons from said cathode, a control electrode disposed outside the normal path of electron flow from said cathode to said anode for controlling the flow of electrons to said anode, and means for producing a magnetic field radially with respect to said anode, said field being in the direction of said electron flow and preventing diversion of said electrons from said normal path.

2. A radial-type vacuum tube comprising a tubular anode of magnetic material, means for sealing one end of said anode, a member of magnetic material having an external diameter smaller than the internal diameter of said tubular anode and positioned within said anode, means for sealing said member to said anode, both of said sealing means and at least a portion of said anode forming a chamber and at least a portion of said member being within said chamber, electron emissive means encircling said member, control electrode means disposed outside the normal path of electron flow from said electron emissive means and said anode for controlling the flow of electrons from said emissive means to said anode, and means for producing a magnetic field between said member and said anode, said field being in the direction of said electron flow and preventing diversion of said electrons from said normal path.

3. A vacuum tube according to claim 1 wherein said anode comprises magnetic material.

4. A vacuum tube according to claim 1, wherein said anode is of magnetic material and forms a portion of the envelope of said vacuum tube, said control electrode comprising a centrally disposed portion of magnetic material, carrying a plurality of radial fins, said cathode being arranged between said centrally disposed portion and said anode, and further comprising means for applying a magnetizing force to said anode and said centrally disposed member.

5. A vacuum tube according to claim 1, wherein said control electrode comprises a plurality of radially positioned vanes.

CHARLES V. LITTON.