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VACUUM TUBE

Original Filed March 19, 1930

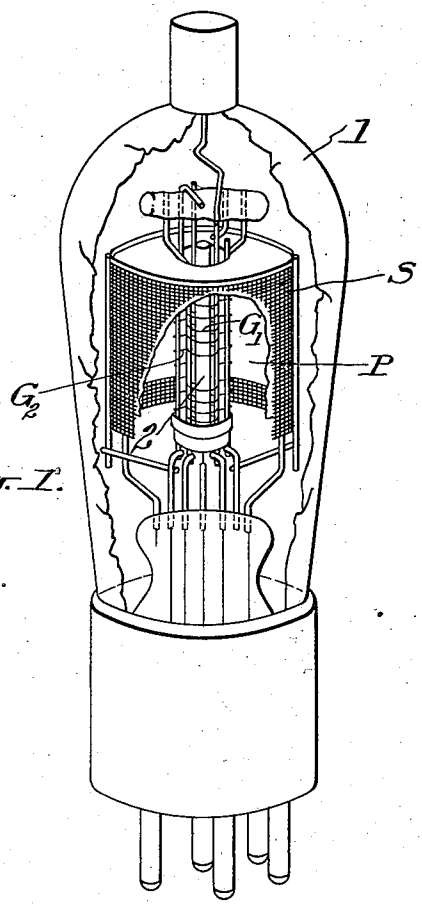


Fig. 1.

Fig. 2.

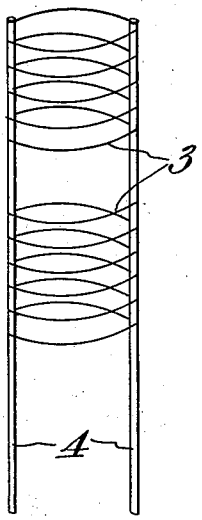
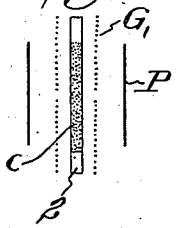


Fig. 3.



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VACUUM TUBE

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Original application March 19, 1930, Serial No. 437,225. Divided and this application March 12, 1931, Serial No. 522,063. Renewed November 1, 1935. In Canada September 13, 1930

5 Claims. (Cl. 250—27.5)

This invention relates to vacuum or electronic tubes suitable for the amplification of modulated carrier waves.

This application is a division of my copending application, Ser. No. 437,225, filed March 19, 1930 and for a more extended discussion of the method of operation and the advantages of vacuum tubes of the poly-mu, or variable mu-factor, type disclosed and claimed in this application, reference is made to the aforesaid application and to the article by Stuart Ballantine and Harold A. Snow in the "Proceedings of the Institute of Radio Engineers", December, 1930, pages 2102 to 2127, "Reduction of Distortion and Cross-Talk in Radio Receivers by Means of Variable-Mu Tetrodes".

An object of the invention is to provide a vacuum tube in which the electrodes are constructed and arranged to produce a desired relation between the current flow in one electrode circuit and the voltage on another electrode, for example, between plate current and control grid voltage. A further object is to provide a tube of the type stated in which the control grid is so constructed that the space current path adjacent different parts of the cathode is characterized by substantially different mu factors and transconductance values. By transconductance is meant the ratio of the change in the current in the circuit of an electrode to the change in the voltage on another electrode, under the condition that all other voltages remain unchanged. By mu-factor is meant the ratio of the change in one electrode voltage to a change in the other electrode voltage, under the condition that a specified current remains unchanged. A further object is to provide a vacuum tube of the equipotential cathode type in which the control grid has the form of a helical winding of non-uniform pitch. More specifically, an object is to provide a vacuum tube of the type having cylindrical elements, and in which the control grid has the form of a helical winding having one or more gaps at an intermediate portion of the winding.

These and other objects of the invention will be apparent from the following specification when taken with the accompanying drawing, in which

Fig. 1 is a perspective view of a vacuum tube embodying the invention, parts being broken away to illustrate the construction of the control grid,

Fig. 2 is an enlarged detail view of a control grid such as shown in Fig. 1, and

Fig. 3 is a diagrammatic view illustrating another embodiment of the invention.

In Fig. 1, the invention is illustrated as embodied in a form of vacuum tube known commercially as a screen grid tube having a separate heater for energizing an equal-potential cathode. As is well known, this particular type of tube comprises an evacuated envelope 1 enclosing a cathode 2 heated by a resistance (not shown) within the cathode, an inner or control grid G_1, and its novel functional relationship to the remaining elements of the tube, a screen grid G_2, a plate P and an outer screen S. Except for the novel construction of the control grid G_1, the several elements of the tube and their physical arrangement may be substantially the same as that employed in the present commercial tubes.

In tubes of this general type, the control grid G_1 comprises a helical winding, of uniform pitch with its turns constituting transverse conductors connected to and supported by one or more foundation supports or wires which extend parallel to the axis of the cathode 2. Furthermore, it is the accepted practice to make the axial length of the control grid somewhat greater than the axial length of the cooperating tube elements, i. e., the emitting portion of the cathode, the plate and, in the case of tetrodes, the screen grid.

In accordance with the present invention, the desired poly-mu or variable mu-factor, operating characteristics of the tube are obtained by forming the grid as a helical winding having turns omitted therefrom to make the winding of less length than the plate. The turns may be omitted from one or more intermediate sections of the winding. From the viewpoint of the geometry of the tube, the effect is to produce gaps in the control grid, and, from an operating standpoint, the effect is to give different mu characteristics to the electron current established at different parts of the cathode.

In the particular embodiment of the invention illustrated in Figs. 1 and 2, the helical winding is not continuous, as in previously known constructions, but comprises two sections 3 that are separated by a distance of the order of twice the pitch of the winding. The windings of each section are of the same pitch, which may be the same as that now employed in tubes of this type. This particular physical embodiment of the invention therefore differs from the known constructions, of the same general physical design, by the absence of two complete circumferential turns of the control grid winding. One convenient method of forming the control grid G_1

is to form a continuous winding on the foundation supports or supporting wires 4, and to cut out one or more turns to leave spaced sections 3 of uniform pitch. The sections 3 may, however, be separately formed on the supporting wires 4 and may be spaced apart by either integral or fractional multiples of the pitch distance.

This particular construction results in a tube in which the control exercised upon the electron stream is not uniform over the entire extent thereof, and which is so proportioned that practically no distortion is introduced when, for increasing signal strengths, the operating potentials of the tube are adjusted to reduce the amplification rate to a small fraction of the maximum amplification and produce a relatively low amplification of strong signals, with a change in transconductance for a given change in gain control voltage much lower than with known types of tubes, enabling the tube to give an undistorted output of approximately constant magnitude over a wide range of applied signal voltages. This variation in the control over portions of the electron stream from different parts of the cathode may be effected by other constructions in which the effective pitch of the control grid winding is rendered non-uniform over that portion of the control grid which lies within the electron stream by the omission of one or more turns of the winding.

The invention is applicable to tubes having more than one grid in addition to the control grid, and also to tubes of the triode type. As shown in Fig. 3, the equipotential cathode 2 and its electron emission coating C and plate P may be of a conventional design, and the control grid G_1 may be a helical winding having a gap formed at the central portion thereof by the omission of a single turn.

As explained in more detail in my copending application of which this is a division, it is well known that the amplification of a vacuum tube may be regulated by adjusting the bias voltage upon the control grid, the amplification decreasing as the bias voltage becomes more negative. Curves showing the relation between plate current and grid bias, i. e., transfer characteristics, afford an indication of the amplification at different bias voltages since the slope of the curve at any point is a measure of the amplification when the tube is biased for operation at that point.

With tubes embodying the invention, a control of amplification extends over a range of control grid bias of from zero to more than −30 volts, while with the known tubes, the curvature of the transfer characteristic approaches zero at a control grid bias of about −15 volts. In other words, an increase of the grid bias above approximately 15 volts negative will not be accompanied by a decrease in amplification when the known type of tube construction is employed, but with tubes embodying the invention, the amplification may be varied with changes of control grid bias throughout a range of from zero to upwardly of −30 volts. The tubes will still pass signals, by leakage transmission when the control grid biases exceed these respective values, but control of amplification is no longer possible in regions where the transconductance curves become substantially horizontal.

The useful range of transmission control is considerably extended by the present invention. In the known constructions with the control grid biased about 3 volts negative and the plate current between 4 and 5 milliamperes, a decrease of the transconductance from about 500 micromhos to the value, about 0.8 micromho, at which leakage transmission prevents further amplification control, corresponds to a change in control grid bias of about ten volts. The corresponding ranges of control grid bias for tubes embodying my invention may be 30 volts or more.

It will be apparent that the invention is not limited to the particular types of tubes or to the particular grid constructions which are illustrated in the drawing.

I claim:

1. A unipotential control grid electrode for electron discharge devices comprising a metal rod and a grid wire coiled into windings of substantially the same pitch and diameter coaxially mounted end to end on said rod and longitudinally spaced along said rod with the turns at the adjacent ends of said windings spaced to form between said windings a gap equal to two turns of said windings to permit a radial flow of electrons between said spaced end turns, the turns of each winding being secured to said rod and spaced to control a flow of electrons radially through said windings.

2. A unipotential grid electrode for electron discharge devices comprising a conducting support, and two helical windings of the same diameter and pitch throughout their length mounted end to end on said support coaxial with a common axis parallel to said support and with each turn of each winding secured to said support, the turns of each winding being spaced to permit an electron stream to flow radially and between turns, said windings being spaced axially on said support to leave between the adjacent end turns of said windings an unobstructed gap as wide as two turns of said windings and through which an electron stream may flow radially under a control by the adjacent end turns of said windings less than the control exerted by the other turns of said windings on the electron stream flowing between said other turns.

3. A unipotential grid electrode for electron discharge devices comprising foundation supports and transverse conductors connected to said supports and spaced to permit an electron stream to flow between said conductors and having between two adjacent conductors intermediate its ends an unobstructed gap and between the remainder of said conductors a uniform spacing substantially one-half the width of said gap.

4. An electron discharge tube comprising a cylindrical equipotential cathode, a tubular anode of uniform diameter coaxial with and surrounding said cathode, and a unipotential tubular grid electrode interposed between and coaxial with said cathode and said anode, said grid electrode comprising a metal rod and a grid wire coiled into windings of substantially the same pitch and diameter coaxially mounted end to end on said rod and longitudinally spaced along said rod with the turns at the adjacent ends of said windings spaced to form between said windings a gap equal to two turns of said windings to permit a radial flow of electrons between said spaced end turns, the turns of such winding being secured to said rod and spaced to control a flow of electrons radially through said windings.

5. An electron discharge tube comprising a cathode, a tubular anode coaxial with and surrounding the active length of said cathode, and

a unipotential tubular grid electrode interposed between and coaxial with said cathode and said anode and covering the active length of said cathode, said grid electrode comprising foundation supports and transverse conductors connecting said supports with two adjacent conductors at the middle spaced to leave between said conductors an unobstructed gap and the remaining conductors spaced to uniformity and substantially one-half the width of said gap to permit an electron stream to flow radially of said grid between all the transverse conductors of said grid and through said gap and under lesser control through said gap than through the remainder of the grid.

HAROLD A. SNOW.