July 21, 1936. H. A. SNOW 2,048,230

VACUUM TUBE

Original Filed March 19, 1930

Fig. 1.

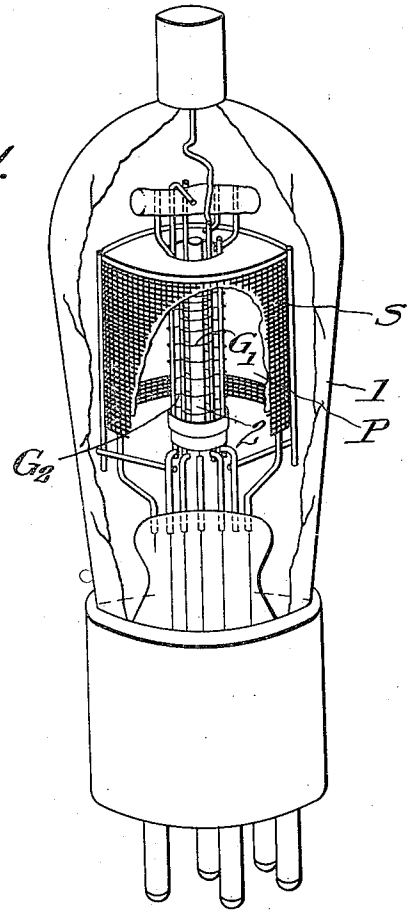
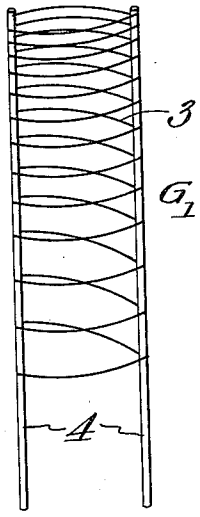


Fig. 2.



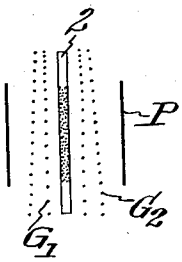


Fig. 3.

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UNITED STATES PATENT OFFICE

2,048,230

VACUUM TUBE

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Original application March 19, 1930, Serial No. 437,225. Divided and this application March 10, 1931, Serial No. 521,577. Renewed June 26, 1934. In Canada September 13, 1930

9 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 of the type having two or more grid electrodes between the thermionic cathode and the plate 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 and another grid such as a screen grid are so constructed that the space current path adjacent different parts of the cathode is characterized by substantially different mu factors and transconductance values. A further object is to provide a vacuum tube of the type stated having an equipotential cathode and 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 stated having coaxial cylindrical elements, and in which the control grid has the form of a helical winding of progressively varying pitch.

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 heater (not shown) within the cathode, an inner or control grid G_1, a screen grid G_2, a plate P and an outer screen S. Except for the novel construction of the control grid G_1 and of the screen grid G_2, 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, supported by one or more wires which extend parallel to the axis of the cathode 2.

In accordance with the present invention, the desired operating characteristics of the tube, as explained in my copending application and the aforesaid publication, are in part obtained by making the control grid winding of non-uniform pitch. As shown in Fig. 2, the control grid G_1 may take the form of a winding or coil 3 of progressively varying pitch which is supported by parallel wires 4. As the control grid portions of greater pitch exercise a lesser rate of control of the electron stream than the control grid portions of lesser pitch, the mu factor of a tube with such a control grid is relatively low at the area of the cathode adjacent the control grid portions of greater pitch, and both the space current and the transconductance of the space current path from the low mu area of the cathode are relatively high.

Greater freedom of design is permitted by altering the geometry of more than one of the electrodes. For example, with a control grid of variable pitch, I find it of advantage to provide a screen grid of variable diameter. One effect of this composite structure is the reduction of the relatively high space current and relatively high transconductance at a portion of the space current path where the mu-factor is low. Variation of the screen grid diameter also permits control of the effects of secondary emission, which also influences the plate current and transconductance and to that extent enters into the problem of producing characteristics of desired shape.

An example of such construction applied to the reduction of transconductance at the low mu area of the cathode is shown in Fig. 3. In the diagram, the cathode 2, control grid G_1 and plate P have substantially the same construction and arrangement as is illustrated in Fig. 1, but the screen grid G_2 is a helical winding of conical form. The larger diameter portion of the screen grid G_2 lies between the plate P and the more widely spaced turns of the control grid winding G_1, thus reducing the accelerating action of the screen grid at the portion of the space current

path over which the control grid exercises a lesser control of space current flow.

The desired variation in control at different parts of the electron stream may be effected when the control grid of non-uniform pitch takes other forms than the one herein illustrated and described.

In my aforementioned copending application, I have described and claimed embodiments of the present invention in which a control grid of non-uniform pitch takes the forms, respectively, of a plurality of sections each of uniform but of different pitch, and a grid having turns of uniform pitch but from which one or more of the turns are missing. Other variations in construction which are effective to secure operation in accordance with the present invention will occur to those familiar with the design and operation of vacuum tubes. It is therefore to be understood that the term "non-uniform pitch" as employed in the following claims is not restricted to a progressive variation in the pitch or spacing of the turns of a grid winding.

While the invention has been described as applied to a known type of tetrode, it will be apparent that it is applicable to various types of tubes which may or may not include electrodes additional to the cathode, control grid and plate. 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.

I claim:

1. An electron discharge device comprising an equipotential cathode, a control grid having a winding of non-uniform pitch and exercising different rates of control over parts of the electron stream established at different portions of said cathode, and a plate, a screen grid between said control grid and plate, the diameter of the said screen grid being greatest in that part of the electron stream over which said control grid exercises the least rate of control.

2. An electron discharge device comprising an equipotential cathode, a control grid exercising a lesser rate of control over the electron stream established from one portion of the cathode than it exercises over the electron stream from other portions of the cathode, and a plate, a screen grid between said control grid and plate, said screen grid comprising a helical winding which is of greater diameter at one portion of said cathode where the rate of control by said control grid is less.

3. A screen grid tube having a variable mu-factor, a cathode, an anode, a control grid constructed to exercise lesser and greater rates of control over parts of the electron stream, and a screen grid comprising a winding which varies in diameter from point to point along the winding, the larger diameter section of the screen grid being positioned adjacent a portion of the control grid exercising said lesser rate of control.

4. An electron discharge tube comprising an equipotential cathode, a control grid comprising a helical winding having a pitch which varies progressively from one end thereof to another, a screen grid and a plate, said screen grid comprising a helical winding which progressively increases in diameter from point to point along said winding and is mounted with its greatest diameter adjacent the more open end of said control grid winding.

5. An electron discharge tube comprising an equipotential cathode, a control grid comprising a helical winding having a pitch which varies progressively from one end thereof to another, a screen grid and a plate, said screen grid having substantially the form of a truncated cone, the portion of said cone having the widest diameter being disposed adjacent the portions of the control grid winding having the largest pitch whereby there is secured reduction of the relatively high space current and relatively high transconductance at a portion of the space current path where the mu-factor is low.

6. An electron discharge tube comprising a cylindrical equipotential cathode, a grid comprising a helical winding of non-uniform pitch surrounding and coaxial with said cathode, a second grid surrounding and coaxial with said first grid and comprising a helical winding which varies in diameter from point to point along said winding with a portion of larger diameter in registry with a portion of said first grid which is of greater pitch and a tubular plate surrounding and coaxial with said second grid.

7. An electron discharge tube comprising a cylindrical equipotential cathode, a grid surrounding and coaxial with said cathode and comprising a helical winding which increases in pitch progressively from one end to the other, a second grid substantially coextensive with said first grid and comprising a helical winding of uniform pitch and progressively increasing diameter from one end to the other and positioned with its large end adjacent the end of said first grid where the pitch of said first grid is greatest, and a tubular plate surrounding and coaxial with said second grid.

8. An electron discharge device comprising a cylindrical equipotential cathode, a tubular plate concentric with said cathode, and two concentric grids interposed between said cathode and said plate, one of said grids exerting different rates of control on electron streams from different portions of said cathode, and the other having portions spaced from said first grid at distances increasing with the extent of decrease in control exerted by the first grid.

9. A vacuum tube comprising a cathode, a screen grid, and a plate, of a control grid positioned between said cathode and plate and having a winding of non-uniform pitch and exercising at different points along said cathode different rates of control over parts of the electron stream between said cathode and plate, said screen grid being conical and positioned coaxially of said cathode with its larger portions in registry with the less effective portions of said control grid, whereby said screen grid exercises a lesser accelerating action upon the electron stream at those points on the cathode at which the control action of said control grid is less.

HAROLD A. SNOW.