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ELECTRON DISCHARGE DEVICE

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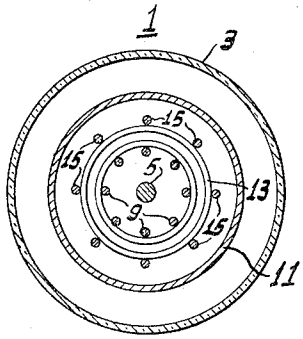


Fig. 2

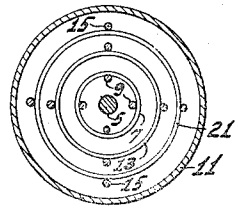


Fig. 3

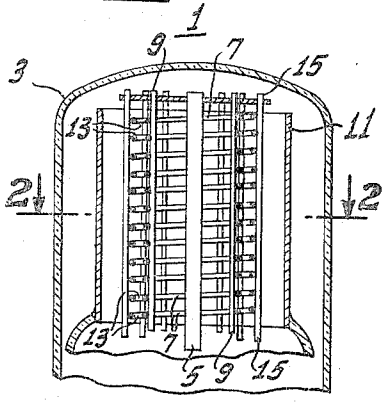


Fig. 1

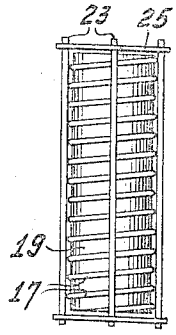


Fig. 4

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ELECTRON DISCHARGE DEVICE

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3 Claims. (Cl. 313—299)

This invention relates to electron discharge devices, and particularly to improvements in grid structures for power tubes which may be operated at very high frequencies.

Two problems which must be faced in designing power tubes which will operates efficiently at very high frequencies are those of excessive grid current and excessive transit time for the passage of electrons from the cathode to the output electrode.

In tetrodes excessive screen grid current reduces the efficiency of the tube, since the screen current must be subtracted from the available cathode current, and also causes heating of the grid structures, with the result that the grid structures often bow or buckle. This bowing or buckling changes the electron optics of the tube, or in many cases may cause short circuits between adjacent electrodes of the tube. Thus, excessive control grid or screen grid current is a limiting factor in determining the maximum allowable power input to the tube.

At very high operating frequencies the time spent by the electrons in traveling from cathode to output electrode must be a small part of the time required for a single alternation of the high frequency output current, particularly if high conversion efficiencies are to be obtained. When conversion efficiencies become too low the tube may not develop sufficient power to supply its own internal and external circuit losses, in which case the tube becomes inoperative. This effect limits the upper operating frequency of most simple grid controlled electron tubes.

Electron transit time can be reduced by decreasing the distance through which the electron moves or by increasing the voltage of the electrodes between which it moves, or both. Since increasing of voltages results in greater power dissipation, which in itself is undesirable, the most practical expedient may be to manufacture tubes having closer spacing between electrodes. However, when a conventional screen grid is tested, that is, one having the support rods on the interior surface of its winding; the support rods limit the close spacing between control grid and screen grid winding.

Two general approaches have been made towards solving the problem of excessive grid current: either the heat caused by the excess grid current must be conducted away from the grid, or the grid current must be reduced to an amount where the grid structure will not overheat. Conduction of heat away from the grid structure is the less desirable solution because in that case the inefficiency of the grid operation is tolerated so long as the grid structure can withstand the physical effects of the high grid current.

With respect to tetrode tubes, screen grid current in prior art tubes has been reduced to a useful extent by aligning the turns of the control grid with the turns of the screen grid, with the result that the electrons are directed, in the form of pencils or beams, through the spaces between the turns of the screen grid winding. However, the above mentioned prior art practice is not

entirely satisfactory, mainly because of divergence of the electron beams or pencils, whereby a substantial amount of electrons do impinge on the turns of the screen grid winding.

The principal object of this invention is to provide a power tube which will operate efficiently at very high frequencies and which will have high power output capabilities.

Another object of my invention is to provide an improved grid structure especially adapted for use in high frequency power tubes, and one which shall obviate the foregoing and other less apparent disadvantages of present day grid assemblies.

Still another object of this invention is to provide a construction for a power tube, capable of operation at very high frequencies, which will have efficient grid action and which will be mechanically strong.

A further object of this invention is to provide a tube having high power output and in which the grid structure is not excessively heated.

A still further object of this invention is to provide a power tube wherein close electrode spacing between control grid and screen grid are obtained, and improved electron beaming action results therefrom.

As applied to a tetrode tube in which screen grid and control grid turns are in register and in which corresponding grid side support rods shadow each other, the present invention provides a grid structure which produces improved electron beaming, with the result that the screen current in the tube is lowered. Improved electron beaming is accomplished as a result of the side support rods of the screen grid being attached to the outer surface of the helical grid winding, for with such a construction the screen grid winding and the conventionally constructed control grid may be positioned very close together, and the control grid thus becomes very effective in shielding the screen grid from the electron stream. It is also apparent that closer spacing between screen grid and control grid result in better transit time characteristics, since the electron transit time between cathode and screen grid, for tetrodes, has a direct bearing on tube performance at high frequencies.

Besides advantages of improved electron beaming and improved transit time characteristics, the present invention permits the use of larger and more rugged side support rods for the screen grid, because the support rods are positioned in the relatively large space between screen grid and anode.

The invention will be described in greater detail with reference to the accompanying drawings, in which corresponding parts have the same reference numerals, and in which:

Fig. 1 represents a longitudinal section view of an electron discharge device of the tetrode type constructed according to my invention;

Fig. 2 is a transverse sectional view taken along line 2—2 of Fig. 1;

Fig. 3 represents a transverse section view of an electron discharge device of the pentode type constructed according to the invention;

Fig. 4 shows a suitable method for constructing a helical grid for use according to the invention.

Referring to Fig. 1, there is shown an electron tube **1** having envelope **3** enclosing the operating electrodes of the tube which are spaced from each other in conventional manner. A cathode **5**, which is shown as an indirectly heated cathode, may however be a filament, or any other suitable form of emitter, is surrounded by a helical control grid which consists of grid wires **7** and support rods **9**. Positioned intermediate said control grid and a conventional anode electrode **11** is a helical screen grid which consists of grid wires **13** and support rods

15. The turns of the screen grid wires 13 have the same pitch as the turns 7 of the control grid and are positioned in registry therewith.

Likewise, as may be seen in Figure 2, the support rods 9 and 15 are symmetrically located around the circumference of their respective helices so that corresponding support rods of the control grid shadow the corresponding support rods of the screen grid.

Acording to the invention, the support rods 9 of the control grid are attached to the inner surface of the helical grid winding 7, and the support rods 15 of the screen grid are attached to the outer surface of the helical grid winding 13. This arrangement of the support rods allows (*a*) the tube grid windings to be spaced very close to each other, which results in considerable improved electron beaming action as explained heretofore, and (*b*) the support rods, 15, since they are located in the relatively large space between the screen grid and anode 11, may be made larger and stronger, making a more rugged grid support structure which is capable of withstanding high temperatures without buckling or of withstanding physical shock such as vibrations.

Such an arrangement has been found to provide greatly improved beaming action, with the result that far less electrons impinge on the screen grid than occurs when the grid structures are made according to the prior art practice.

Figure 3 shows the top view of a pentode vacuum tube structure in which the present invention is used. Control grid winding 7 and screen grid winding 13 are constructed similarly to those described in Figures 1 and 2, but a suppressor grid 21, positioned between screen grid winding 13 and anode 11, has been added. It should be apparent that the support rod construction of control grid 7 and screen grid 13 could be used for any pair of adjacent grids.

Ease of constructiton of a helical grid with externally attached support rods is illustrated in Figure 4. A grid wire 7 is wound on a solid mandrel 19, and then support rods 23, held in position by jig 25, are welded thereon. This arrangement is particularly suitable for use with roller welding machines, since the rollers of the welder can ride on the side rods instead of on the helix wires, thereby eliminating the danger of burning the individual wires of the grid.

From the foregoing discussion, it will be apparent that the invention provides an electrode arangement, in a power tube, which results in improved efficiency of operation and which provides a more rugged mechanical structure.

What is claimed is:

1. An electron discharge device including a cathode and anode and a pair of electrically independent grid electrode structures, each having a circular cross sectional configuration and all in concentric and coaxial array, said grid electrode structures each including a circular array of side support rods and a helical grid winding for each of said arrays of support rods, each winding comprising conducting elements extending transversely of and attached to its support rod array, the winding of the inner grid structure being attached to the outer surface of its support rod array and the winding of the outer grid structure being attached to the inner surface of its support rod array, said windings being close spaced one from another with the spacing between the grids being at least as small as the cross sectional thickness of said support rods radially of said device, the windings and corresponding support rods of each of said pair of grid structures being in register with each other.

2. An electron tube comprising a cathode electrode, a first grid electrode positioned adjacent to said cathode, a second grid electrode positioned adjacent to and close spaced from said first grid electrode, and an anode electrode, said cathode and each of said grid electrodes being of similar tubular configuration and all of said electrodes being coaxially and concentrically arranged, said grid electrodes being electrically independent of each other and each including support rods and a helical winding comprising conducting elements, said conducting elements and corresponding support rods of each grid electrode being in register with said conducting elements and support rods of the other grid, all the support rods of said first grid electrode being positioned between its conducting elements and said cathode, and all the support rods of said second grid electrode being positioned between its conductive elements and said anode.

3. An electron discharge device including a cathode, a control grid, a screen grid, and an anode, each having a circular cross sectional configuration and all being coaxial and concentric, said control grid comprising a circular array of side support rods and a helical grid winding, said winding comprising conducting elements extending transversely of and attached to said support rods about the outer surface of said array of support rods, said screen grid comprising a second circular array of side support rods and a second helical grid winding, said second winding comprising conducting elements extending transversely of and attached to said second array of support rods about the inner surface of said second array, said windings being close-spaced from each other with the spacing between the windings being at least as small as the cross sectional thickness of said side support rods radially of said device, the corresponding conducting elements and support rods of said control grid and said screen grid being in register with each other.

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