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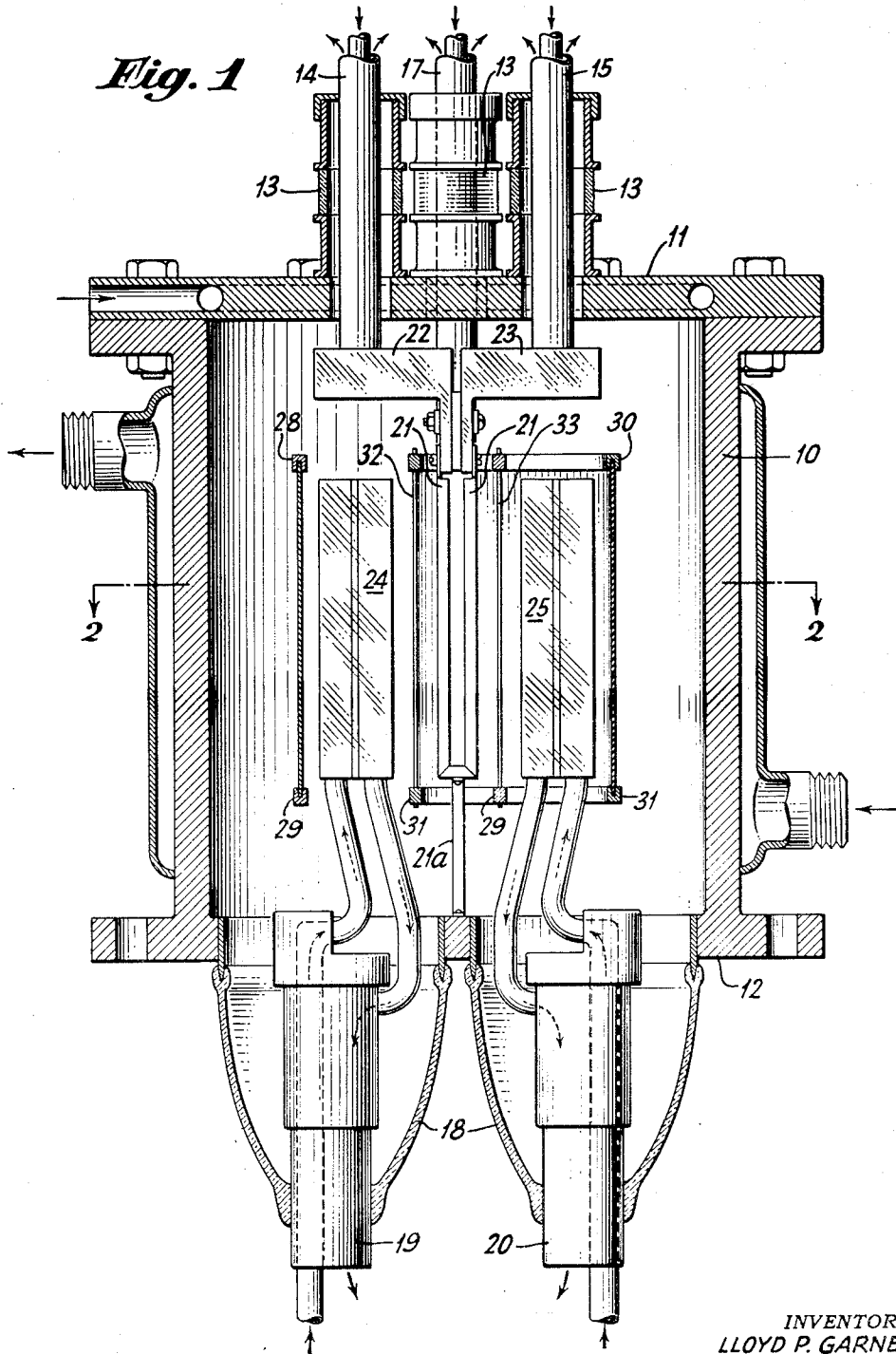
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2,257,794

ELECTRON DISCHARGE DEVICE

Filed July 29, 1939

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

Fig. 2

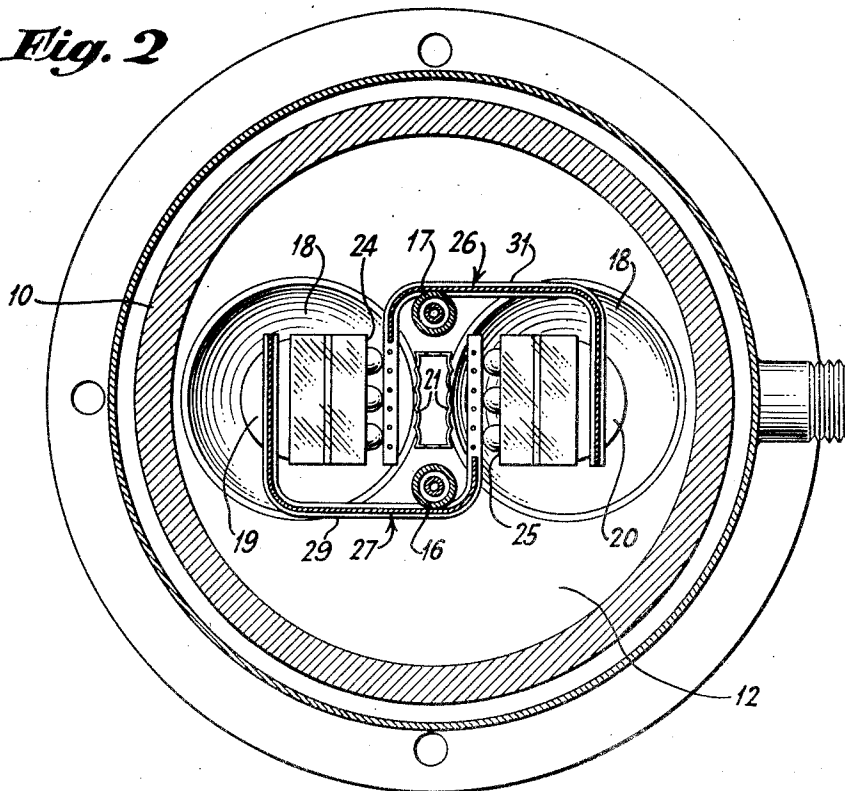
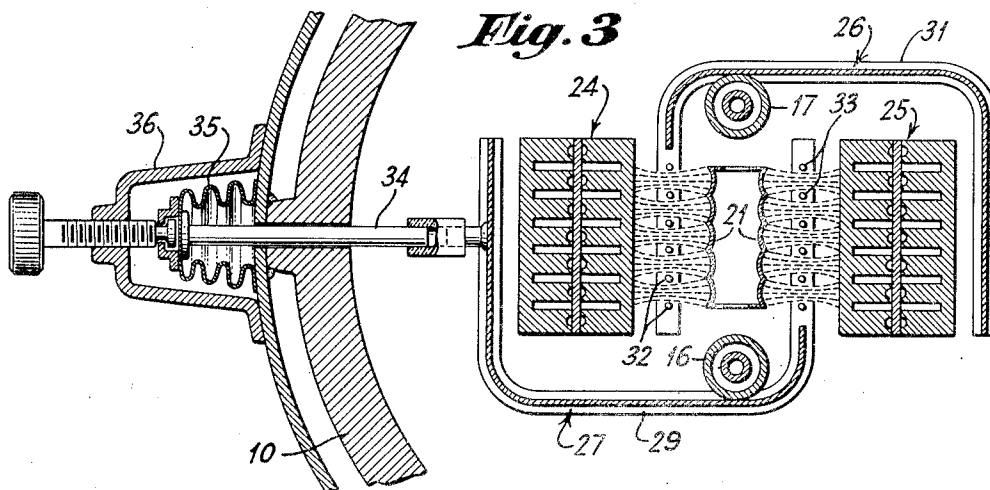


Fig. 3



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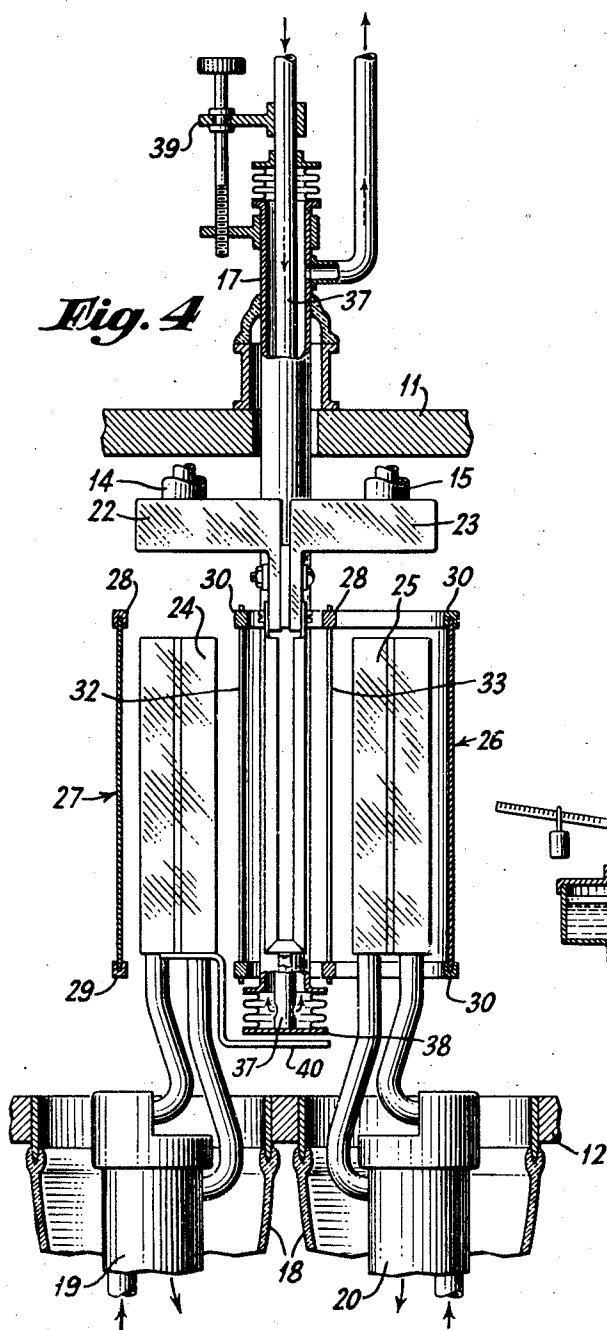
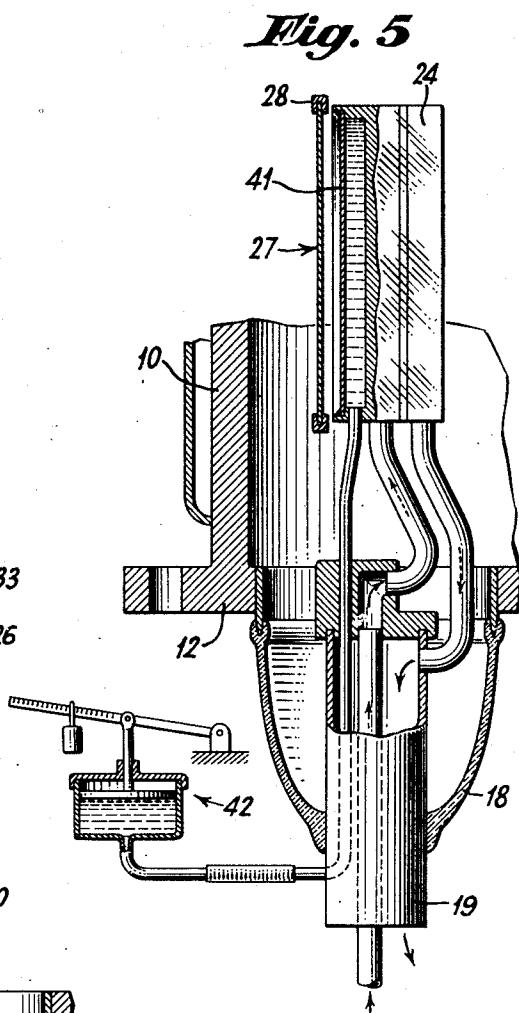
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ELECTRON DISCHARGE DEVICE

Filed July 29, 1939

4 Sheets-Sheet 3



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4 Sheets-Sheet 4

Fig. 6

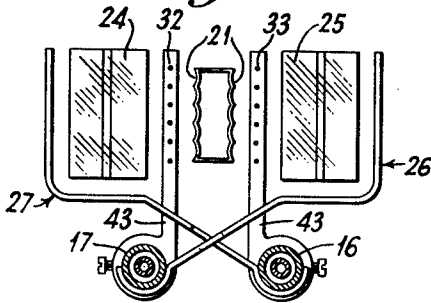


Fig. 9

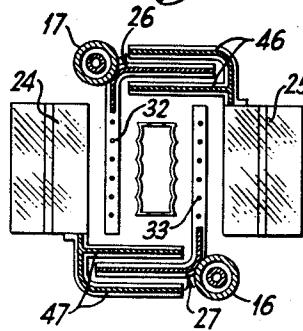


Fig. 7

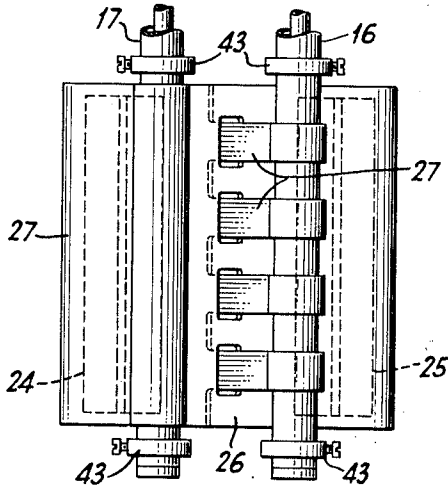


Fig. 10

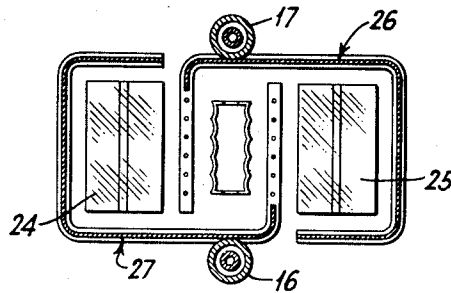


Fig. 8

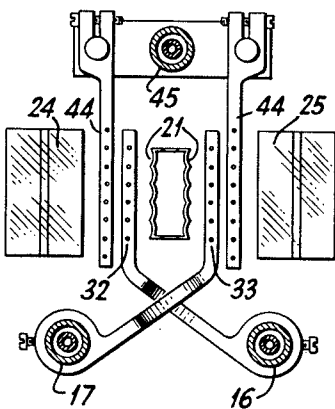
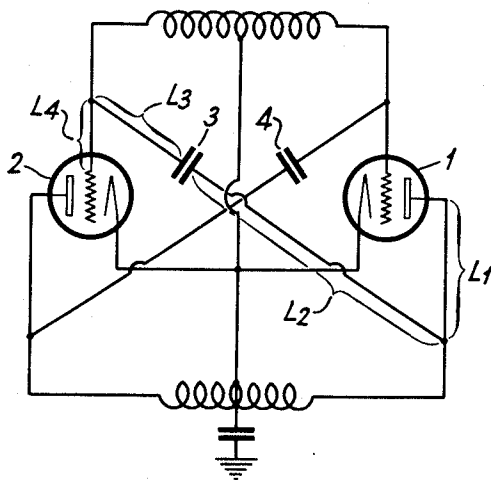


Fig. 11



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UNITED STATES PATENT OFFICE

2,257,794

ELECTRON DISCHARGE DEVICE

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Application July 29, 1939, Serial No. 287,235

9 Claims. (Cl. 250—27.5)

This invention relates to high frequency electron discharge devices, particularly devices for generating or amplifying ultra short waves of considerable power.

Since the high power necessary for radio transmission is usually greater than the power rating of conventional tubes, it has become common to connect several tubes in parallel or in push-pull in the output stage of the transmitter, the push-pull connection being preferred because of its symmetry and greater stability. The usual circuits for neutralizing parasitic oscillations in push-pull connected tubes utilize neutralizing condensers and are not only difficult to adjust, but become impractical at ultra high frequencies because of inherent inductance in the leads of the neutralizing circuits. This inductance comprises, with the neutralizing capacities, a resonant circuit which can be adjusted for resonance at one frequency only, and where the signal band is as wide as in television transmission the usual neutralizing circuit is particularly ineffective. The lead inductance, further, is common to the input and output circuits and to the neutralizing circuits and causes undesired inductive coupling between the circuits.

An object of my invention is an efficient electron discharge device adapted to deliver large amounts of short wave power.

Another object of my invention is a tube for ultra short wave operation in which the interaction between input, output and neutralizing circuits at ultra high frequencies is, for practical purposes, absent or negligible.

A more specific object of my invention is a single radio tube with sufficient power for transmission purposes, which is adapted for push-pull circuit connections, and which is stable in wide band operation.

According to my invention a filamentary cathode comprising a relatively wide ribbon of refractory metal is supported between two planar anodes, with each of the two outer faces of the cathode opposite and parallel to the anodes. A unique control grid is mounted between each anode and the opposing face of the cathode, the control grid for one anode being so constructed that it is capacitively coupled to the other anode. The capacity couplings between the grids and anodes are adjusted to impress upon each grid sufficient high frequency power of the proper phase to prevent parasitic oscillations, thus obviating the conventional neutralizing condensers.

Unusually high space current density characterizes my novel tube, the high radio frequency

power of the tube being effectively and efficiently controlled by my novel control grid structures without the generation of unwanted oscillations.

The characteristic features of my invention are specifically set forth in the appended claims and preferred embodiments of the invention are described in the following specification and shown in the accompanying drawings in which Figures 1 and 2 show longitudinal and transverse sections of one tube embodying my invention, Figures 3, 4 and 5 are detailed sectional views of means for adjusting interelectrode capacities in my novel tube, Figures 6 and 7 are end and side views, respectively, of another tube embodying my invention, Figure 8 is an end view of a screen grid tube embodying my invention, Figures 9 and 10, respectively, show specific forms of grid-plate coupling means of my invention, and Figure 11 shows a push-pull circuit, with inductances, which will aid in the discussion of my novel tube.

The conventional push-pull circuit comprises two tubes with their grids connected to opposite ends of an input transformer and with their anodes connected to opposite ends of an output transformer as shown in Figure 11. To overcome high frequency potential variations impressed upon the grid of one tube by its adjacent anode, it is customary to impress upon that grid a high frequency potential of opposite phase from the anode of the other tube. A neutralizing condenser 3 coupled between the grid of tube 2 and the anode of tube 1, for example, may be adjusted to impress upon the grid of tube 2 a potential of the necessary amplitude to neutralize undesired feedback potentials. At radio frequencies, such as in commercial broadcasting, there is practically no inductance in series with the neutralizing condenser, and the phase of the neutralizing voltage is 180° from the potential to be neutralized and prevents undesired oscillations. However, inherent inductance in each of the neutralizing circuits, such as L_1 in the lead-in wire to the anode of tube 1, inductance L_2 between the anode contact pin and condenser 3, L_3 between the condenser and the grid pin of tube 2, the L_4 of the lead-in conductor of grid of tube 2, becomes appreciable at ultra high frequency and converts the neutralizing circuit to a series tuned circuit which is resonant to only one frequency and renders the neutralizing circuit effective for only that frequency. In wide band amplification, such as in television or multi-channel communication, the conventional neutralizing circuit of Figure 11 becomes impractical. Even by placing tubes 1 and 2 as close together

as possible the inherent inductance in the electrode lead-in conductors and condenser corrections cannot be completely eliminated. The tube constructed according to my invention combines the electrode systems of tubes 1 and 2 in one envelope, eliminates inductance L_1 , L_2 , L_3 and L_4 , and replaces condenser 3 by interelectrode capacities within the tube.

The envelope of my novel tube shown in Figures 1 and 2 comprises a metal cylinder 10 closed at each end by metal plates or headers 11 and 12. Bushings 13 on the top plate electrically isolate and seal in the cathode leads 14 and 15 and control grid lead-in conductors or rods 16 and 17. Relatively long glass bushings 18 at the bottom of the envelope seal in and support the anode lead-in conductors 19 and 20. Depending centrally from the upper end of the envelope is the relatively wide ribbon-like filamentary cathode 21 of refractory electron emissive metal, such as tantalum or molybdenum, the ribbon being U-shaped and bent into two parallel sections flanged along the edges for strength, each section being formed with longitudinal vertical grooves or flutes and joined at their upper ends through metal terminal blocks 22 and 23 to the two cathode leads 14 and 15. The electrical center or bight of the cathode is preferably grounded to the envelope by a strap 21a, and to prevent emission from the flanged edges of the cathode a shield, not shown, may be mounted along and in close spaced relation with the flanges. Opposite each outer face of the filamentary cathode and parallel therewith is the electron collecting face of anodes 24 and 25, each anode comprising a rectangular block of metal with internal fluid cooling ducts supported upon fluid cooling pipes connected with the upper end of the anode lead-in conductors 19 and 20.

Each control grid electrode 26 and 27 shown in transverse cross section in Figure 2, comprises a U-shaped metal structure with the flat legs of the U parallel to the operative surfaces of the anodes and cathode and with the transverse portion of the U joined firmly to support the lead-in conductors 16 and 17. The transverse portion and one leg of grid structure 27 comprises an impervious sheet of metal, the edges of which are set into grooves of reinforcing bars 28 and 29, the bars extending from one end of the metal sheet opposite the rear of one anode to points opposite the forward edge of the other anode. Grid 26 is reinforced with bars 30 and 31. The end of each metal sheet terminates short of the electron space and is disposed parallel to a number of parallel wires 32 and 33 arranged opposite the ridges of the cathode between the cathode and anode. The grid wires are held at their ends in holes in the bars.

In operation, the field distribution between the control grid wires and at the curved surfaces of the cathode flutes is such that electrons leave normal to the surface of the cathode, form beams which pass between the spaced conductors of the control grid and terminate on the anode. The number of electrons striking the grid is accordingly reduced to a minimum so that most of the heating of the grid wires is by radiation, and practically all of the energy of the space current is dissipated at the bombarded face of the anode and in the anode circuit.

Novel means is provided to conduct away the heat generated at the face of the anode, it having been found that conventional methods of water cooling become ineffective where the

energy dissipated per unit area is of the order of several hundred watts per square centimeter. Each anode comprises a chamber fashioned from solid blocks of metal, the blocks being milled lengthwise to make a number of internal channels or fluid passages through which cooling fluid may flow, and as described in greater detail in co-pending application Serial No. 258,868, filed February 28, 1939, assigned to the assignee of this application, and in which I am co-inventor, the water flow through the channels is continuous and unimpeded by formation of steam bubbles. This anode has been found to dissipate greater amounts of power and heat per unit area of electron collecting surface than any anode known heretofore.

My improved tube may conveniently be connected in a conventional push-pull circuit by connecting the two grids in phase opposition to an input circuit and the two anodes to opposite ends of an output transformer, center tapped and radio frequency grounded. When so connected, it has been found that my tube may be efficiently operated as an amplifier without spurious oscillations by making equal the two capacities between any one grid and the two anodes. These capacities may be conveniently fixed during manufacture. With the capacity between any one grid structure and the two anodes of equal value, the radio frequency potentials impressed upon that grid by the two anodes are in phase opposition and neutralize each other. External neutralizing condensers, such as 3 and 4 in Figure 11, are thus obviated. The tube may be used as an efficient oscillator merely by unbalancing the capacities between the grids and anodes to provide the necessary feedback.

To adjust the grid-to-anode capacities in operation, movable levers or links may be sealed gas-tight in the wall of the envelope as shown in Figure 3. A grid structure of sheet metal may be flexible so that one leg of the grid structure may be flexed. The lever may comprise a rod 34 joined at one end through an insulating block to the outer leg of the grid and connected at its other end to the inside of a siphon bellows 35. By moving the rod inwardly or outwardly by a screw threaded yoke 36, the capacity between anode 24 and grid 27 may be accurately adjusted. Similar adjusting means may, of course, be provided for the other grid.

Grid-to-anode capacities may, alternatively, be adjusted by a linkage system which requires no special envelope lead-in seals. In Figure 4, for example, a rod 37 extending along the hollow water-tight cooling fluid channel of the control grid lead-in conductor 17 bears at its inner end on a plate 38 joined gas-tight to the lower end of grid conductor 17 through an expansible bellows, and is connected at its upper end to a water-tight bellows and to the screw adjusted bracket 39. Plate 38 is in close spaced relation and capacitively coupled relation to a second plate 40 mounted on the lower end of anode 24. By merely adjusting the thumb screw of bracket 39, the capacity between grid 27 and anode 24 may be easily varied.

A third alternative for adjusting interelectrode capacities is shown in Figure 5, where in the back side of anode 24 is provided a fluid chamber, separate from the fluid cooling channels in the anode, and comprising a flexible diaphragm 41 parallel to and in close spaced relation with the metal sheet of grid 27. Fluid pressure behind diaphragm 41 controlled by static fluid pressure

device 42 may easily adjust the spacing and capacity between the anode and the grid.

An alternative grid structure embodying my invention is shown in end and side views in Figures 6 and 7. The electrode assembly comprises a planar cathode 21 with the control grids and anodes on opposite sides of the cathode, and with the two lead-in conductors for the grids on the same side of the electrode assembly. The grid wires are supported and tensioned between arms 43 fixed to the lead-in conductors and the sheet metal portions of the grid structures are perforated along the line where the grids cross, as best shown in Figure 7, to make the electrical connection between the lead-in conductors and the grid structures substantially free of any resistance or inductance.

Where the capacity between an anode and its cooperating grid is reduced by a screen grid, the necessary capacity coupling between one grid and the opposite anode becomes correspondingly small. In the tube of Figure 8 two screen grids 44 are mounted on a single water-cooled support rod 45, which is preferably joined to the metal envelope. The lead-in conductor of one control grid is placed comparatively close to the anode on the opposite side of the cathode and the arms supporting the grid wires cross as shown. The grid arms may have offsets to electrically separate them at their cross-over points or may be displaced longitudinally along the grid lead-in conductors.

One end of each grid structure may, if desired, be interleaved with plates mounted directly on the anode on the opposite side of the cathode, as shown in Figure 9. One or more condenser plates 46 and 47 attached to form integral parts of the anodes are disposed in capacity relation with the grid structures as shown.

Anode capacities to ground increase the tube output impedance and narrow the band. Substantially all anode-to-ground capacities may be eliminated in tubes constructed according to my invention merely by extending the grid structures to substantially surround the anodes as shown in Figure 10. The metal sheet of each grid structure is extended to surround the three outer sides of each anode so that all lines of force emanating from the anode are intercepted by the grid structure. The capacities between any one grid and the two anodes may easily be made equal to completely neutralize undesired oscillations.

An electron discharge device constructed according to my invention is capable of amplifying large amounts of ultra short wave power, is easy to adjust for stable operation, is efficient in operation and inexpensive to manufacture.

I claim:

1. An electron discharge device comprising a metal envelope, a cathode in said envelope, two anodes, two control electrodes, each control electrode comprising wires between said cathode and the adjacent anode and a metal plate, said plate being positioned in capacitive relation with the anode adjacent the other control electrode, the plates extending between the anodes and the metal wall of the envelope to reduce anode-to-envelope capacity, and means for manually adjusting the spacing between said plates and said anodes.

2. An electron discharge device comprising an envelope, a cathode in said envelope, a first anode, a second anode, a first control electrode and a first screen grid between the cathode and said

first anode, a second control electrode and a second screen grid between the cathode and said second anode, the capacity between either control electrode through the screen grid to its adjacent anode being substantially equal to the capacity between said control electrode and the other anode.

3. An electron discharge device comprising an envelope, a cathode in said envelope, a first anode with a rear surface and an electron collecting surface facing said cathode, a second anode with a rear surface and an electron collecting surface facing said cathode, a separate control electrode between the cathode and the electron collecting surface of each anode, each control electrode comprising wires between the cathode and the electron collecting surface of its anode, and a metal sheet, the metal sheet of one control electrode extending from the boundary of the operative portions of said one control electrode to and between the envelope and the rear surface of the anode adjacent the other control electrode to shield said other anode from ground.

4. An electron discharge device comprising a tubular metal envelope, a planar filamentary type cathode having two oppositely directed rectangular emitting surfaces, parallel electron beam forming channels on each emitting surface, a planar anode with a rectangular electron collecting face spaced from and parallel to each of said emitting surfaces, two relatively heavy grid support rods forming lead-in conductors, each extending into the envelope and parallel to the anode-cathode spaces, a grid between each anode and its adjacent cathode emitting surface, each grid comprising parallel wires in registry with and opposite the boundaries between said channels of one of the emitting surfaces, a relatively large sheet of metal attached to the support rod of one grid and extending between the envelope and the anode adjacent the other grid.

5. An electron discharge device comprising a metal envelope, a planar filamentary type cathode having two oppositely directed rectangular emitting surfaces, a planar anode with a rectangular electron collecting face spaced from and parallel to each of said emitting surfaces, two relatively heavy lead-in conductor rods sealed in the end of said envelope and extending along and parallel to the edge of each anode, grid wire supported on one rod and held between one anode and the cathode, a non-inductive neutralizing element comprising a sheet of metal supported on said rod and extending between the metal wall of the envelope and the rear surface of the anode adjacent the other emitting surface.

6. An electron discharge device comprising an envelope, a planar type cathode having two rectangular emitting surfaces, a planar anode with a rectangular electron collecting face substantially coextensive with one emitting surface of said cathode and spaced from and parallel to each of said emitting surfaces, two relatively heavy lead-in conductor rods sealed in the end of said envelope and extending along the anode-cathode spaces, two grid structures each being supported on one of said rods, and each grid structure comprising wires supported between one anode and cathode and a sheet of metal supported on said one rod spaced from the rear surface of the other anode, the overall area of the grid in the anode-cathode space being substantially equal to the area of said sheet in registry with the adjacent anode.

7. An electron discharge device comprising an envelope, a filamentary cathode having two oppositely directed rectangular emitting surfaces in the envelope, a planar anode with a rectangular electron collecting face spaced from and parallel to each of said emitting surfaces, a lead-in conductor, a U-shaped grid structure, the transverse portion of the U being fixed to a lead-in conductor, one leg of the U extending between one anode and the cathode, and the other leg of the U extending parallel to and spaced from one face of the other anode, the operative portions of the two legs of the grid structure opposite the two anodes being substantially equal and having substantially equal capacities with their adjacent anodes.

8. An electron discharge device comprising an envelope, a planar cathode having two rectangular emitting surfaces, two planar anodes each with an electron collecting surface substantially coextensive with one of said emitting surfaces, spaced from and parallel to the emitting surface, a planar grid between each anode and the adjacent emitting surface of the cathode, a rod supporting each grid, a neutralizing element for

equalizing the capacity between each anode and any one grid, said neutralizing element comprising a condenser plate supported on said rod and extending into capacity relation with the anode adjacent the opposite grid, the area of the plate opposite the anode being substantially equal to the area bounded by the grid opposite the other anode.

9. An electron discharge device comprising an envelope, a filamentary cathode comprising a relatively wide ribbon of refractory electron emissive metal with a plurality of side-by-side electron beam forming channels, two anodes facing different portions of said cathode, a control grid between each anode and the cathode comprising a plurality of wires parallel to and opposite the boundaries between said channels, a relatively heavy lead-in conductor, the wires of one grid being supported on said conductor, a metal plate supported upon said conductor and spaced a predetermined distance from the rear surface of the anode adjacent the other grid, said plate being substantially coextensive with said surface.

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