

Aug. 18, 1942.

H. M. WAGNER

2,293,418

ELECTRON DISCHARGE DEVICE

Filed Sept. 27, 1940

3 Sheets-Sheet 1

Fig. 1

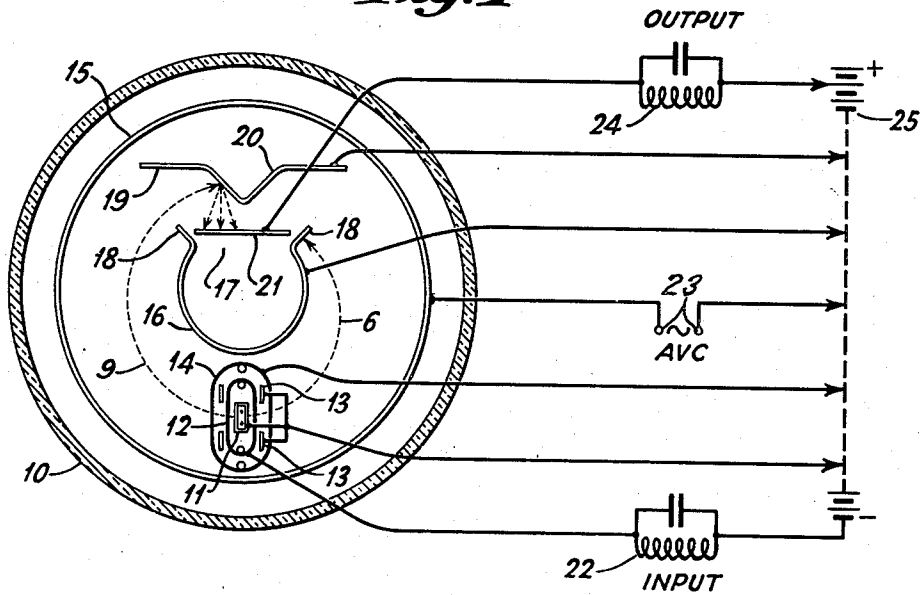
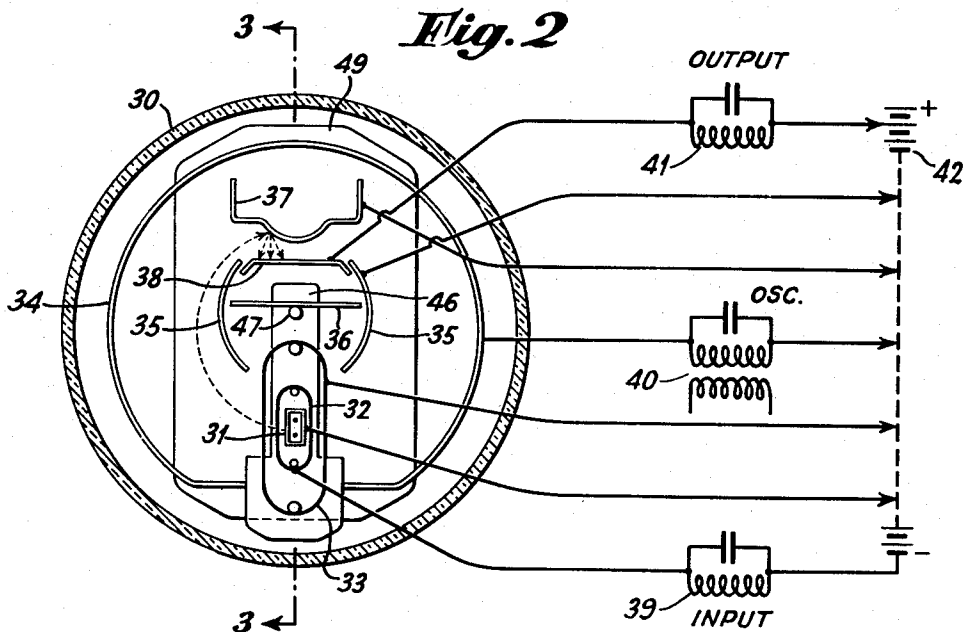


Fig. 2



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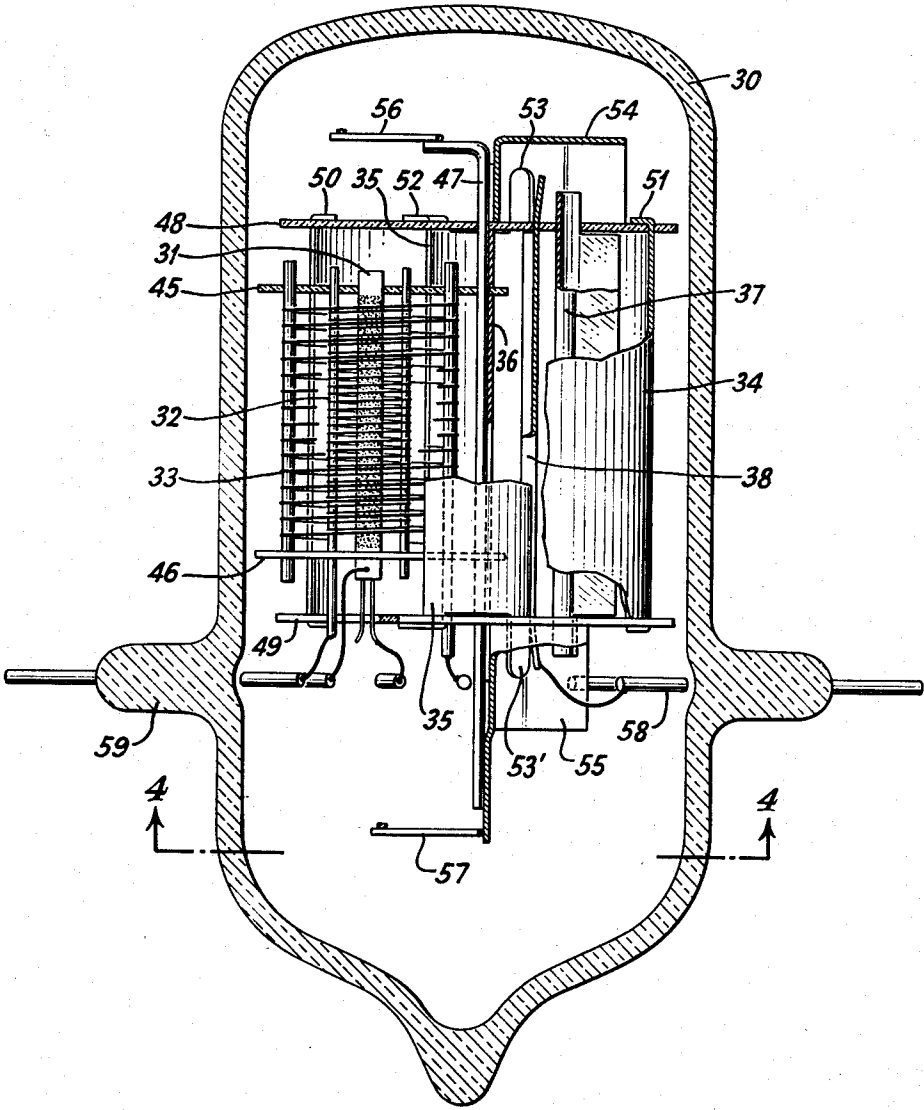
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3 Sheets-Sheet 2

Fig. 3



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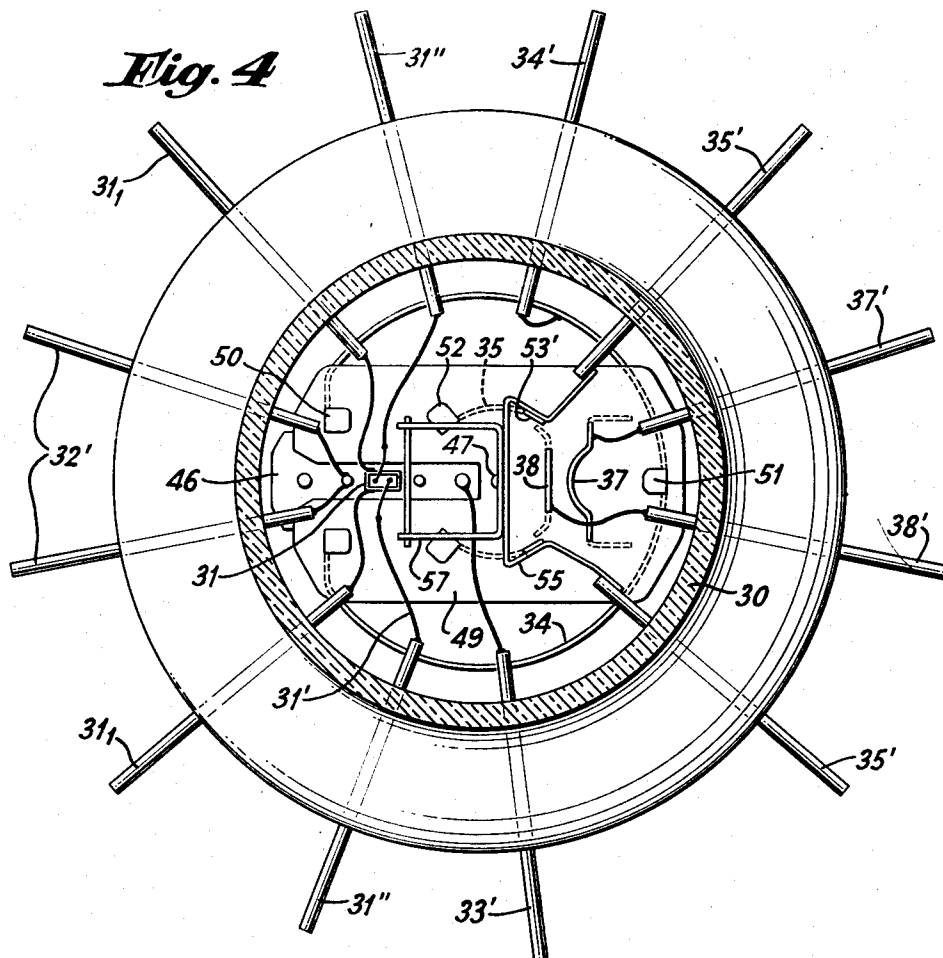
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ELECTRON DISCHARGE DEVICE

Filed Sept. 27, 1940

3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE DEVICE

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Application September 27, 1940, Serial No. 358,629

20 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices, more particularly to beam tubes utilizing an orbital beam and secondary emission amplification and useful for many different applications at both low and ultra high frequencies.

Straight beams and secondary emitting surfaces have been utilized for increasing the transconductance of conventional and beam type tubes but where the straight beam is used and where secondary emitting surfaces are exposed directly to the cathode, material evaporated from the thermionic cathode may deposit on the secondary emitting surfaces and cause reduction of emission from the secondary emitting surfaces. Further, where straight beams are used comparatively long beam paths are necessary to provide a desirable sensitivity where deflection is useful and in some tubes of this type the beam focus is affected when the beam is deflected by the deflecting electrodes, especially when a single deflection electrode is used for control instead of a push-pull arrangement of deflecting electrodes. In order to accommodate the electrode system of straight beam tubes, the tube envelopes must be of some length and sometimes of an odd shape.

In utilizing conventional radio tubes at the ultra-high frequencies as amplifiers, one of the difficulties encountered is excessive coupling between the input and output electrodes. To overcome this difficulty a separation of function between the control electrodes and output electrodes must be provided for. Excessive coupling is usually due to mutual capacitance and mutual inductance between electrodes, the leads and other circuit elements. While very thorough shielding, the use of short leads and the use of novel circuits serve to rectify this difficulty at least to a certain extent, in many cases, to reduce the interelectrode coupling, a considerable increase in separation between the high frequency electrodes must be made, which in turn affects the operation of the tube at high frequencies when the transit time of the electrons becomes important. Again at the high frequencies in beam type tubes utilizing orbital beams, due to the transit time of the electrons at high frequencies and particularly where secondary electrons are utilized, the electrons may be collected at the output electrode in an out of phase relation, reducing the effectiveness of the device.

In automatic and manual volume control circuits where customary grid bias control is used, due to the fact that the cathode current does not remain constant, a change in input capacitance and damping and consequent detuning in

high frequency circuits results. Hence, means which will permit control of the volume without changing the cathode current is desirable.

It is therefore the principal object of my invention to provide an electron discharge device employing a beam and secondary emission amplification, and having improved characteristics.

More specifically an object of my invention is to provide such an electron discharge device in which the secondary emitting surfaces are protected from deposition of evaporated material from the cathode which would reduce the secondary emitting qualities of the secondary emitting surfaces.

Another object of my invention is to provide an electron discharge device utilizing a beam and having an increased sensitivity over conventional beam devices using straight beams and of comparable overall dimensions.

Another object of my invention is to provide an electron discharge device in which both the input and output capacitances are reduced.

A further object of my invention is to provide a beam tube in which while the sensitivity is increased no ill effects of defocusing of the beam are experienced when the deflecting electrodes go into operation.

It is a still further object of my invention to provide such a device particularly suitable for use at high frequencies and in which the undesirable effects of the transit time of the electrons in said devices when utilized at high frequencies are substantially eliminated.

Another object of my invention is to provide an electron discharge device which is particularly suitable as an amplifier at ultra high frequencies.

Still another object of my invention is to provide an electron discharge device employing a beam which is particularly suitable for volume control purposes at high frequencies.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a transverse view of an electron discharge device made according to my invention and its associated circuit when utilized as an automatic volume control device, and Figure 2 is a top end view of the electrode mount partially schematic for clarity of a modification of the electron discharge device shown in Figure 1, and its associated circuit when used as a mixer tube, Figure 3

is a longitudinal section of the tube shown in Figure 2, showing details of construction, and Figure 4 shows the lead arrangement and details of construction of the tube shown in Figure 3.

Referring to Figure 1, an electron discharge device made according to my invention comprises an evacuated envelope 10 containing the electrodes of the electron discharge device. A flat cathode 11 coated on opposite sides with emitting material is surrounded by a control grid 12, and provides a pair of oppositely disposed beams from the cathode. Beam forming electrodes 13 normally maintained at cathode potential are positioned outside the control grid and between the control grid 12 and screen grid 14. The oppositely directed beams indicated by the dotted lines pass between the oppositely disposed surfaces of the tubular electrode 15 and inner tubular electrode 16 provided with an opening 17 substantially 180° removed from the cathode and having radial shielding extensions 18. A secondary emitting electrode 19 is disposed outside of and opposite opening 17 in the inner tubular member 16. It is provided with an extending V-shaped surface 20 for purposes to be described below. The surface of electrode 19 facing the opening is coated with material for emitting secondary electrons when struck by the electron beams from the cathode 11. Positioned within the opening 17 and oppositely disposed to the V-shaped surface of the secondary emitting electrode 19 is the flat output electrode 21.

An input circuit 22 is connected between the control grid 12 and the cathode, and the output circuit 24 to the output electrode 21. The automatic volume control voltage may be applied to the outer tubular member 15 at the terminals 23. A source of voltage for applying proper potentials to the various electrodes is indicated at 25.

In operation the beam is directed against the inclined surfaces of the V-shaped portion 20 of the output electrode for releasing secondaries which travel toward and are collected by the output electrode 21. If the device is used as a mixer tube the local oscillating frequency may be applied to the electrode 15, causing the beam to travel between the two positions indicated by the dotted lines 6 and 9, the input voltage being applied to the control grid. When used as an automatic volume control tube the outer electrode 15 may again be used to deflect the beam so that more or less of the beam strikes the emitting surface of electrode 19 to vary the output current. The advantages of using the tube as a volume control device is that the current and transconductance of the output electrode can be controlled by deflecting the electron beam without varying the cathode current which remains substantially constant. This avoids changes in input capacitance and the consequent detuning which would result in high frequency circuits.

Electrode 19 is specially formed so that the spacing between it and electrode 21 decreases toward the center of the electrodes, that is toward the apex of the V. Electrons from different parts of the cathode leaving the cathode at the same time may strike different portions of the V-shaped part 20 of the secondary emitting electrode 19. Those hitting nearer the edges of the electrode 20 reach that electrode sooner because they have a shorter orbital path to

travel than electrons hitting nearer the apex of the V. Thus secondary electrons are released sooner nearer the outer edges of the electrode 19 than nearer the apex of the V-shaped surface by primary electrons leaving the cathode the same time. But the secondary electrons from the surface of electrode 19 nearer the outer edge of the electrode require more time to reach electrode 21 than the secondary electrons released from the apex of the V-shaped portion of the secondary emitting surface since they have a greater distance to travel. Hence substantially all of the secondary electrons released by the primary electrons leaving the cathode together reach the surface of electrode 21 and are absorbed by this electrode at substantially the same time and in the proper phase relationship. This difference in the time of travel or transit time of the primary and secondary electrons becomes important at the ultra high frequencies. The shaping of the electrodes provides not only proper spacing but a desirable electrostatic field and also prevents interaction between the two oppositely directed beams. While shown as a V, other arrangements will satisfy the requirements for proper operation at high frequencies provided that the surfaces of the secondary electron emitting electrode and the output electrode approach each other in travelling toward the center of the electrodes. Thus the V-shaped portion could, for example, be replaced by a rounded portion and the plane surface of the collector by some other surface whereby the spacing between the electrodes increases as the outer edges of the electrodes are approached.

The modification shown in Figure 2 comprises envelope 30 containing the flat cathode 31, control grid 32 and screen grid 33. A tubular electrode 34 is positioned with respect to the cathode so that oppositely directed beams pass along the inner surface of this electrode. The inner tubular electrode in this case comprises a pair of arcuate shaped members 35 electrically connected to the shield member 36. The beams are directed between the oppositely disposed surfaces of the outer tubular electrode 34 and the arcuate shaped electrodes 35. The secondary emitting electrode 37 is disposed 180° removed from the cathode and is provided with a rounded raised surface which could be of V-shape extending toward the output electrode 38 positioned within the opening formed by the arcuate shaped members 35.

This modification is shown used in connection with a mixer tube circuit, the input being applied to the control grid 32 by input circuit 39 and the local oscillator voltage to the electrode 34 by the oscillator circuit 40, the output circuit 41 being connected to the output electrode 38, the source of voltage 42 providing the voltages for the various electrodes.

One very effective means of minimizing input capacitance in a receiving tube is to use small input electrodes, for example, a small cathode and control grid which provide a small modulated current, and then making use of the phenomena of secondary emission to generate a larger current, thus effectively increasing the transconductance of the low capacitance input structure.

The actual constructional features of a tube for accomplishing this purpose and incorporating the electrodes shown in Figure 2 are shown in Figures 3 and 4. As there shown the cathode 31, which is made flat in order to produce two well-

defined beams, emerging from the cathode in opposite directions, control grid 32 and screen grid 33 are supported between a pair of insulating supports and spacers 45 and 46 which may be of mica, all of these electrodes being shorter than the other electrodes comprising the mount. This assembly is supported by and locked to the shield 36 by extending the micas 45 and 46 through slots in the shield 36 and extending a locking rod 47 through apertures in the mica and welding or otherwise securing this side rod or locking rod to the shield.

One of the reasons for making the cathode, control grid and screen grid assembly shorter in length than the rest of the electrodes was to eliminate the effects of the fields at the top and bottom of the mount. It is desirable to subject the electrons to substantially the same field throughout the beam and by keeping the electron beam away from the upper and lower ends of the mount the electrons are subjected to a more uniform field than they would otherwise be. While it would have been possible to reduce the emitting surface by spraying only a portion of the cathode and extending the cathode and grid wires through the top and bottom micas 48 and 49, this would increase the interelectrode capacities and make the cathode and grid assembly less rigid for assembly.

In order to obtain maximum current controlling action by the control grid 32, it is mounted as close as practical to the cathode. The subsequent current multiplication at the secondary emitter increases the effectiveness of grid control by a factor approximately equal to the secondary emission ratio which in tubes made according to the present invention is about five. Thus a small control grid having a low interelectrode capacitance effectively controls a large output current, which is an important factor for wide-band operation. From the high frequency standpoint this feature is also beneficial because low capacitance produces low circulating current and thus circuit losses are reduced.

A pair of mica spacers 48 and 49 have positioned between them and support the outer cylindrical electrode 34 secured to the mica by means of extensions 50 and 51 extending through the micas. The arcuate shaped electrodes 35 are secured to the mica by means of ears or extensions 52 and 53 extending through the micas, the extension 52 being bent over against the mica and the ear 53 secured to a shield 54 which is also electrically connected to the rod 47 and shield 36 so that the top shield 54 and shield 55 at the bottom of the mount are electrically connected. The lower end of shield 35 is also electrically connected to the lower shield 55 by extensions 53' of members 35. These two shields effectively shield the output comprising the secondary emitter 37 and output electrode 38 from the input. Getter assemblies 56 and 57 may be provided at the top and bottom of the mount.

As shown in Figure 2, the focusing system consisting of the outer tubular member 34 and inner arcuate-shaped members 35 provide a radial field between them which deflects the electron beams toward the secondary emitter 37. The radial field in addition to deflecting beams tends to focus the electrons. The two beams which initially leave the cathode are slightly diverging when issuing from the openings of the screen grid 33 but are focused by the action of the radial field to converge on the emitter electrode 37. Thus the width of the beam on the secondary

emitter may be reduced to the width of the primary cathode. For best focusing action the potentials on the focusing electrodes and the velocity of the electrons in the beam must be properly adjusted. The electrodes in the tube are designed so that good focusing is obtained when the voltage on the outer cylinder or tubular member 34 is made zero or slightly negative with respect to the cathode, when the tube is used as an amplifier.

Because the secondary emitter 37 and output electrode 38 are mounted on the side of the tube opposite the cathode side, the focusing electrodes 35 and shield 36 serve as a screen between the input and output of the tube; that is, between the cathode and the secondary emitter and output electrode, so that material evaporated from the oxide coated cathode, which would affect the secondary emitting surfaces, impinges on the tubular electrodes rather than on the secondary emitting surface.

The loss of transconductance due to space charge effects during electron transit time from the screen 33 to the secondary emitter is small even though the transit time from the screen to the emitter may be comparable to the period of oscillation. This result is due to the fact that current in the long beam is comparatively small. The effect is, that the large output current is generated only at the secondary emitter, and the transit time of secondary electrons to the plate is short.

As shown in Figures 3 and 4, the mount assembly is electrically connected to and supported by radially extending leads which are sealed into the radial lip 59 formed when the upper and lower cup-shaped portions of the tube envelope are sealed together. The lead arrangement is best shown in Figure 4 which also shows details of construction of the lower end of the tube. Two leads are provided for most of the electrodes with the low potential leads positioned to act as shields for other electrode leads. As shown the two control grid leads 32' are shielded by means of the low potential cathode leads 31', the cathode heater leads 31'' being positioned on the other side of the cathode leads. The outer tubular lead 34' and the screen lead 33' are electrically shielded by means of the shield leads 35' connected to shield 35, the shield 55 and leads 35' shielding the secondary emitter lead 37' and output electrode lead 38'. Thus in the arrangement shown maximum shielding and separation are provided between input and output electrodes and electrode leads. The use of two leads for the same electrode minimizes lead inductance and reduces loss due to circulating currents. The two cathode leads provide low impedance for the grid-cathode circulating current. All of the auxiliary electrodes may be by-passed to radio frequency ground by means of by-pass condensers and circuits connected to the tube. At the highest frequencies special circuits may be used to tune out lead impedance.

Tubes made according to my invention have transconductances of approximately 20,000 micromhos while some tubes tested as high as 24,000 micromhos. Tubes incorporating my invention have also shown a gain of 6 and 7 when used as wide-band amplifiers at 400 or 500 megacycle operation.

While I have indicated the preferred embodiments of my invention of which I am now aware

and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device including an envelope containing a cathode for supplying electrons, a control grid for said cathode and means for forming electrons from the cathode into a beam, means including a second control electrode adjacent the beam of electrons for causing said beam to travel along a curved path, an electrode positioned in the path of said beam and coated with emitting material for emitting secondary electrons when struck by said beam, and an output electrode adjacent the secondary electron emitting electrode for receiving secondary electrons emitted by said secondary electron emitting electrode, said output electrode being positioned between the cathode and the secondary emitting electrode and having a plane surface and the secondary emitting electrode having a plane surface disposed at an angle to said output electrode, and means for shielding said output electrode from direct bombardment by the electron beam.

2. An electron discharge device including an evacuated envelope containing a cathode for supplying electrons, and means for forming electrons from the cathode into a beam, a control electrode for said beam of electrons, an electrode positioned in the path of the beam and coated with emitting material for emitting secondary electrons when struck by said beam, and an output electrode adjacent the secondary electron emitting electrode and between said cathode and secondary emitting electrode for receiving secondary electrons emitted by said secondary electron emitting electrode, said secondary emitting electrode and said output electrode having surfaces approaching each other in the direction of travel of the electron beam, and means for shielding said output electrode from direct bombardment by the electron beam.

3. An electron discharge device having an envelope containing a cathode for emitting electrons, a grid surrounding the cathode, means adjacent the grid and cathode for forming electrons from the cathode into a pair of oppositely disposed beams, means in the path of said beams for causing said beams to travel curved paths and including a second control electrode, an intercepting electrode for intercepting the beams and coated with secondary emitting material for releasing secondary electrons when struck by said beams, said intercepting electrode having a V-shaped surface and an output electrode having a plane surface oppositely disposed to said V-shaped surface, the surfaces of the V-shape being directed at an angle to the plane surface of the output electrode, the peak of said V-shaped surface being closest to said plane surface of the output electrode, and means for shielding said output electrode from direct bombardment by the electron beam.

4. An electron discharge device including an evacuated envelope containing a cathode for supplying electrons, and means for forming electrons from the cathode into a beam, a control electrode for said beam of electrons, means in-

cluding a second control electrode adjacent the beam of electrons for deflecting said beam, an electrode positioned in the path of the beam and coated with emitting material for emitting secondary electrons when struck by said beam, and an output electrode adjacent the secondary electron emitting electrode and between said cathode and output electrode for receiving secondary electrons emitted by said secondary electron emitting electrode, said secondary emitting electrode and said output electrode having surfaces approaching each other in the direction of travel of the electron beam, and means for shielding said output electrode from direct bombardment by the electron beam.

5. An electron discharge device having an envelope including a cathode surrounded by a control grid, means for forming the electrons from the cathode into a beam, a pair of concentric tubular electrodes, one of said tubular electrodes being positioned on each side of said cathode and control grid so that the beam of electrons passes between the opposed surfaces of the tubular electrodes for causing said beam to travel a curved path, the inner tubular electrode being provided with an opening removed substantially 180° from the cathode, and an electrode positioned in the path of the beam and having a plane surface, said surface being coated with secondary electron emitting material whereby secondary electrons are released from said surface when struck by the beam of electrons, and an output electrode positioned in the opening in the inner tubular electrode and having a plane surface positioned at an angle to the surface coated with secondary emitting material for collecting secondary electrons.

6. An electron discharge device having an evacuated envelope containing a cathode for emitting electrons, a grid surrounding the cathode, means for forming said electrons into a pair of oppositely disposed beams, means in the path of said beams for causing said beams to travel curved paths and including a second control electrode, an electrode for intercepting the beams and coated with secondary electron emitting material for releasing secondary electrons when struck by said beams, an output electrode adjacent the secondary electron emitting electrode and between said cathode and the secondary emitting electrode for receiving the secondary electrons, said intercepting electrode and said output electrode having surfaces approaching each other in the direction of travel of the electron beams, and means for shielding said output electrode from direct bombardment by the electron beam.

7. An electron discharge device having a cathode surrounded by a control grid and means for forming electrons from the cathode into a pair of oppositely disposed beams, a pair of concentric tubular electrodes mounted adjacent the cathode and the control grid so that the beams of electrons pass between the opposed surfaces of the tubular electrodes for causing said beams to travel curved paths, the inner tubular electrode having a longitudinal opening on the opposite side of the tubular electrode from the cathode, an output electrode positioned within said opening and having a plane surface, an electrode positioned between the outer tubular electrode and the output electrode for intercepting the electron beams and having a V-shaped surface extending toward said opening and said output electrode whereby secondary electrons released from the

surfaces of the V-shaped portion of the secondary emitting electrode are absorbed by the output electrode.

8. An electron discharge device having an envelope containing a cathode for emitting electrons, a grid surrounding the cathode, means adjacent the grid and cathode for forming electrons from the cathode into a pair of oppositely disposed beams, means in the path of said beams for causing said beams to travel curved paths toward each other and including a second control electrode, an electrode for intercepting said beams and coated with secondary emitting material for releasing secondary electrons when struck by said beams, said intercepting electrode having a raised surface intermediate its ends for intercepting said beams and keeping said beams separated, and an output electrode having a plane surface oppositely disposed to said raised surface, the raised surface of the secondary emitting electrode and the plane surface of the output electrode approaching each other in the direction of travel of the electron beams toward the center of said raised surface, and means for shielding said output electrode from direct bombardment by the electron beam.

9. An electron discharge device having an envelope including a cathode for supplying electrons, means for forming electrons from the cathode into a beam, a pair of concentric tubular electrodes, one of said concentric electrodes being positioned on each side of the cathode so that the beam of electrons passes between the opposed surfaces of the concentric electrodes causing said beam to travel a curved path, the inner concentric electrode being provided with an opening removed substantially 180° from the cathode and an electrode positioned in the path of the beam opposite said opening and coated with secondary electron emitting material whereby said secondary electrons are released from said surface when struck by said beam of electrons, an output electrode positioned in the opening in the inner concentric electrode and having a plane surface positioned at an angle to the surface coated with secondary emitting material for collecting secondary electrons.

10. An electron discharge device having an envelope including a cathode for supplying electrons, means for forming electrons from the cathode into a beam, a pair of concentric tubular electrodes, one of said concentric electrodes being positioned on each side of the cathode so that the beam of electrons passes between the opposed surfaces of the concentric electrodes causing said beam to travel a curved path, the inner concentric electrode being provided with an opening removed substantially 180° from the cathode and an electrode positioned in the path of the beam opposite said opening, and an electrode positioned in the opening in the inner concentric electrode.

11. An electron discharge device having a cathode surrounded by a control grid and means for forming electrons from the cathode into a pair of oppositely disposed beams, a pair of concentric tubular members mounted adjacent the cathode and the control grid so that the beams of electrons pass between the opposed surfaces of the tubular electrodes for causing said beams to travel curved paths, the inner tubular member having a longitudinal opening on the opposite side of the tubular member from the cathode and radial fins extending outwardly from the longitudinal edges of said opening, an out-

put electrode positioned within said opening and having a plane surface, an electrode positioned between the outer tubular electrode and the output electrode for intercepting the electron beams and having a V-shaped surface extending toward said opening and said output electrode whereby secondary electrons released from the surfaces of the V-shaped portion of the secondary emitting electrode are absorbed by the output electrode.

12. An electron discharge device having a cathode surrounded by a control grid and a screen grid, and electrodes between said grids for forming electrons from the cathode into a pair of oppositely disposed beams, a pair of concentric tubular members mounted adjacent the cathode and the control grid so that the beams of electrons pass between the opposed surfaces of the tubular electrodes for causing said beams to travel curved paths, the inner tubular member having a longitudinal opening on the opposite side of the tubular member from the cathode, an output electrode positioned within said opening and having a plane surface, an electrode positioned between the outer tubular electrode and the output electrode for intercepting the electron beams and having a V-shaped surface extending toward said opening and said output electrode whereby secondary electrons released from the surfaces of the V-shaped portion of the secondary emitting electrode are absorbed by the output electrode.

13. An electron discharge device having an envelope including a cathode surrounded by a control grid and means for forming electrons from the cathode into a pair of oppositely disposed beams, a tubular electrode surrounding said cathode and control grid but eccentric thereto, an inner electrode comprising a pair of oppositely disposed arcuate shaped members adjacent the cathode and control grid and within said tubular electrode, the oppositely disposed electron beams from the cathode being directed between the opposed surfaces of the tubular electrode and the arcuate shaped elements of the inner electrode during operation of the electron discharge device, a secondary emitting electrode positioned within said tubular electrode and on the opposite side of the inner electrode from said cathode and an output electrode positioned opposite the secondary emitting electrode and within the space provided between the arcuate shaped members of the inner electrode for receiving secondary electrons from the secondary emitting electrode.

14. An electron discharge device having an envelope including a cathode surrounded by a control grid and means for forming electrons from the cathode into a pair of oppositely disposed beams, a tubular electrode surrounding said cathode and control grid but eccentric thereto, an inner electrode comprising a pair of oppositely disposed arcuate shaped members adjacent the cathode and control grid and within said tubular electrode, the oppositely disposed electron beams from the cathode being directed between the opposed surfaces of the tubular electrode and the arcuate shaped elements of the inner electrode during operation of the electron discharge device, a secondary emitting electrode positioned within said tubular electrode and on the opposite side of the inner electrode from said cathode, and an output electrode positioned between the secondary emitting electrode and within the space provided between the arcuate

shaped members of the inner electrode for receiving secondary electrons from the secondary emitting electrode, said secondary emitting electrode having a V-shaped surface extending toward the output electrode and said output electrode having a plane surface transverse to the apex of the V-shaped surface.

15. An electron discharge device having an envelope containing an electrode assembly comprising a cathode surrounded by a control grid and screen grid, and including means for forming the electrons emitted by the cathode into two oppositely directed electron beams, a tubular electrode provided with a longitudinal slot and substantially surrounding the cathode, control grid and screen grid but eccentrically positioned with respect thereto whereby a portion of the electrode assembly extends through said longitudinal slot, an inner electrode centrally disposed with respect to the tubular electrode and having a pair of oppositely disposed arcuate shaped elements electrically connected together, the beam from the cathode being directed between the oppositely disposed surfaces of the outer tubular electrode and the inner electrode during operation of said electron discharge device, a secondary emitting electrode positioned within the outer tubular electrode and on the opposite side of the inner electrode from said cathode and provided with a surface coated with secondary electron emitting material for intercepting the electron beams and an electrode having a plane surface positioned within the arcuate shaped members and oppositely disposed to said surface of the secondary emitting electrode to receive secondary electrons from the said surface.

16. An electron discharge device including an evacuated envelope containing a cathode surrounded by a control grid, said cathode and control grid being supported between a pair of spaced insulating members, a tubular electrode surrounding said cathode and grid and eccentric therewith, an electrode oppositely disposed to said cathode and grid within said tubular electrode, and an electrode comprising arcuate shaped elements and a sheet metal shielding member positioned between the cathode and the electrode oppositely positioned thereto, the insulating members supporting said cathode and grid extending through and supported by said shielding member, and insulating supporting members secured to said tubular electrode insulatingly supporting the other electrodes and shielding member within the tubular electrode.

17. An electron discharge device comprising an evacuated envelope and containing a cathode, control grid and screen grid, and a pair of supporting and spacing insulating members secured to opposite ends of the cathode and grids, a tubular electrode eccentric with respect to and surrounding said cathode and grids, and a pair of oppositely disposed electrodes positioned within but on the opposite side of the tubular electrode from the cathode and grids, an electrode intermediate said cathode and pair of oppositely disposed electrodes and comprising a sheet metal shielding electrode and a pair of oppositely disposed arcuate shaped elements providing with the tubular electrode a curved passageway between the cathode and the oppositely disposed electrodes, the insulating members supporting the cathode and grids extending through and supported by the shielding electrode, and sheet insulating members at the opposite ends

of the tubular electrode supporting the other electrodes within the tubular electrode, the cathode and grids being of shorter length than said tubular electrode.

18. An electron discharge device comprising an evacuated envelope and containing a cathode, control grid and screen grid, and a pair of supporting and spacing insulating members secured to opposite ends of the cathode and grids, a tubular electrode eccentric with respect to and surrounding said cathode and grids, and a pair of oppositely disposed electrodes positioned within but on the opposite side of the tubular electrode from the cathode and grids, an electrode intermediate said cathode and pair of oppositely disposed electrodes, and comprising a sheet metal shielding electrode and a pair of oppositely disposed arcuate shaped elements providing with the tubular electrode a curved passageway between the cathode and the oppositely disposed electrodes, the insulating members supporting the cathode and grids extending through and supported by the shielding electrode, and sheet insulating members at the opposite ends of the tubular electrode supporting and spacing the other electrodes within the tubular electrode, the cathode and grids being of shorter length than said tubular electrode, and shielding members extending above and below the sheet insulating members for shielding the oppositely disposed electrodes from the other electrodes within the envelope.

19. An electron discharge device comprising an evacuated envelope and containing a cathode, control grid and screen grid, and a pair of supporting and spacing insulating members secured at opposite ends of the cathode and grids, a tubular electrode eccentric with respect to and surrounding said cathode and grids, and a pair of oppositely disposed electrodes positioned within but on the opposite side of the tubular electrode from the cathode and grids, an electrode intermediate said cathode and pair of oppositely disposed electrodes and comprising a sheet metal shielding electrode and a pair of oppositely disposed arcuate shaped elements providing with the tubular electrode a curved passageway between the cathode and the oppositely disposed electrodes, the insulating members supporting the cathode and grids extending through and secured to the shielding electrode, and sheet insulating members at the opposite ends of the tubular electrode supporting and spacing the other electrodes within the tubular electrode, and shielding members extending above and below the sheet insulating members for shielding the oppositely disposed electrodes from the other electrodes within the envelope, and radial leads extending through the wall of the envelope and electrically connected to the various electrodes within the envelope.

20. An electron discharge device including an evacuated envelope containing a cathode and a closely spaced control grid and screen grid surrounding said cathode, and a pair of insulating spacer members at opposite ends of the cathode and grids supporting said cathode and grids in spaced relation, a tubular electrode lying along the same longitudinal axis as said cathode and surrounding said cathode and grids but eccentric thereto, a secondary emitting electrode and an oppositely disposed output electrode positioned at the other side but within said tubular electrode, an electrode intermediate the cathode and the secondary emitting and output

electrodes and comprising a sheet metal shield member transverse to the plane passing through the cathode and output electrode, and a pair of arcuate shaped members at opposite sides of the metal shield and forming with the outer tubular electrode curved passageways between the cathode and the secondary emitting electrode, the insulating spacer members supporting the cathode and grids extending through said shield member and secured thereto supporting the cathode and grids in a spaced relation with

5 respect to said tubular member, said output electrode lying between the arcuate shaped members on one side of the shield member and the cathode and grid assembly extending between the arcuate shaped members on the other side of the shield member, the electrons from the cathode passing between the surfaces of the arcuate shaped members and the outer tubular electrode during operation of said electron discharge device.

10
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