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Dec. 14, 1948. D. G. BURNSIDE 2,456,579

ELECTRON DISCHARGE DEVICE FOR ULTRA HIGH FREQUENCIES

Filed Oct. 30, 1942 4 Sheets-Sheet 1

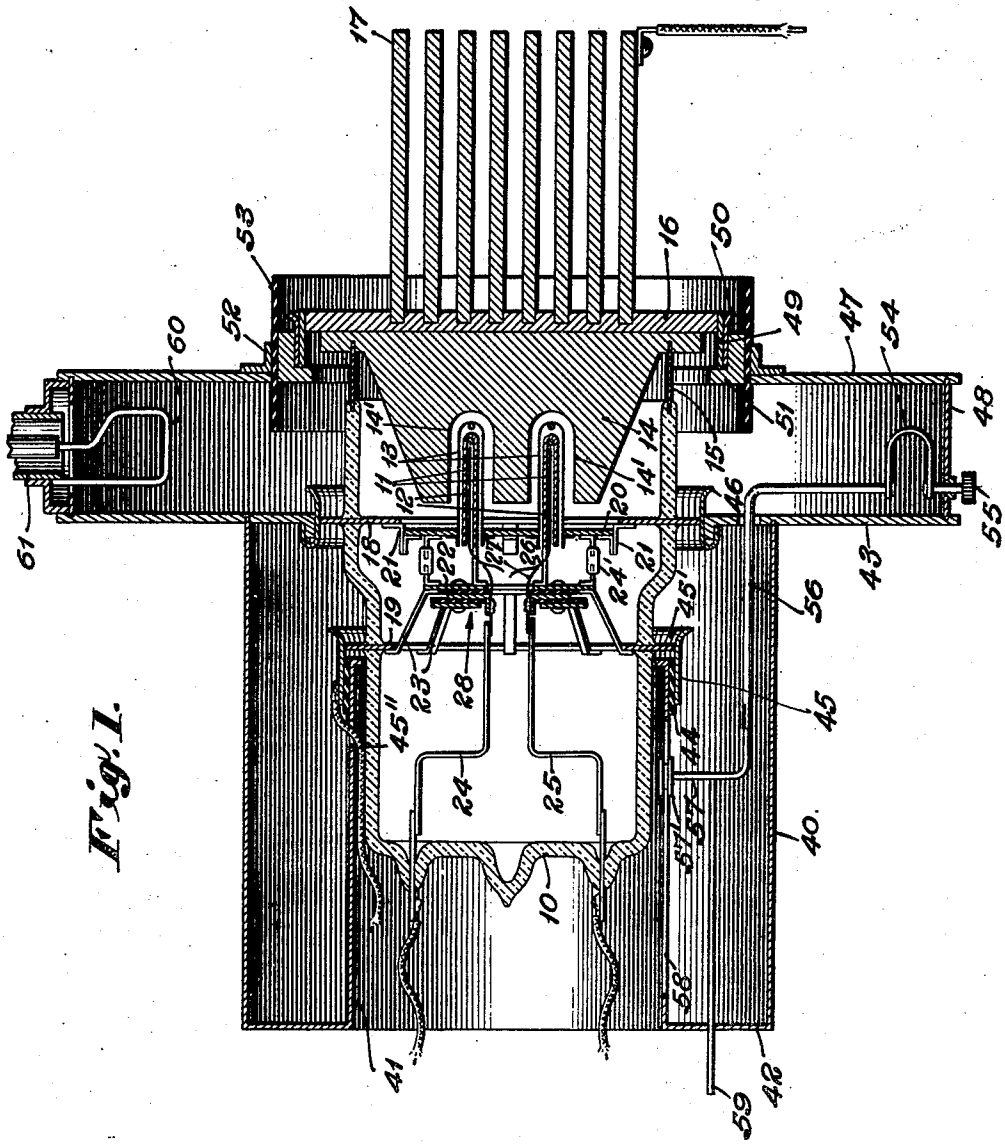


Fig. 1.

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Fig. 3.

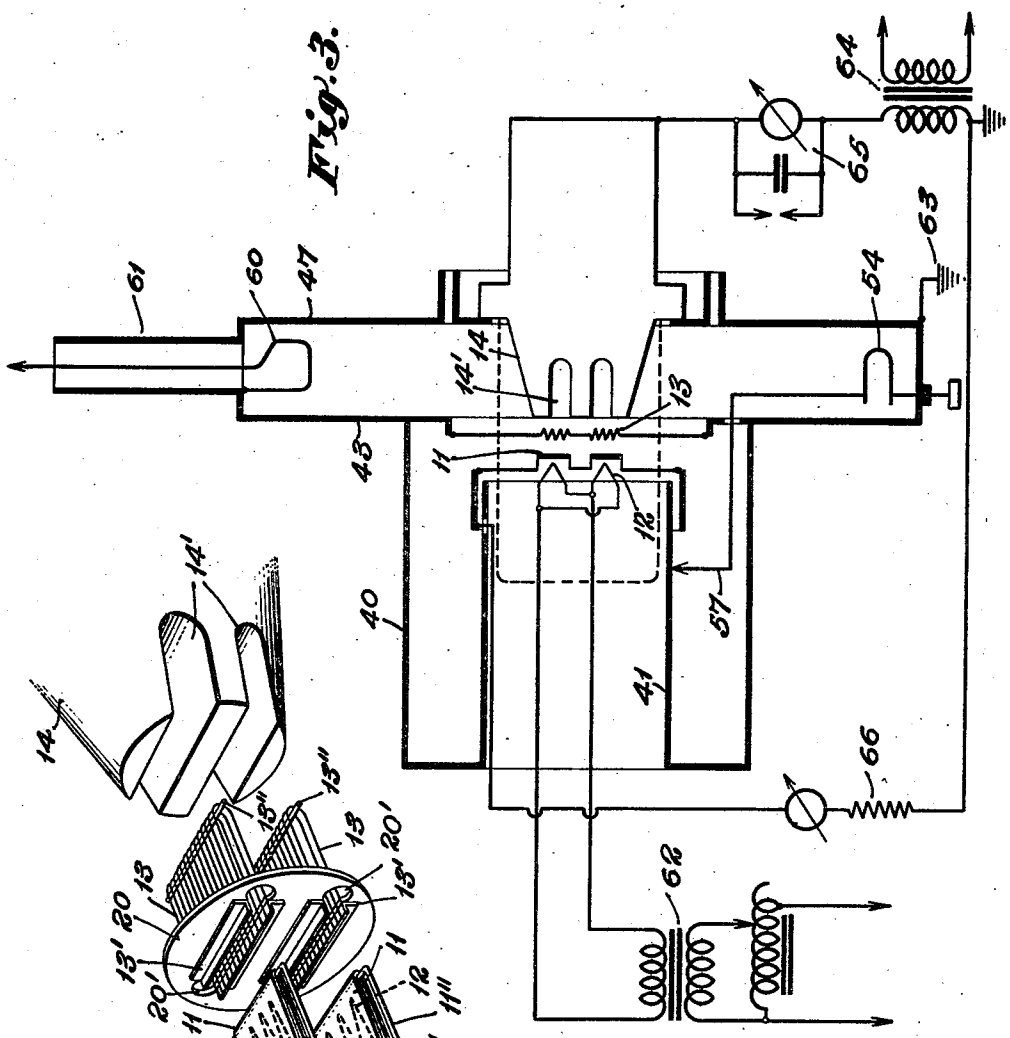


Fig. 4.

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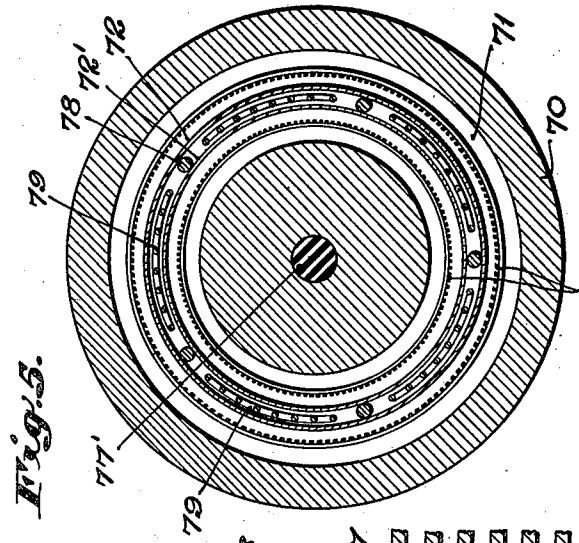


Fig. 5.

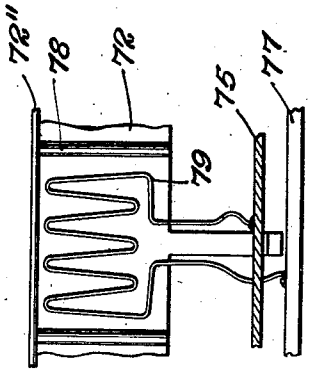


Fig. 6.

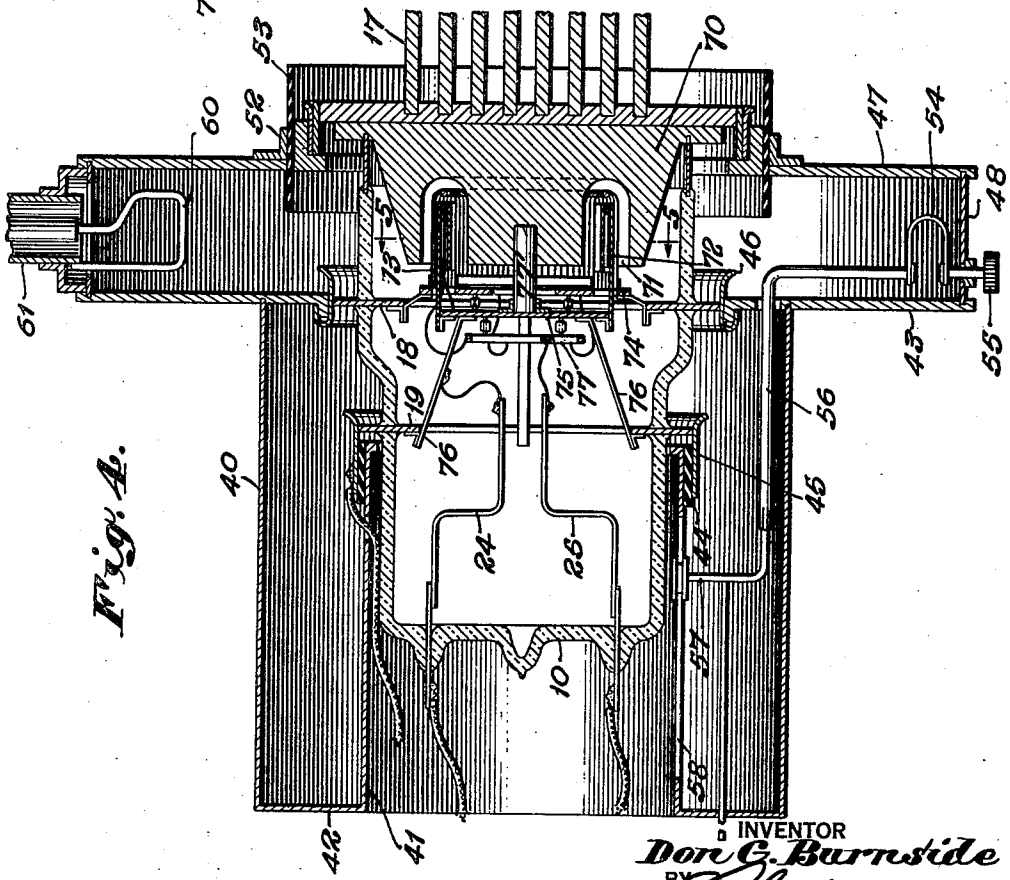


Fig. 4.

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ELECTRON DISCHARGE DEVICE FOR ULTRA HIGH FREQUENCIES

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Fig. 7.

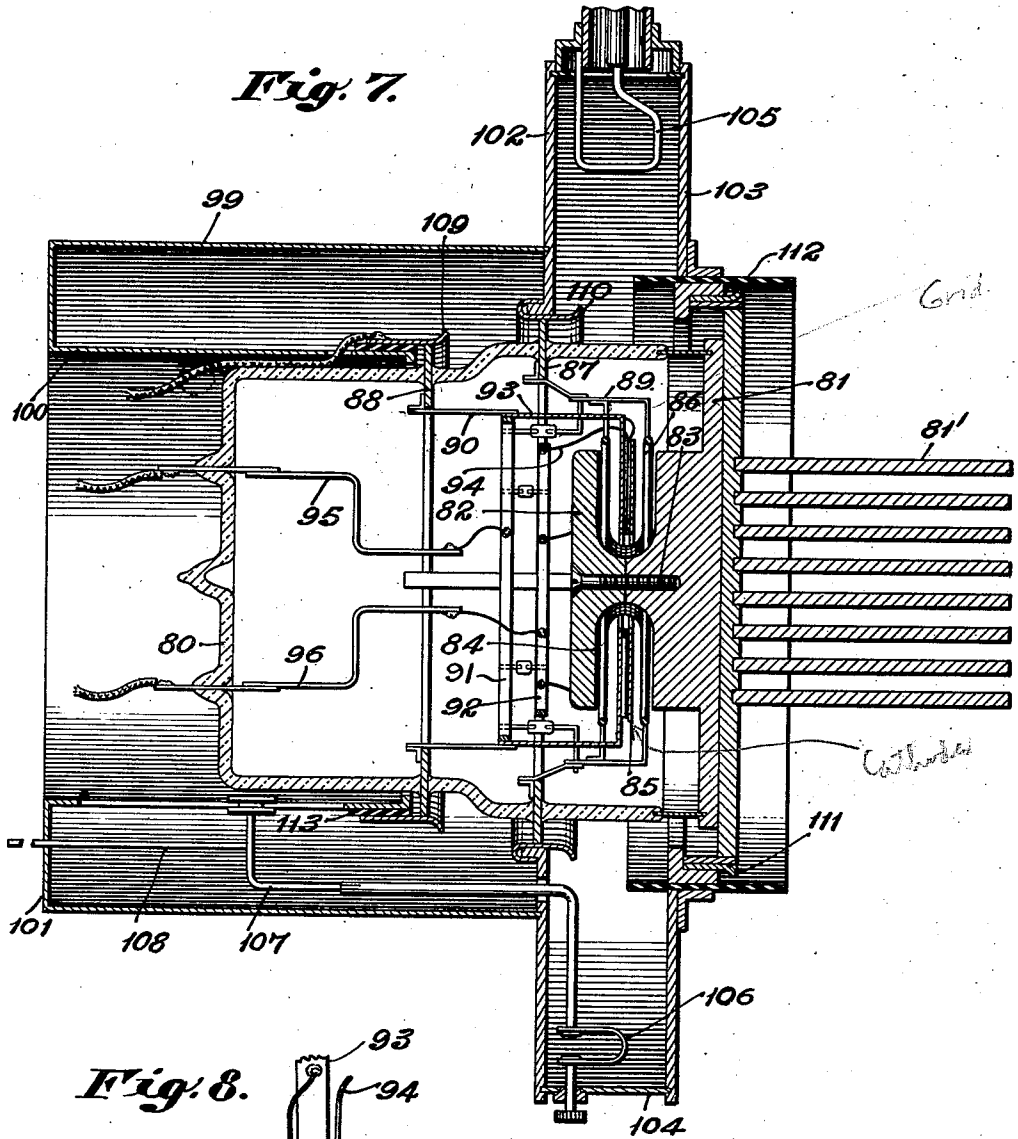
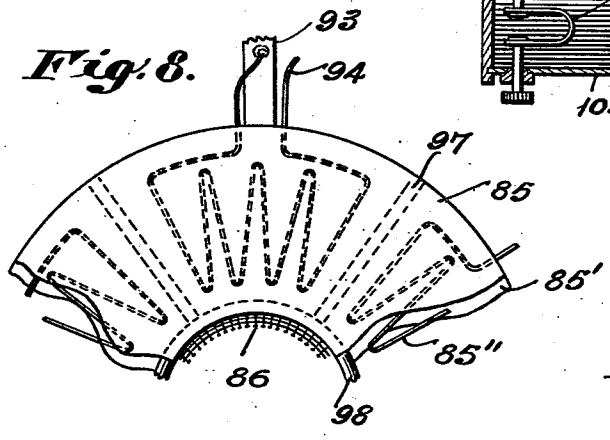


Fig. 8.



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Patented Dec. 14, 1948

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UNITED STATES PATENT OFFICE

2,456,579

ELECTRON DISCHARGE DEVICE FOR ULTRA HIGH FREQUENCIES

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Application October 30, 1942, Serial No. 463,972

27 Claims. (Cl. 250—27.5)

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My invention relates to electron discharge devices and associated circuits particularly useful at ultra high frequencies.

For certain applications it is necessary to have electron discharge devices which will generate large amounts of microwave power. Tube structures for devices of this type which will satisfy the requirements of high power output at very high frequencies vary from orthodox structures in several particulars.

More important features for such devices are as follows:

The cathode must be capable of providing extremely large emission currents.

Close spacing between electrodes must exist to permit advantageous use of high emission currents.

The tube structures must be such that there exists a minimum capacitance between the electrodes, considering other characteristics.

Connections of high conductance and low inductance must be provided between tube electrodes and external circuit.

The insulation used for supports between the electrodes must withstand high voltages and have low losses at high frequencies.

All structural designs must be such as to permit large power heat dissipation by thermal conduction and radiation.

It is, therefore, an object of my invention to provide an electron discharge device and associated circuit particularly useful at ultra high frequencies and capable of generating high power.

Another object of my invention is to provide an electron discharge device in which the cathode is capable of providing very large emission currents.

A further object of my invention is to provide such a device having close spacings between electrodes which will enable advantageous use to be made of the emission currents.

Another object of my invention is to provide an electron discharge device of the type described, having minimum capacitance between electrodes.

A still further object of my invention is to provide an electron discharge device and associated circuit of the type described in which the connections between the electrodes of the electron discharge device and external circuits are of high conductance and low inductance.

A further object of my invention is to provide such a device in which the insulation losses are low at high frequencies and the structural design is such as to provide high power heat dissipation by thermal conduction and radiation.

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A further object of my invention is to provide such a device and circuit which is of reasonable size and economical to operate.

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 longitudinal section of an electron discharge device and associated circuit made according to my invention, Figure 2 is an exploded perspective of the electrode structure used in the device shown in Figure 1, Figure 3 is a schematic diagram of the tube and circuit and voltage sources of the device shown in Figure 1, Figure 4 is a longitudinal section of a modification of the electron discharge device shown in Figure 1, Figure 5 is an enlarged transverse section taken along the line 5—5 of Figure 4 showing details of the electrode structure, Figure 6 is a detail, partially in section, of the cathode structure employed in the device shown in Figure 4, Figure 7 is a longitudinal section of a still further modification of an electron discharge device and associated circuit made according to my invention, and Figure 8 is an enlarged view partially in section of the cathode employed in the device shown in Figure 7.

In accordance with my invention the electron discharge device is provided with an evacuated envelope 10, enclosing a plurality of cathodes 11 provided with heaters 12 and surrounded by U-shaped grid structures 13. The anode 14 of a solid mass of conducting material and of truncated-cone shape is provided on its inner surface with a pair of transversely extending channels 14' into which the cathodes and grids are received. The anode is provided with the collar 15 which is sealed to the end of the envelope 10 and a transverse flange 16 from which radiating fins 17 extend. The shape of the anode promotes rapid heat conduction from the electron receiving surfaces to the radiating fins 17 over which cooling air may be blown.

The grid structures shown in greater detail in Figure 2 and which will be described below is supported on a conducting disc 20, in turn supported from the grid ring 18 by means of the angular members 21. The grid ring 18 is sealed through the wall of the glass envelope 10. The cathode structures are supported by means of a cathode disc 22 in turn supported from the cathode ring 19 sealed through the wall of the envelope, the supporting fingers 23 being welded between the

ring 19 and the disc 22. In practice the cathode and grid are assembled as a unit and maintained in fixed insulated relationship by means of the glass bead spacing structure 24', the cathode and grid being secured to the cathode and grid rings 19 and 18 as a unit during assembly. The cathode heater leads 26 and 27 are cross connected to the cathode heater lead wires 24—25 to put the heater wires in parallel.

The details of the electrode structure are shown in an exploded view in Figure 2. The U-shaped grids 13 are secured to the disc 20 by means of the angle members 13' welded to disc 20, and the grid wires maintained in proper spaced relation by means of the transverse rod 13'' at the top of the grid. The grid wires extend through apertures 20' and are welded to the members 13'. The cathodes 11 may be formed of flat ribbon material folded to U-shape and supported from the cathode disc 22 by means of the legs 11' and by the U-shaped member 11'' engaging the top of the cathode, the heaters 12 being supported within the fold of the cathodes 11. The outside surfaces of the cathodes 11 are coated with electron emitting material so that the opposite sides of the cathode each provide a stream of electrons during operation. Cathode heater leads 26 and 27 extend through apertures 22' in disc 22.

As shown in Figures 1 and 2 a by-passing condenser designated generally 28 in Figure 1 for by-passing R.-F. currents in the cathode heater leads, includes an insulating disc 29 preferably of mica and segmentally shaped conducting plates 30 and 31, which plates are provided with legs 32, 33, and 32', 33', to which the cathode heater wires are connected. This by-passing condenser is completed by means of insulating discs 34 and 35, and clamping plates 36 and 37, the entire assembly including disc 22 being secured together as a unit.

As shown in Figure 1 the input circuit comprises a resonator of the coaxial line type and includes outer cylinder 40, inner cylinder 41, one being closed by member 42 and the other by member 43. The cathode ring 19 is capacity coupled to the inner cylinder 41 by means of the collar 45 insulatingly supported from the inner cylinder 41 by the insulating collar 44, the collar 45 being provided with spring fingers 45' engaging the rim of the cathode ring 19. The closure wall 43 is provided with spring fingers 46 which contact the outer rim of the grid ring 18. Thus the R. F. voltage within the resonator appearing across the space between the members 45 and 46 is impressed between the cathode and grid when the input resonator is excited.

An external voltage may be applied to the cathode by means of the conductor 45'' electrically secured to the conducting collar 45.

The output circuit includes a resonator formed by the members 43 and 47 and the collar 48. The anode is capacity coupled to the wall 47 by means of the collar 49 engaged by spring fingers 50 fastened to the collar 51, which is capacity coupled through the insulating collar 53 secured to the collar 52 on the wall 60 of the resonator. Since the anode is insulated from the tank circuit for D. C., a different fixed potential may be applied to the anode than to the tank.

Energy may be coupled back from the output tank circuit to the input circuit by means of a transmission line, including coupling loop 54 rotatable about an axis lying in the plane of the drawing, by means of rotating knob 55, to increase or decrease the amount of coupling. The

transmission line 56 is hollow and telescopically connected with the loop 57 supported by means of the sliding clamp 57' slidable in the slot 58 of the inner tubular member 41 of the input resonator. The output may be taken by means of the loop 60 which terminates in the coaxial transmission line 61.

The formation and arrangement of the cathode is such that a large emitting area is provided to produce large emission currents without unduly increasing the heating power required. The shape of the grids, cathodes and anode is such that close spacing of all electrodes is permitted to take advantage of the high emission current. Because of the arrangement of the grids and their supports, and the fact that the grid is operated at ground potential, the input and output circuits are completely shielded from each other, reducing the capacity coupling between the cathode and the anode and permitting critical control of the feedback by means of the coupling loop and feedback arrangements. The ring supports offer high conductance and low inductance between the tube electrodes and the tank circuit, and the anode design is such as to readily dissipate large amounts of heat which may be generated in the anodes, since the mass of the anode increases toward the exterior of the envelope, permitting ready flow of heat away from the electron receiving surfaces of the anode channels and dissipation by means of the radiating fins 17. If desired the resonant cavities may be provided with apertures through which a cooling medium can be directed over the ring seals as well as over the radiating fins 17. The arrangement of the electrode supports within the envelope and the design of the resonator circuits are such as to readily provide for engagement and disengagement of the electron discharge device and circuits. Thus by means of my invention all of the desirable characteristics are provided.

A schematic diagram of an electron discharge device and circuit according to my invention with associated power supplies is shown in Figure 3. The cathode heater is supplied by means of transformer 62. Since the grid and tank circuit are grounded at 63, and the cathode and anode, with no exciting voltage applied, are at substantially the same potential, no current normally flows. When it is desired to permit the flow of current to excite the output resonator, a voltage differential is applied between the cathode 11 and anode 14 by means of the pulsing transformer 64. A safety overload device 65 consisting of a condenser and a spark gap is inserted between the anode and the transformer 64. Resistor 66 is for the purpose of supplying a biasing voltage between grid and cathode.

A modification of the structure shown in Figure 1 is shown in Figures 4 to 6 inclusive. In Figures 4 to 6, inclusive, the same numerals designate the same parts as in Figure 1. The construction of the electron discharge device shown in Figure 4 differs from that shown in Figure 1 in the electrode arrangement. The anode 70 of truncated-cone shape is provided with an annular channel of elongated U-shape transverse section and into which the indirectly heated annular cathode 72 and grid 73 extend. The grid is supported from the grid disc 74 again secured to and supported by grid ring 18, and the cathode is supported by means of the cathode disc 75 supported from the cathode ring 19 by means of the supporting members 76. One of the cathode heater leads of each cathode heater is connected to

the cathode disc or plate 75 and the other lead to ring 77 insulatingly supported from disc 75. The disc 75 is electrically connected to lead 24 and ring 77 to lead 25. The cathode and grid structures are again assembled as a unit externally of the tube and then mounted on rings 18 and 19 within the tube.

In order to properly space the grid from the anode a stop member 77' of insulating material may be supported on the cathode disc and is received within the anode. The relation of the cathode, grid and anode is shown in the large transverse cross sectional view of Figure 5 taken along section 5—5 of Figure 4.

As shown in Figures 5 and 6 the cathode is made of concentric collar-like members 72 and 72' spaced by means of spacer rods 78, the cathode being heated by a plurality of cathode heater units 79 positioned within the cathode between the members 72 and 72'. The upper end of the cathode cylinders may be closed by means of ring-like member 72''.

This apparatus functions in substantially the same manner as shown in Figure 1 and has all of the inherent advantages of the structure shown in Figure 1 plus a greater possible cathode area within an equivalent anode (or envelope) bulk.

A still further modification of my invention is shown in Figure 7. In this modification the envelope 80 is closed at one end by means of the anode comprising two parts 81 and 82 and secured together by means of the screw 83. The device is made in the manner shown to permit assembly of the grid and cathode within the annular channel 84 extending around the circumference of the anode. However, in heat dissipation properties the two parts of the anode may be considered a solid mass of conducting material, as in Figs. 1 and 4. The cathode 85 is surrounded by the grid 86 which is supported from the grid ring 87 by means of supporting elements 89. The cathode in turn is supported from the cathode ring 88 by means of the structure 90 including the conducting ring 91 and supporting members 93. A second conducting ring 92 is supported from the ring 91. One of the cathode heater leads of each cathode heater is connected to the conductors 93 and the other of the cathode heater leads 94 is connected to the cathode heater ring 92, the connection to the source of heating voltage being by means of the leads and conductors 95 and 96.

As shown by the enlarged view partially in section in Figure 8, a cathode is made of a pair of flat ring like members 85—85' separated by means of rods 97 and supporting between them the heaters 85''. The inner edges of the rings are closed by means of the conducting member 98.

The input circuit comprises the resonator including the cylinder members 99—100 closed by means of member 101. The output resonator includes members 102, 103 and 104. Energy is taken from the output resonator by means of the loop 105 and energy is fed back into the input circuit by means of adjustable loop 106 and loop 107 adjusted by means of operating handle 108. Contact between the electrode elements and the input and output resonators is made by means of conducting contact fingers 109, 110 and 111, the anode being insulated from the output resonator by means of insulating collar 112 and the cathode from the input tank circuit by means of the insulating collar 113.

The apparatus shown in Figure 7 also functions in a manner similar to the device shown in Figure 1.

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 having an elongated envelope closed at one end by an anode, said anode being sealed to said envelope and extending inwardly of said envelope, the inner end of said anode being of smaller transverse section than the part sealed to said envelope, said anode having a channel extending transversely of the inner end and a cathode and grid supported within said channel, said cathode being of flat construction and having oppositely disposed emitting surfaces registering with the opposite faces of said channel, the grid being positioned between said cathode and said anode.

2. An electron discharge device having an elongated envelope closed at one end by an anode, said anode being sealed to said envelope and extending inwardly of said envelope, the inner end of said anode being of smaller transverse section than the part sealed to said envelope, said anode having a channel extending transversely of the inner end, and a cathode and grid supported within said channel, said cathode being of flat construction and having oppositely disposed emitting surfaces registering with the opposite faces of said channel, the grid being positioned between said cathode and said anode, said anode having a flange extending transversely of the envelope and a first resonator coupled between the cathode and grid and a second resonator coupled between said grid and anode, said grid being directly connected to said resonators and said cathode and anode flange being capacitively coupled to said resonators.

3. An electron discharge device having an elongated envelope closed at one end by an anode, said anode being sealed to said envelope and extending inwardly of said envelope, the inner end of said anode being of smaller transverse section than the part sealed to said envelope, said anode having a channel extending transversely of the inner end and a cathode and grid supported within said channel, said cathode being of flat construction and having oppositely disposed emitting surfaces registering with the opposite faces of said channel, the grid being positioned between said cathode and said anode, said anode having a flange extending transversely of the envelope, radially extending conducting supports extending through the wall of the envelope and supporting said cathode and said grid, and a first resonator coupled between the cathode and grid and a second resonator coupled between said grid and anode, the grid support being directly connected to said resonators and the cathode support and said anode flange being capacitively coupled to said resonators.

4. An electron discharge device having an elongated envelope closed at one end by an anode, said anode being of a truncated longitudinal section and sealed to said envelope and extending inwardly of said envelope, the inner end of said anode being of smaller transverse section than the part sealed to said envelope, said anode

having a deep channel extending transversely of its inner end and a cathode and grid supported within said channel, said cathode being of flat construction and having oppositely disposed emitting surfaces registering with the opposite faces of said channel, said anode having a flange extending transversely of the envelope and an input resonator coupled between the cathode and grid, and an output resonator coupled between said grid and anode, said grid being directly connected to said resonators and said cathode and anode being capacitively coupled to said resonators, and a transmission line for transferring energy between said resonators and including a rotatably mounted coupling loop at one end within said output resonator and an adjustable coupling loop at the other end of said transmission line within said input resonator.

5. An electron discharge device having an anode comprising a solid conducting mass of truncated shape, said anode having a transverse channel extending across the smaller end of said anode, a flat cathode supported within said channel and having oppositely disposed emitting surfaces registering with the opposite faces of said channel and a grid member of U-shape positioned between the cathode and the anode within said channel, a transverse conducting member supporting said grid and a second transverse conducting member supporting said cathode, said conducting members being secured in fixed spaced relation, ring-like supports and conducting leads secured to said cathode and said grid conducting members, and an envelope enclosing said cathode, grid and anode.

6. An electron discharge device having an anode comprising a solid conducting mass of truncated shape, said anode having a transverse channel extending across the smaller end of said anode, a flat cathode supported within said channel and having oppositely disposed emitting surfaces registering with the opposite faces of said channel and a grid member of U-shape positioned between the cathode and the anode within said channel, a transverse conducting member supporting said grid and a second transverse conducting member supporting said cathode, said conducting members being secured in fixed spaced relation, ring-like supports and conducting leads secured to said cathode and said grid conducting members and an envelope enclosing said cathode, grid and anode, the larger end of said anode being provided with a transverse flange sealed to said envelope.

7. An electron discharge device having an anode comprising a solid conducting mass of truncated shape, said anode having a transverse channel extending across the smaller end of said anode, a flat cathode supported within said channel and having oppositely disposed emitting surfaces registering with the opposite faces of said channel and a grid member of U-shape positioned between the cathode and the anode within said channel, a transverse conducting member supporting said grid and a second transverse conducting member supporting said cathode, said conducting members being secured in fixed spaced relation, an envelope enclosing said cathode, grid and anode, ring-like supports and conducting leads secured to said cathode and said grid conducting members, said ring-like supports extending through and sealed to said envelope, the larger end of said anode being provided with a transverse flange sealed to said envelope, said cathode and grid ring supports and conducting

leads and said anode flange being adapted to be engaged by spring finger contacts of resonators connected between the cathode and grid, and the grid and the anode.

8. An electron discharge device having a cathode assembly including a conducting plate, a cathode proper supported from one side of said plate and a heater within said cathode provided with a pair of heater leads, said plate having an aperture through which said heater leads extend, an insulating member mounted on the other side of said plate from said cathode, and a pair of flat conducting elements mounted on said insulating member and insulated from said plate, one of said heater leads being connected to one of said flat conducting elements and the other of said heater leads being connected to the other of said flat conducting elements.

9. A cathode assembly for an electron discharge device including a conducting plate having an aperture centrally thereof, a flat cathode supported from one side of said conducting plate in a plane transverse to said plate, a heater for said cathode and having a pair of heater leads, an insulating member mounted on the other side of said conducting plate from said cathode, and having an aperture registering with the aperture in said plate, a pair of conducting members mounted on said insulating member and oppositely disposed from said plate, said pair of conducting members having legs, one of said heater leads being connected to a leg of one of said pair of conducting members and the other of said heater leads being connected to a leg of the other of said pair of conducting members, and means for securing said plate, insulating member and said pair of conducting members together as a unit.

10. A cathode electrode assembly for an electron discharge device including a conducting plate-like member having a central aperture, a plurality of flat cathodes mounted and supported from one side of said conducting plate and perpendicularly to said plate, cathode heaters positioned within and supported by said cathodes, each of said heaters being provided with a pair of leads, an insulating member secured to the opposite side of said conducting plate from said cathodes and a pair of conducting members mounted on said insulating member and provided with legs, one lead of each of said heaters being connected to a leg of one of said pair of conducting members and the other heater lead of each of said heaters being connected to a leg of the other of said pair of conducting members, and means securing said conducting plate, insulating member and pair of conducting members together as a unit.

11. An electron discharge device having an anode increasing in transverse section from one end of said anode to the other, said anode having an annular channel formed in the smaller end thereof, said channel being of elongated transverse section, a collar-shaped cathode positioned within said channel and a grid positioned between said cathode and said anode.

12. An electron discharge device having an anode comprising a solid mass, said anode having an annular channel formed in surface thereof, said channel being of elongated transverse section, a collar-shaped cathode positioned within said channel, a conducting member to which said cathode is secured and upon which said cathode is supported and a conducting ring insulatingly supported on said conducting member and a

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heater for said cathode having a pair of heater leads, one of which is connected to said conducting member and the other of which is connected to said conducting ring.

13. An electron discharge device having an anode of solid mass increasing in transverse section from one end of said anode to the other, said anode having a deep annular channel formed in one end thereof, a collar-shaped cathode positioned within said channel and a grid positioned between said cathode and said anode, a flat conducting member to which said cathode is secured and upon which said cathode is supported, and a conducting ring lying parallel to said flat conducting member and supporting said grid, said cathode and grid being mounted in fixed spaced relation as a unit, and means supported on said flat cathode supporting conducting member and contacting said anode for determining the spacing between the cathode, grid and anode.

14. A cathode for an electron discharge device comprising a pair of concentric collar-like members, means spacing and securing said collar-like members together and a plurality of heater members mounted between said collar-like elements of said cathode, only those surfaces of said collar-like members opposite the surfaces exposed to said heater elements being coated with electron emitting material.

15. A cathode for an electron discharge device comprising a pair of concentric collar-like members, means spacing and securing said collar-like members together and a plurality of heater elements mounted between said collar-like members of said cathode, said collar-like members being provided with conducting supporting legs and a conducting disc member to which said legs are secured.

16. A cathode for an electron discharge device comprising a pair of concentric collar-like members, means spacing and securing said collar-like members together and a plurality of heater elements mounted between said collar-like members of said cathode, said collar-like members being provided with conducting supporting legs and a conducting disc member to which said legs are secured, and a conducting ring insulatingly supported on the opposite side of said disc-like member from said cathode, each of said heater elements being provided with a pair of leads, one of said leads being connected to said conducting disc member and the other of said leads being connected to said ring.

17. An electron discharge device having a two-part anode, each of said parts being of plate-like shape with a centrally positioned raised portion, said raised portions being in contact providing oppositely disposed faces forming an annular channel of elongated transverse section, a flat ring-like cathode positioned within said channel and a grid positioned between the cathode and the surfaces of said channel, and means supporting said cathode, grid and anode in spaced relation.

18. An electron discharge device having a two-part anode, each of said parts being of plate-like shape with a centrally positioned raised portion, said raised portions being in contact providing oppositely disposed faces forming an annular channel of elongated transverse section, a flat ring-like cathode positioned within said channel and a grid positioned between the cathode and the surfaces of said channel, and means supporting said cathode, grid and anode in spaced relation, said means including a conducting ring to which said grid is secured and connected and a second conducting ring to which said cathode is secured and connected.

19. An electron discharge device having a two-part anode, each of said parts being of plate-like shape with a centrally positioned raised portion, said raised portions being in contact providing oppositely disposed faces forming an annular channel of elongated transverse section, a flat ring-like cathode positioned within said channel and a grid positioned between the cathode and the surfaces of said channel, and means supporting said cathode, grid and anode in spaced relation, said means including a conducting ring to which said grid is secured and connected and a second conducting ring to which said cathode is secured and connected, and an envelope for said cathode, grid and anode, said rings extending through and sealed to the wall of said envelope, said anode being sealed to and closing one end of said envelope.

20. An electron discharge device having a two-part anode, each of said parts being a plate-like shape with a centrally positioned raised portion, said raised portions being in contact providing oppositely disposed faces forming an annular channel of elongated transverse section, a flat ring-like cathode positioned within said channel and a grid positioned between the cathode and the surfaces of said channel, and means supporting said cathode, grid and anode in spaced relation, said means including a conducting ring to which said grid is secured and connected and a second conducting ring to which said cathode is secured and connected, and a pair of ring-like members supported on said cathode ring, one of said ring-like members being electrically connected to the cathode ring and the other of said ring-like members being insulatingly supported from said first ring-like member, a cathode heater for said cathode and having a pair of leads, one of said leads being connected to one of said ring-like members and the other of said leads being connected to the other of said ring-like members.

21. An electron discharge device having an anode comprising a mass of conducting material and having a portion of circular transverse cross section, said elongated portion having an annular channel lying in a plane transverse to the longitudinal axis of said anode and a flat ring-like cathode positioned within said channel and means maintaining said cathode and anode in fixed spaced relation.

22. An electron discharge device having an anode comprising a solid mass of conducting material, said anode having at one end a transverse flange and provided adjacent its other end with an annular channel lying in a plane transverse to the longitudinal axis of said anode, a flat ring-like cathode positioned within said channel and a grid between said cathode and the walls of said channel, and an envelope for said grid, cathode and anode, the flange of said anode being sealed to said envelope.

23. A cathode for an electron discharge device and comprising a pair of spaced flat ring-like members, means maintaining said ring-like members in fixed spaced relationship and a plurality of heaters positioned between said rings for heating said cathode, only the surfaces of said plates opposite the surfaces exposed to said heaters being coated with electron emitting material.

24. A cathode for an electron discharge device comprising a pair of flat ring-like members, conducting rods radially positioned between said flat

ring-like members and secured to said ring-like members to maintain them in fixed spaced relationship, a ring element adjacent the inner edges of the flat ring-like members closing the space between the ring-like members and a plurality of heater elements positioned between the flat ring-like members and between the radially positioned rods for heating said cathode.

25. An electron discharge device having an elongated cylindrical envelope closed at one end by an anode, said anode comprising a solid mass of conducting material of truncated-cone shape having its larger diameter end sealed to said envelope and its smaller diameter end extending within said envelope, a plurality of heat radiating fins secured to and extending outwardly from said larger diameter end of said anode, said anode having a deep channel in its inner end, a cathode supported within said channel and having oppositely-disposed emitting surfaces of large area registering with the opposite faces of the channel, and a grid positioned between the cathode and the anode.

26. An electron discharge device according to claim 25, wherein said grid has a U-shaped transverse section, and said heat radiating fins extend parallel to the longitudinal axis of said anode.

27. An electron discharge device having an elongated envelope closed at one end by an anode, said anode comprising a solid mass of conducting material and being sealed at one end to said envelope with the opposite end extending inwardly

of said envelope, the inner end of said anode being of substantially smaller transverse section than the end sealed to said envelope, said anode having a channel in its inner end, a cathode supported in said channel and having oppositely-disposed emitting surfaces registering with the channel walls, and a grid positioned between said cathode and said anode.

DON G. BURNSIDE.

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