

May 24, 1949.

R. R. LAW
ELECTRON DISCHARGE DEVICE EMPLOYING
CAVITY RESONATORS

2,471,037

Filed June 29, 1944

3 Sheets-Sheet 1

Fig. 1.

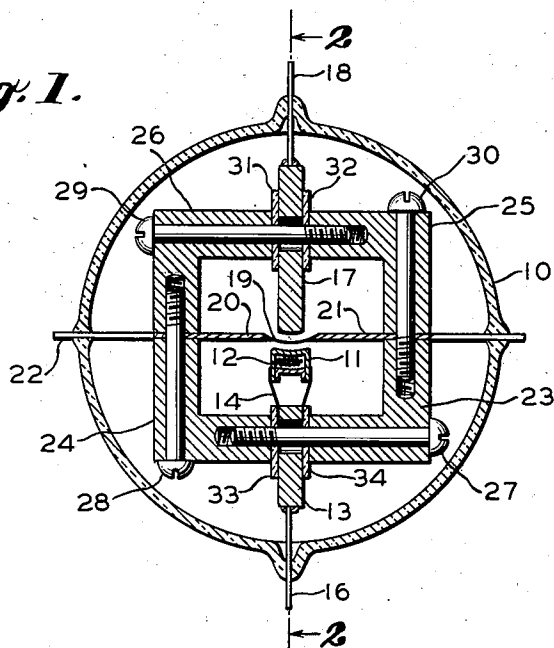
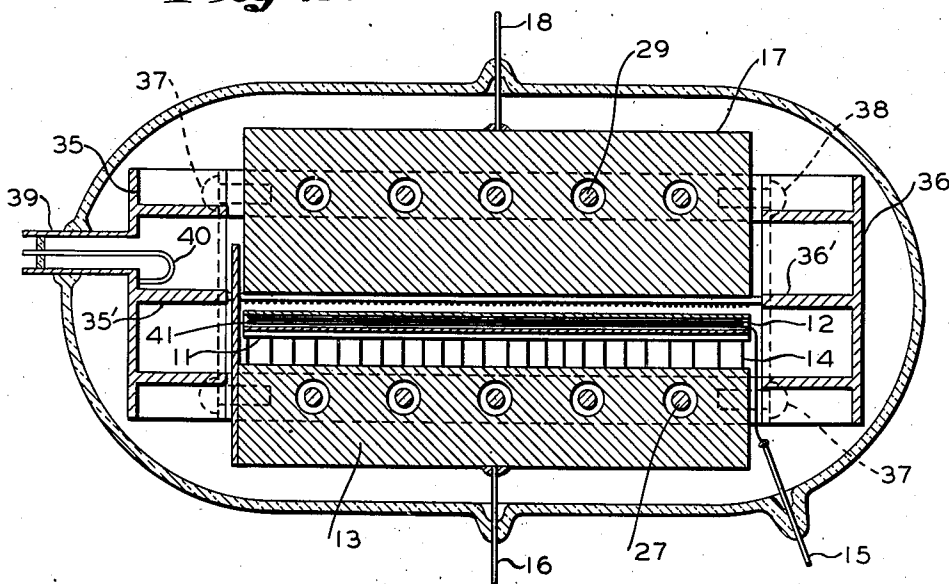


Fig. 2.



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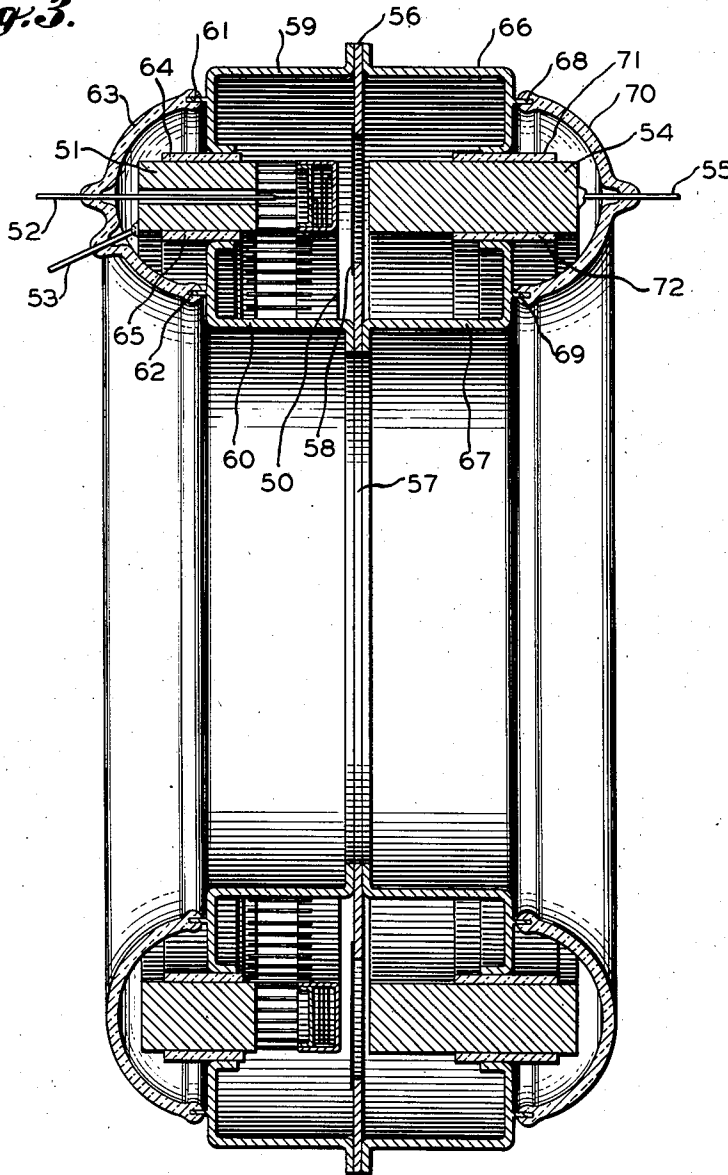
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Fig. 3.



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Fig. 4.

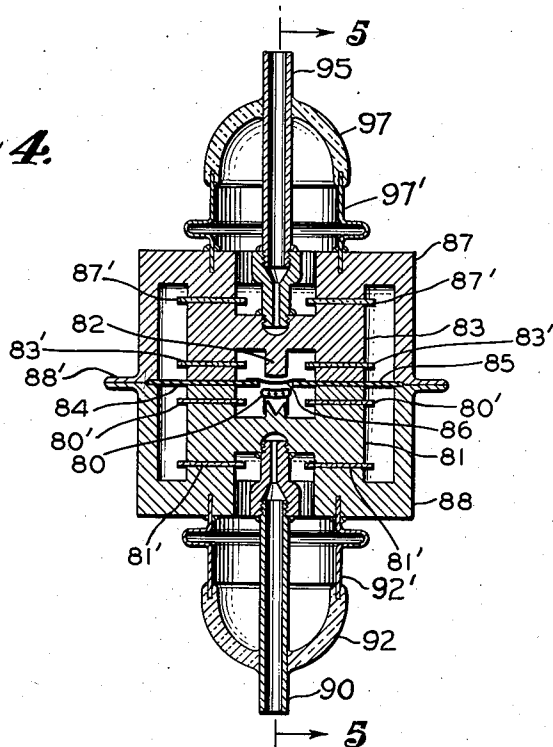
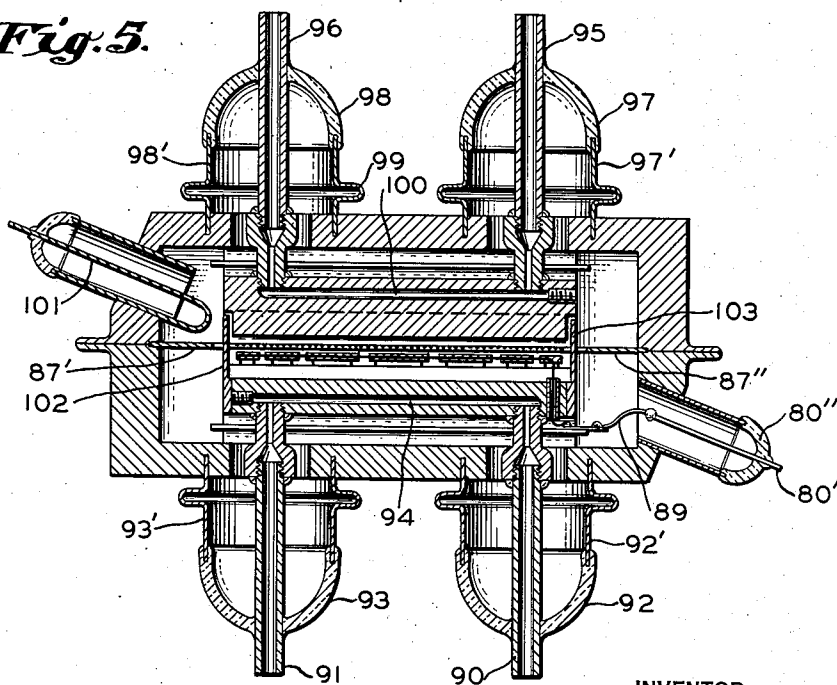


Fig. 5.



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UNITED STATES PATENT OFFICE

2,471,037

ELECTRON DISCHARGE DEVICE EMPLOYING
CAVITY RESONATORSRussell R. Law, Princeton, N. J., assignor to Radio
Corporation of America, a corporation of Dela-
ware

Application June 29, 1944, Serial No. 542,717

18 Claims. (Cl. 315—6)

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

Certain types of triode electron discharge devices or tubes having a cathode, grid and an anode provided with registering planar surfaces of disc-shape have been found satisfactory for moderate power at moderately high frequencies. However, as the frequency is raised the overall size of the tube and circuit, usually of the cavity resonator type, must diminish, thereby bringing about a reduction in the power output. For example, inasmuch as the tube elements must be relatively small compared to the wavelength, at 3000 megacycles it would be inadvisable to use a cathode much larger than one centimeter in diameter; in this event a 3000 megacycle tube would be limited to a peak power output of about 10 kilowatts, and the power output would vary inversely as the frequency.

It is, therefore, an object of my invention to provide an electron discharge device and circuit of improved design useful at ultra high frequencies.

A further object of my invention is to provide such a device capable of large power outputs.

A still further object of my invention is to provide such a device utilizing cavity resonators and in which the electrodes of the electron discharge device are supported from and merge into the resonator walls.

More specifically it is an object of my invention to provide such a device which will operate in a mode, such that at least one of the dimensions determining the electrode area is independent of the frequency at which the device is to be operated.

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 section transverse to the longitudinal axis of an electron discharge device and associated circuit made according to my invention, Figure 2 is a section taken along the line 2—2 of Figure 1, Figure 3 is a transverse longitudinal section of a modification of an electron discharge device and associated circuit made according to my invention, Figure 4 is a section transverse to the longitudinal axis of another form of electron discharge device made according to my invention, and Figure 5 is a section taken along the line 5—5 of Figure 4.

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In an electron discharge device and associated circuit made according to my invention, there is one mode of oscillation in which the resonant frequency is determined only by the geometry of the cross section transverse to the longitudinal axis of the device. Thus, although the transverse cross section dimensions must shrink as the frequency is raised, the dimension perpendicular to the cross section is unlimited. Thus, according to my invention I provide a device having means for abating the difficulties enumerated above. This results in an elongated electrode principle which is employed in the electron discharge device and circuit made according to my invention.

Referring to Figures 1 and 2 showing one form of my invention, I provide an envelope 10 in which the electrode unit mount and associated circuit are enclosed. The electrode mount assembly includes the elongated cathode 11 heated by the heater 12 and both supported from the elongated plate-like element 13 by wire-like elements 14 which reduce heat conduction to element 13 to a minimum. A cathode lead 15 is provided. Oppositely disposed to the cathode is the anode block 17, also in the form of an elongated plate member, one edge of which provides the anode working surface, the anode being provided with the anode lead 18 for applying a positive voltage to the anode during operation of the device. Positioned between the cathode and anode is the grid 19 having a pair of elongated plate-like supporting elements 20 and 21. The surfaces of the electrodes are concave in order to maintain proper spacing during operation and prevent shorts which may occur when temperature variations take place within the device.

The electrodes are mounted within and form part of the circuit construction comprising four elements 23, 24, 25 and 26 of L-shaped transverse section. The L-shaped elements 23 and 24 provide with the grid plates 20 and 21 the grid-cathode input cavity resonator into which the cathode 11 extends. The elements 25 and 26 form the output cavity resonator into which the anode 17 extends. These elements are all secured together by means of screws 27, 28, 29 and 30.

While I have shown in Figure 2 end members in the form of semi-circular drum members 35 and 36 provided with intermediate partitions 35' and 36' which close the ends of the resonators and provide communicating passageways on opposite sides of the cathode, I have found that the tube will function without these members. These enclosure members are maintained in place by screws 37 and 38.

The device may be used either as an amplifier or oscillator. If used only as an amplifier, a conventional input coupling loop may be coupled to the grid-cathode space to excite this resonator and control the electron flow to the anode. The output may be taken by means of the coupling loop 40 within the output resonator between grid and anode and extending through the envelope 10 of the tube in the form of a coaxial line 39. If the device is to be used as an oscillator, an ordinary loop coupling between the two resonators may be employed or a coaxial line resonator may be employed. Both are well known means for providing such operation. I prefer to employ capacity coupling elements such as 41 which capacity couple the cathode and grid. This coupling arrangement is described and claimed in the copending application of Robert P. Stone, Serial No. 547,189 filed July 29, 1944, and assigned to the same assignee as the present application and now United States Patent No. 2,433,634, granted December 30, 1947.

In order to permit the application of proper biasing voltages between the various electrodes, the cathode plate is supported between the elements 23 and 24 and insulated therefrom by means of insulating spacer members 33 and 34, preferably of mica. The same supporting arrangement is employed for the anode 17, micas 31 and 32 being utilized for this purpose. Grid leads 22 are provided for applying a grid biasing voltage and leads 15 and 16 for supplying heating current to the heater 12, one end of which is connected to the lead 15 and the other end of which is connected through the cathode sleeve to the cathode block 13 and lead 16.

A tube of this type having a length of circuit 2.75", a cathode-grid spacing of .010", an anode-grid spacing .010", a cathode .150" wide, an anode .125" wide with 144 turns per inch for the grid and 2.2 mil wire and providing a cathode area of 2.6 cm.² had a resonant frequency of approximately 3000 megacycles.

A modification of the device shown in Figure 1 is shown in Figure 3. In this arrangement annular electrodes and resonators are employed. An indirectly heated cathode 50 is supported in a manner similar to that in Figure 1 from the annular cathode collar 51 through which one of the cathode heater leads 52 extends, the lead 53 providing the cathode lead and the lead for the other side of the heater wire. Oppositely disposed to the cathode is the annular anode electrode 54 provided with anode lead 55. Positioned between the anode and the cathode is the grid comprising the two ring members 56 and 57 between which extend the grid wires 58.

The input cavity resonator comprises a pair of annular members 59 and 60 between which the cathode ring 51 is insulatingly supported by means of the insulating collars 64 and 65, preferably of mica. These resonator elements are provided with annular lips 61 and 62 to which the annular element of transverse cup-shape 63 is sealed to provide an envelope. The output resonator comprises elements 66 and 67 provided with lips 68 and 69 to which the annular member 70 of cup-shape is sealed to complete the envelope. The cavity resonator elements 59, 60, 66 and 67 are sealed to the grid rings 56 and 57 to provide a vacuum-tight envelope which may be exhausted in the conventional manner.

In this arrangement the elongated electrode principle is also employed.

A still further modification of an electron dis-

charge device and its associated circuit made according to my invention is shown in Figures 4 and 5. In this arrangement the indirectly heated cathode 80 is supported on cathode block 81 and anode 82 is supported on anode block 83. The elongated grid plates 84 and 85 support the grid wires 86 therebetween. Insulating spacer members 80' and 83' are utilized to insulate the electrodes from each other and to permit different direct voltages to be applied to the various electrodes. This elongated unit structure is enclosed within an outer envelope of conducting material in which the electrode assembly and cavity resonator circuits are mounted. This envelope comprises the elongated U-shaped element 87 and 88 sealed at the lip 88'. The insulating spacers 81' and 87' insulate the anode and cathode and the resonators from the envelope. The grid is grounded on the envelope by elements 84 and 85.

The leads for the cathode comprise tubular members 90 and 91 sealed through appropriate apertures in the envelope and are provided with vacuum type cup shells 92 and 93 secured to tubular extensions 92' and 93'. Either may be used as cathode lead and one of the cathode heater leads, the other side of the cathode heater being connected to the lead 80' sealed through an aperture in the envelope by means of the cup-shaped element 80''. The tubular leads 90 and 91 communicate with the passage 94 through the cathode block and may be used for cooling purposes.

The tubular anode leads 95 and 96 are likewise sealed through appropriate apertures in the envelope of the tube, being hermetically sealed therein by means of cup-shaped members 97 and 98 sealed to the collar elements 98' and 97', the bellows portion, such as 99, being provided on the collar members to provide for expansion and contraction of the various elements during operation of the device.

Output loop 101 in the form of a hermetically sealed coaxial line permits extraction of high frequency energy from the grid-anode space or output cavity resonator, which is separated from the grid-cathode space or input cavity resonator by means of the partition elements 87' and 87''. Feedback, if the device is to be utilized as an oscillator, may be by means of cavity elements 102 and 103 supported by cathode block and extending into the grid-anode space and capacitively coupled to the anode.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also described 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 for use at high frequencies and having a cathode provided with an elongated emitting surface, and anode having an elongated surface registering with the emitting surface of said cathode and a grid therebetween, and cavity resonators coupled between said grid and cathode and between said grid and anode and having transverse sectional dimensions less than the length of said elongated emitting surface and having longitudinal walls coextensive with the elongated surfaces of said anode and said cathode.

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2. An electron discharge device for use at high frequencies and having a cathode having an elongated emitting surface, an anode having an elongated surface on said cathode and a grid therebetween, and cavity resonators coupled between said grid and cathode and between said grid and anode and having transverse sectional dimensions less than the length of said elongated emitting surface and having longitudinal walls coextensive with the elongated surfaces of said anode and said cathode, said anode and cathode being insulatingly supported from the walls of said cavity resonators.

3. An electron discharge device including adjacent elongated cavity resonators having a common wall provided with an elongated aperture, a grid electrode mounted in said aperture, an anode insulatingly supported by the wall of one of said cavity resonators and extending toward said grid and a cathode insulatingly supported by the resonator wall of the other cavity resonator and extending toward said grid from the opposite direction, said cathode and anode being in registering positions on opposite sides of said grid, and said cathode having an elongated emitting surface and said anode having an elongated surface registering with the emitting surface of said cathode, said cathode and anode being coextensive with the longitudinal walls of said resonator.

4. An electron discharge device including adjacent cavity resonators having a common wall provided with an elongated aperture, a grid electrode mounted in and closing said aperture, an anode supported by the wall of one of said cavity resonators and extending within said resonator and toward said grid and a cathode supported by the resonator wall of the other cavity resonator and extending within said other cavity resonator and toward said grid from the opposite direction, said cathode and anode being in registering positions on opposite sides of said grid, and said cathode having elongated emitting surface, said anode having elongated surface registering with the emitting surface on said cathode, the elongated surfaces of said cathode and anode being coextensive with the grid.

5. An electron discharge device including oppositely disposed electrodes, one of said electrodes including an anode comprising an elongated electrode, one edge of which provides the anode working surface, and a cathode, said cathode being coextensive with said anode, and a grid element positioned between said cathode and anode and including elongated conducting elements supporting said grid between said cathode and anode, and cavity resonators coupled between said cathode and said grid and between said grid and said anode, and including oppositely disposed conducting structures of U-shape transverse section supporting said cathode and anode, the grid conducting elements providing a common wall between said resonators and means maintaining said cavity resonators in fixed position.

6. An electron discharge device including oppositely disposed electrodes, one of said electrodes including an anode having a comparatively narrow extended work surface, and a cathode oppositely disposed to said anode, said cathode having a work surface coextensive with said anode, and a grid element positioned between said cathode and anode and including conducting elements supporting said grid between said cathode and said anode, and cavity resonators coupled between said cathode and said grid and between said grid and said anode, and including oppositely

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disposed conducting structures of transverse cup-shaped sections supporting said cathode and anode, the grid conducting elements providing a common wall between said cavity resonators.

7. An electron discharge device including oppositely disposed electrodes, one of said electrodes including an anode having an elongated working surface and a cathode coextensive with said anode, and a grid element positioned between said cathode and anode and including conducting elements supporting said grid between said cathode and anode, and cavity resonators coupled between said cathode and said grid and between said grid and said anode, each resonator including L-shaped sections with legs in registering relationship and supporting said cathode and anode at the juncture of said legs, the grid conducting elements providing a common wall between said resonators.

8. An electron discharge device including an elongated plate-like anode, one longitudinal edge of which provides the anode working surface, a cathode oppositely disposed to said anode and an elongated plate-like element supporting said cathode, and a grid positioned between said anode and cathode and including a pair of elongated plate-like elements positioned transversely to a plane passing through said anode and cathode, cavity resonators coupled between said grid and cathode and between said grid and anode, each of said cavity resonators comprising elongated elements of transverse L-shaped section, said cathode plate-like elements being mounted between oppositely disposed legs of a pair of L-shaped elements, and the plate-like anode being mounted between another pair of said L-shaped elements, the grid plate-like elements being positioned between the other of the legs of the L-shaped elements and providing a common conducting wall between said resonators.

9. An electron discharge device including an annular anode, an oppositely disposed annular cathode for supplying electrons to said anode and a grid positioned between said cathode and anode, and cavity resonators coupled between said cathode and grid and between said grid and anode and comprising annular members having a common wall between said resonators and electrically connected thereto, said common wall having an annular aperture registering with said anode and said cathode, said grid extending across and closing said aperture.

10. An electron discharge device including an annular anode, one edge of which provides an electron receiving surface of the anode, an oppositely disposed annular cathode for supplying electrons to said anode and a grid positioned between said cathode and anode, and cavity resonators coupled between said cathode and grid and between said grid and anode and comprising annular members having L-shaped transverse sections, one leg of each of said annular members of one resonator being coupled to said cathode and the other leg being sealed to said grid, and one of the legs of each of the other resonator elements being coupled to said anode and its other leg being sealed to said grid.

11. An electron discharge device including an annular anode element, one edge of which provides an electron receiving surface of the anode, an oppositely disposed annular cathode for supplying electrons to said anode and a grid positioned between said cathode and anode, and cavity resonators coupled between said cathode

and grid and between said grid and anode and comprising annular members having L-shaped transverse sections, one leg of each of said annular members of one resonator being coupled to said cathode and the other being sealed to said grid, and one of the legs of each of the other resonator elements being coupled to said anode and its other leg being sealed to said grid, said cathode and anode being capacitively coupled to said resonator elements, said resonator elements having annular lips and annular elements of insulating material having a cup-shaped transverse section sealed to said lips providing with said resonators an envelope for said electrodes.

12. An electron discharge device including an annular anode element, one edge of which provides an electron receiving surface of the anode, an oppositely disposed annular cathode for supplying electrons to said anode and a grid positioned between said cathode and anode, and cavity resonators coupled between said cathode and grid and between said grid and anode and comprising annular members having L-shaped transverse sections, one leg of each of said annular members of one resonator being coupled to said cathode and the other being sealed to said grid, and one of the legs of each of the other resonator elements being coupled to said anode and its other leg being sealed to said grid, said cathode and anode being capacitively coupled to said resonator elements, and said grid being conductively connected to said resonator elements.

13. An electron discharge device including an annular anode element, one edge of which provides an electron receiving surface of the anode, an oppositely disposed annular cathode for supplying electrons to said anode and a grid positioned between said cathode and anode, and cavity resonators coupled between said cathode and grid and between said grid and anode and comprising annular members having L-shaped transverse sections, one leg of each of said annular members of one resonator being coupled to said cathode and the other being sealed to said grid, and one of the legs of each of the other resonator elements being coupled to said anode and its other leg being sealed to said grid, said cathode and anode being capacitively coupled to said resonator elements, said grid including a pair of spaced flat concentric rings with grid wires extending between adjacent edges of said rings, said rings being sealed between said resonators and forming a common wall for said resonators, said resonator elements having annular lips and annular elements of insulating material having a cup-shaped transverse section sealed to said lips providing with said resonators an envelope for said electrodes.

14. An electron discharge device for use at high frequencies and having an elongated cathode, an elongated anode and a grid therebetween, and cavity resonators coupled between said grid and cathode and between said grid and anode and having transverse sectional dimensions less than the length of said elongated cathode and being coextensive with said anode and said cathode, a conducting envelope in which said electrodes and cavity resonators are enclosed and insulatingly supported, and means insulatingly sealed through said envelope and connected with said cathode and with said anode providing leads for said cathode and anode.

15. An electron discharge device including adjacent elongated cavity resonators having a common wall provided with an aperture, a grid elec-

trode mounted in said aperture, an anode insulatingly supported by one of said resonator walls and extending toward said grid and a cathode supported by the resonator wall of the other cavity resonator and extending toward said grid from the opposite direction, said cathode and anode being in registering positions on opposite sides of said grid, and being coextensive with the longitudinal walls of said resonator, a conducting envelope in which said electrodes and cavity resonators are mounted and insulatingly supported, and means insulatingly sealed through said envelope and connected with said cathode and with said anode providing leads for said cathode and anode.

16. An electron discharge device including adjacent elongated cavity resonators having a common wall provided with an aperture, a grid electrode mounted in said aperture, an anode supported by one of said resonator walls and extending toward said grid and a cathode supported by the resonator wall of the other cavity resonator on the other side of the grid and extending toward said grid, said cathode and anode being in registering positions on opposite sides of said grid, and being coextensive with the longitudinal walls of said resonator, an elongated envelope of conducting material surrounding said electrodes and cavity resonators, and insulatingly supporting said electrodes and cavity resonators within said envelope, said anode and its supporting resonator wall being provided with a bore extending therethrough, and a tubular lead mounted at each end of said anode and its supporting resonator wall and communicating with said bore, and means insulatingly sealing said tubular leads through said conducting envelope.

17. An electron discharge device including adjacent elongated cavity resonators having a common wall provided with an aperture, a grid electrode mounted in said aperture, an anode supported by one of said resonator walls and extending toward said grid and a cathode supported by the resonator wall of the other cavity resonator and extending toward said grid from the opposite direction, said cathode and anode being insulated from said grid and in registering positions on opposite sides of said grid, and being coextensive with the longitudinal walls of said resonator, an elongated envelope of conducting material surrounding said electrodes and cavity resonators, and insulatingly supporting said electrodes and cavity resonators within said envelope, said cathode and its supporting resonator wall having a bore extending along the length thereof and a tubular lead at each end of said bore communicating with said bore and extending through said envelope, and means insulatingly sealing said tubular leads through said envelope.

18. An electron discharge device including adjacent elongated cavity resonators having a common wall provided with an aperture, a grid electrode mounted in and closing said aperture, an anode supported by one of the walls of one of said resonators and extending within said resonator and toward said grid and a cathode supported by the resonators of the other cavity resonator and extending within said other cavity resonator and toward said grid from the opposite direction, said cathode and anode being in registering positions on opposite sides of said grid, and being coextensive with the longitudinal walls of said resonators, said cathode comprising a plurality of discrete successively positioned units along the length thereof and heating means

adjacent said cathode for heating said cathode,
and a current supply lead coupled to said heating
means.

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The following references are of record in the
file of this patent:

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