Dec. 16, 1947. A. V. HAEFF 2,432,571

ELECTRON DISCHARGE DEVICE EMPLOYING RESONATORS

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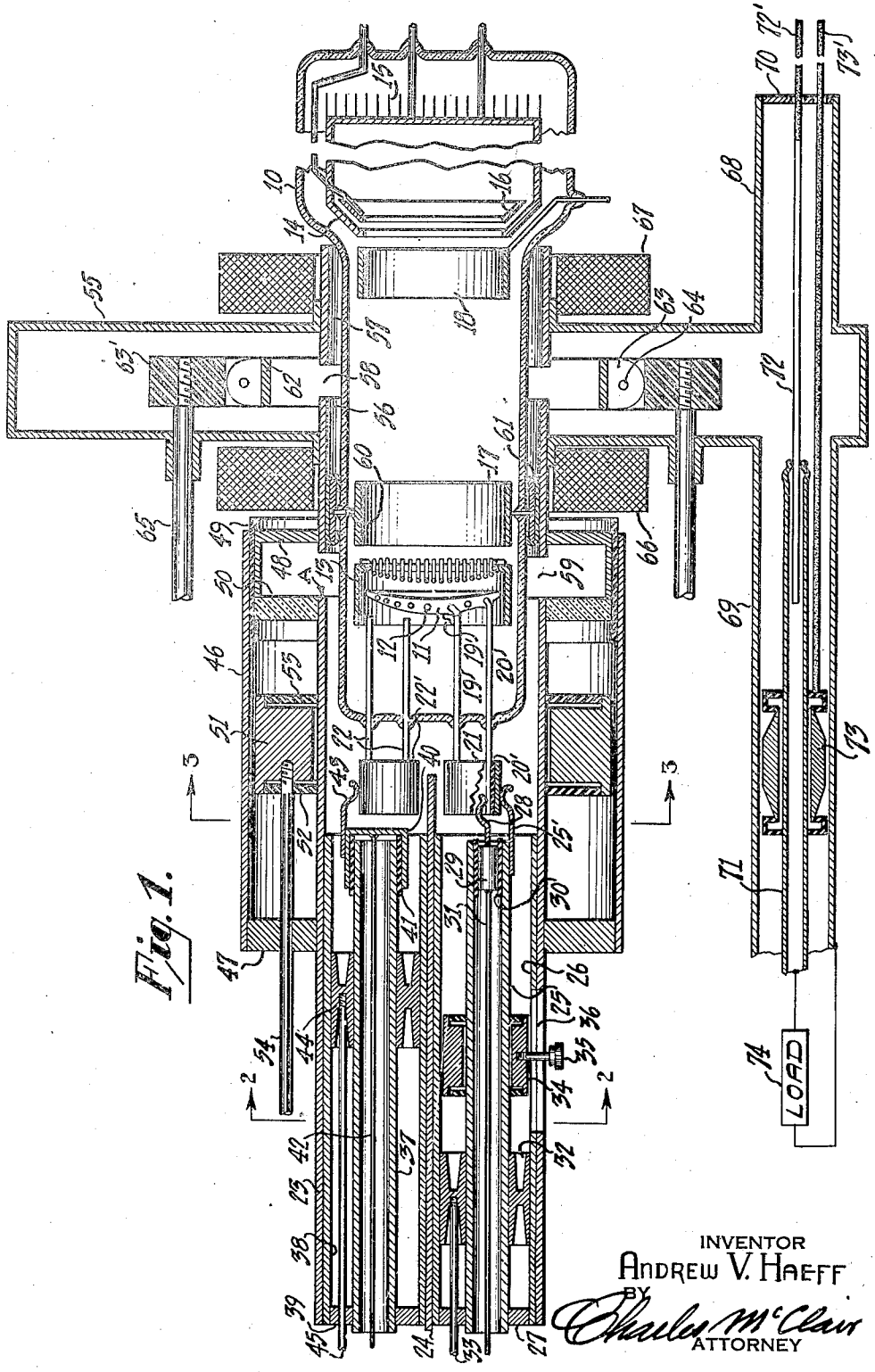


Fig. 1.

INVENTOR
ANDREW V. HAEFF
BY
Charles McClain
ATTORNEY

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Fig. 6.

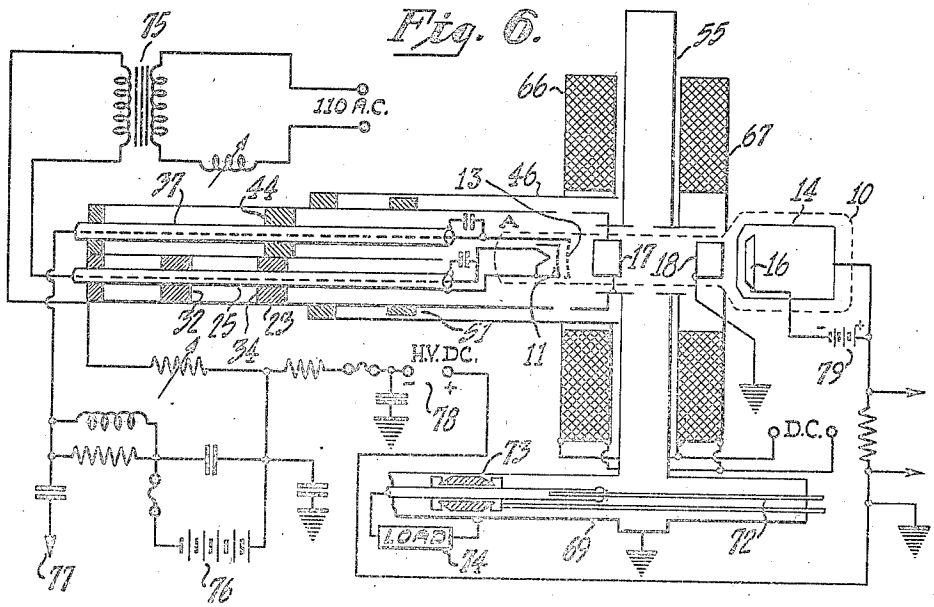


Fig. 2.

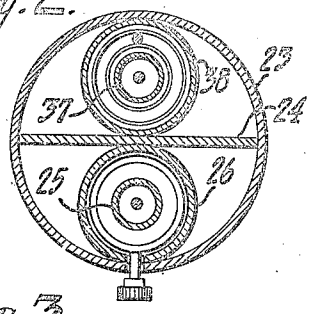


Fig. 4.

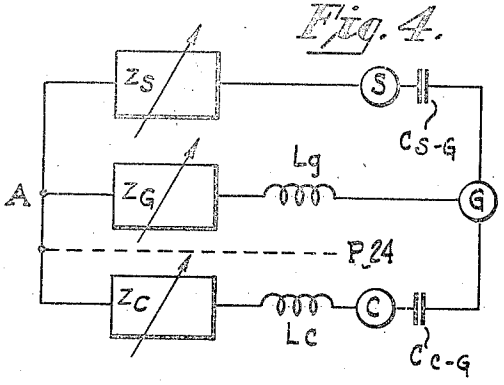


Fig. 3.

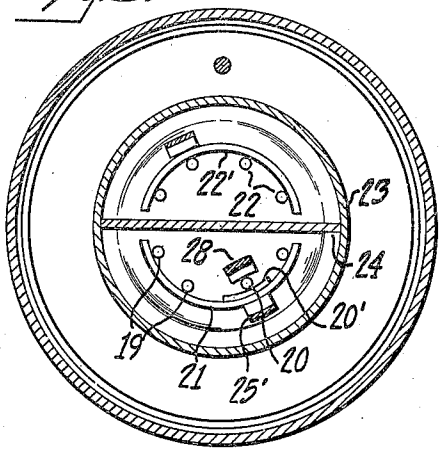
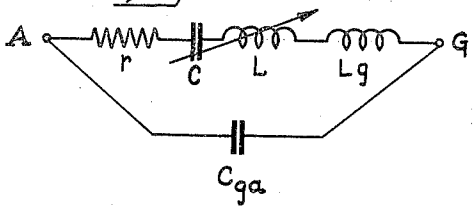


Fig. 5.



INVENTOR
ANDREW V. HAEFF
BY
Charles McClain
ATTORNEY

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ELECTRON DISCHARGE DEVICE EMPLOYING RESONATORS

Andrew V. Haeff, Washington, D. C., assignor to Radio Corporation of America, a corporation of Delaware

Application February 24, 1943, Serial No. 476,893

19 Claims. (Cl. 315—6)

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

As the higher frequencies are approached inter-electrode capacities, inductance of electrode leads and capacities between the electrodes and associated circuits result in undesirable and uncontrolled coupling between input circuits and other circuits associated with the electrode system, since these inter-electrode capacities and lead inductances provide impedances common to the input circuit and the other circuits.

There has recently come into use for high frequency operation an electron discharge device utilizing a controlled beam of electrons, modulated by a conventional grid electrode connected to resonant cavity circuits or cavity resonators, energy being extracted from the modulated beam by induction by means of resonant cavity circuits.

In one form of such tube an elongated evacuated envelope has positioned at one end a cathode and grid and at the other end a collector. Positioned between the grid and collector is an output resonant cavity tank circuit surrounding the envelope and having a gap transverse to the beam of electrons. A screen and accelera'ing electrode is positioned between the grid and the gap in the resonant cavity tank circuit. A concentric line input circuit is coupled between the cathode and the grid and this line is in turn surrounded by another resonant cavity circuit coupled to the screen. A device of this kind is described and claimed in my copending application Serial No. 375,029, filed January 18, 1941, and assigned to the same assignee as the present application. The grid and cathode leads extend through the envelope and are electrically connected to the concentric conducting member forming the resonant cavity circuits.

With this arrangement the grid lead provides a common coupling impedance between the input or cathode-grid circuit and the circuit associated with the screen electrode so that energy is fed back from the screen grid-control grid circuit through the common impedance to the input circuit. Depending upon the phase relationship of the fed back energy and the input signal voltage, either regeneration or degeneration may take place, causing either unwanted oscillations or excessive damping, or loading down of the input circuit.

Tubes of the kind described are primarily designed to eliminate input loading and to reduce ohmic and radiation losses by the proper arrangement of concentric line and resonant cavity tank circuits. However, as pointed out it is essential that the coupling between circuits and the control of energy feedback be provided in order to obtain satisfactory operation of the device. As the higher frequencies are approached the lead impedance and interelectrode capacitances and coupling between the tank circuits and the electrodes become the limiting factors in the operation of such devices.

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In one form of an electron discharge device described and claimed in my co-pending application, Serial No. 437,634, filed April 4, 1942, and assigned to the same assignee as the present application, I show and describe a device in which the electrode leads, particularly those for the cathode and the grid, are extended through the envelope and form part of the circuits themselves, the leads acting as shields to prevent coupling between the input and output circuits. In the specific arrangement described the cathode leads are arranged in a circle and extend through one end of the tube envelope. The grid leads are positioned around the cathode leads and also extend through the tube envelope and form the walls of one of the resonators, shielding the cathode-grid or input circuit from the screen-control grid circuit. However, in a case of tubes of relatively small size, the concentric lead arrangement in the stem of the envelope may be difficult to manufacture and other construction is necessary.

In the form of tube described in my copending application, in order to provide feedback between the screen and input circuits, when it is desired to use the device as an oscillator, coupling loops are necessary, which, to permit feedback in the proper phase and amount, require the use of a coaxial line cable which is adjustable, as well as adjustable coupling loops within the resonators.

It is, therefore, one of the principal objects of my invention to provide an electron discharge device particularly suitable for use at ultra high frequencies.

Another object of my invention is to provide such a device in which the electrode lead impedances and the interelectrode capacitances can be neutralized to permit control of the operation of the device at ultra high frequencies.

A further object of my invention is to provide such an electron discharge device and its associated circuit for operation at ultra high frequencies.

A still further object of my invention is to provide such a device in which restrictions placed

on lead arrangements because of mechanical reasons are avoided.

Another object of my invention is to provide an electron discharge device utilizing circuits of the hollow resonant conducting type in which all of the circuits can be tuned without materially affecting the other circuits.

A further object of my invention is to provide a device of the type described in which the energy interchanged between the circuits may be controlled by tuning arrangements but without the need of extra coupling elements, such as coaxial feed lines.

A still further object of my invention is to provide such an electron discharge device and associated resonant cavity circuits in which the transfer of energy between the screen circuit and the grid circuit can be accomplished without the use of external feed or coupling lines to control regeneration or degeneration.

A still further object of my invention is to provide means for coupling the output of an electron discharge device using resonant cavity circuits to another device for amplification purposes or to an output circuit or load.

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 transverse section of an electron discharge device made according to my invention, Figures 2 and 3 are transverse sections taken along the line 2—2 and 3—3 of Figure 1, Figure 4 is a schematic diagram showing the equivalent circuits of parts of an electron discharge device made according to my invention and shown in Figure 1, Figure 5 is a more detailed equivalent circuit of one of the portions of a device made according to my invention, and Figure 6 is a schematic diagram of a complete electron discharge device made according to my invention and of its associated circuits and power supplies.

In Figure 1 I show a longitudinal section of an electron discharge device made according to my invention and of its associated circuits. The electrode system for providing the modulated electron beam is enclosed within an elongated envelope 10 containing at one end an indirectly heated cathode 11 provided with heater 12. A cup-shaped control grid 13 surrounds and shields the cathode, and modulates the electron stream projected through the tube from cathode 13 to the collector 14 mounted at the other end of the tube. This collector may be provided with heat radiating fins 15 and have within it a secondary electron suppressing ring 16 normally maintained at a lower voltage than said collector. Positioned between the grid and the collector are a pair of accelerating electrodes 17 and 18. The electron beam from the cathode 11 is modulated by the grid 13 and in passing through the accelerating electrodes 17 and 18 to the collector 14 during operation of the device, excites the associated circuits in a manner to be described.

The cathode is supported by a plurality of leads and supports 19 and 20 arranged in a semicircle and extending through the end of the envelope. As best shown in Figures 1 and 3 the leads 19 are connected to a semi-circular conducting member 21. One of the leads 19 is electrically connected to the cathode 11 by strap 19'. The heater lead 20 is spaced from the conductor 21 by means of the insulator 20' to permit a heating current to be applied to the heater 12 through the leads 19 and 20.

The grid is supported by means of the conductors 22 arranged in a semi-circle and electrically connected to the semi-circular conducting member 22'.

The circuits connected to the electrode system will now be described. A tubular conducting member 23, one end of which surrounds the envelope 10 and is spaced closely adjacent the envelope and the collar of grid 13 is provided with a shielding partition 24 of conducting material dividing the member 23 into two shielded compartments. Within one compartment of this tubular member 23 is mounted a coaxial line type resonant cavity circuit connected to the cathode. It comprises an inner tubular member 25 and outer tubular member 26 connected together and closed at one end by the conducting member 27. The cathode and one side of the cathode heater line are connected through the lead 19 and conducting member 21 to the tubular member 25 by means of the spring clip 25'. To supply heating current to the heater a clip 28 engages lead 20 and is electrically connected to and supported by the conducting plug 29, insulated from the tubular member 25 by the insulating collar 30, the other end of the plug being connected to conductor 31 which goes to the other side of the cathode heating circuit. This arrangement by-passes radio frequency voltages and currents and keeps them out of the cathode heater conductors. This concentric line circuit may be tuned by means of the tuning plunger 32 movable longitudinally by means of the rod 33. During operation parasitic oscillations may occur and these may be tuned out by means of a tuning condenser in the form of a ring 34 insulatingly supported on member 25 and movable longitudinally of the coaxial line circuit by means of the operating handle 35 extending through slot 36 in the members 23 and 26.

A grid circuit of the concentric type comprises the inner tubular member 37 surrounded by the coaxial tubular member 38, these members being electrically connected together and closed at one end by means of the conducting member 39. The free end of the member 37 adjacent the grid leads is closed by means of the metallic cup-shaped member 40 and insulated from the tubular member 37 by insulating collar 41. The conductor 42, by means of which a biasing voltage can be applied to the grid, is mounted within the tubular member 37 and electrically connected to the cap 40, the cap 40 being in turn connected to conducting member 22' by means of the spring clip 43 mounted on cap 40. This arrangement by-passes radio frequency voltages and currents which might otherwise flow into the grid voltage biasing circuit.

A tuning collar 44 operated by rod 45 can be moved along the coaxial tuning members in order to tune the grid circuit and to obtain certain results to be described. The partition 24 inserted within the tubular member 23, and extending close to the end of the envelope 10 shields the grid and cathode circuits from each other.

A third resonant cavity circuit is connected to the first accelerating electrode 17 and comprises a tubular member 46 closed at one end by means of the conducting member 47, and forming with the member 23 a third coaxial line circuit. A ring 48 having an L-shaped cross section is mounted within but insulated from the tubular

member 46 by means of the insulating collar 49 which may be of mica. The cylindrical surfaces of member 48 and of member 46 together with the insulating collar 49 form a radio frequency bypass condenser. An insulating ring 50 maintains the members 46 and 23 in spaced relationship. In order to tune this last resonant cavity circuit for purposes to be described, I provide a tuning collar or ring 51 of conducting material which may be slidably supported on the member 23 by means of the insulating flat ring members 52 and 53 mounted within the member 51 and contacting the inner tubular member 23. The ring may be moved longitudinally by means of the insulating rod 54. This last circuit may be referred to as the accelerating electrode circuit. This last circuit is energized in a manner to be described by the modulated electron stream directed from the cathode to the collector.

The output tank circuit comprises a drum-shaped resonant cavity tank circuit or resonator 55, the walls of which are electrically connected to collar shaped members 56 and 57, spaced by a gap 58. The members 56 and 57 serve as the output electrodes in a manner now well known and described in my Patent 2,237,878 assigned to the same assignee as the present application. The member 56 is spaced from tubular member 23 and provides a second gap 59 in the accelerating electrode circuit. The conducting member 56 is electrically connected to the accelerator 17 by means of the short radial leads 60 and spring clip members 61 so that the accelerator and output tank circuit can be maintained at the same potential.

In order to tune the output tank circuit I mount within the resonator 55 the conducting collar-like member 62 provided with the supporting lugs 63 pivoted at 64 to the insulating blocks or members 63' to which are connected the insulating operating rods 65 for varying the position of the ring longitudinally with respect to the gap 58 in the interior of the resonator.

To maintain the beam properly focused in its passage between the cathode 11 and the collector 18, I may provide solenoids 66 and 67 for producing an electromagnetic field parallel to the movement of the electron beam.

To couple the output resonator 55 to a load 74, I provide an coaxial line coupling arrangement comprising tubular members 68 and 69, member 68 being closed by conductor 70. Enclosed within 69 is a second tubular member 71 telescopically receiving conducting rod 72 which may be moved longitudinally by means of insulating operating rod 72'. The position of the rod 72 within the member 68 determines the degree of coupling between the resonator and the coaxial line comprising elements 69 and 71. As an additional means for properly matching the load impedance to the output impedance of the tube, I provide a tuning condenser 73, which can be moved along the concentric line 69—71. By properly positioning this condenser and adjusting the position of the coupling rod 72 an efficient coupling between the load and the output circuit of the tube is obtained.

In order to understand the problem and solution which my invention provides, reference may be had to Figure 4 which shows schematically the equivalent circuits of the input side of the electron discharge device made according to my invention. The output portion of the device is not shown in Figure 4. The elements C, G and S represent, respectively, the cathode, control grid

and screen which are denoted as electrodes 11, 13 and 17 in Figure 1. The inductance L_c represents the inductance of the leads 19 and 20, conductors 20' and the spring clips 25' and 28. The impedance Z_c represents the impedance of the coaxial line tank comprising the elements 25, 26, 27 and tubular member 23. The capacity C_{cg} represents the capacity between the cathode and grid 13. The inductance L_g represents the lead inductance of the conductors 22, 22' and clip 43, and the impedance Z_g represents the impedance of the coaxial line 37, 38 and 39 and that portion of the conductor 23 forming part of the grid circuit. The capacity C_{sg} represents the capacity between the grid 13 and accelerator and screen electrode 17. The impedance Z_s is the impedance of the coaxial line tank circuit represented by tubular members 46, closure member 47 and tubular member 23 and member 48. The point A is indicated as the inner edge of the tubular member 23. Each of the coaxial lines can be tuned by the elements 32, 44 and 51.

Thus by properly tuning the coaxial line tank circuit Z_g the grid lead inductance L_g may be neutralized so that in effect the grid G may be at the same radio frequency potential as the point A. That is, the impedance between A and G can be made substantially zero. If this is done then the circuit Z_s—S—C_{s-g} becomes substantially isolated from the circuit Z_c—L_c—C—C_{c-g} so that substantially no energy transfer can take place between these circuits. To minimize inductive and capacitive coupling between the cathode and grid lines the shield 24 is utilized. Now, if the cathode circuit G—C_{c-g}—C—L_c—Z_c—A and the screen circuit G—C_{s-g}—S—Z_s—A are tuned in such a manner that they represent high impedance between points G and A, and if R.-F. energy is supplied from an external source to the cathode circuit, then the resulting cathode excitation will modulate the electron stream, which in turn, passing through the gap 59, will excite the screen circuit so that R.-F. voltage will appear at the gap 59. The mechanism by which the screen circuit will be excited by a modulated electron stream passing gap 59 is described in my patent referred to above. By properly tuning the screen circuit the phase and amplitude of voltage across gap 59 can be adjusted to attain the effect of "phase focusing," described in my copending application, Serial No. 455,175, filed August 18, 1942, and assigned to the same assignee as the present application, and thus to obtain high efficiency of operation. In order to obtain high power gain when the tube is used as a stable amplifier, part of the energy extricated at gap 59 can be fed back to the cathode circuit, thus neutralizing to the desired degree the losses in the cathode circuit. The transfer of energy from the screen to the cathode circuit can be accomplished by a readjustment of the grid circuit G—L_g—Z_g—A, which controls the coupling between the screen and the cathode circuits. Instead of a previously described adjustment for complete isolation of these circuits, which was obtained when the grid circuit impedance between G and A was made substantially zero by tuning of the grid line, the line now is detuned from this position and now presents a finite impedance of a correct phase and magnitude sufficient to feed energy from screen to the cathode circuit and thus neutralize its lossses to the desired degree. This neutralization which is under control effected by tuning of the grid circuit can be made complete, if desired, in which case self-sustained oscillations

will be generated in the system cathode-grid-screen and the associated circuits. The electron stream after generating oscillations in the C—G—S system retains its modulation and on passing gap 58 excites the output tank circuit 55 to which the load circuit is coupled. Thus this arrangement is equivalent to an "electron coupled" ultra-high frequency oscillator.

A more detailed schematic diagram of a portion of the schematic circuit shown in Figure 4, namely, the grid circuit G—L_g—Z_g—A, is shown in Figure 5. The capacity between point A of the element 23 and the grid is represented by capacity C_{ga}. The inductance of the grid leads is L_g and the equivalent capacitance and inductance of the concentric line grid circuit are represented by C and L. The resistance of the grid circuit is represented by the element *r*. For isolation of screen and cathode circuits the values of C and L are adjusted so (by tuning of plunger 44) the impedance from A to G is very low and is limited only by finite resistance *r* which can be made very low. However, for obtaining regenerative feedback of energy from screen to cathode circuit, the grid circuit from point A to point G must be represented by almost pure inductive reactance. The presence of the capacitance C_{ga} may limit the range of inductive impedance which can be obtained by tuning of the grid circuit. Therefore, in the design of the tube the circuit capacitance of the control grid and its support 13 to the cylinder A is made as small as possible.

In Figure 6 is shown the schematic diagram of an electron discharge device made according to my invention and the associated circuits. The cathode heater is supplied from an A. C. source through a transformer 75. The biasing voltage for the grid is supplied by means of the voltage source 76, and the high voltage potential for the collector 14 and the accelerators 17 and 18 by means of the high voltage D. C. source 78. The biasing voltage source for maintaining the suppressor 16 below the voltage of the collector 14 is indicated at 79. If operated as a pulse transmitter the pulse voltage may be applied through the lead 77. This pulse voltage in effect neutralizes biasing voltage 76 for the period of the pulse length and permits the passage of current from the cathode 11 to collector 16. Under these conditions the device is operated as an "electron-coupled" oscillator as explained above, and pulses of R.-F. energy are generated and delivered to the load. If the device is to be operated as a radio frequency amplifier, a pulse voltage would not be used to neutralize biasing voltage 76. The grid line would be tuned for optimum condition of regeneration as described above and the exciting voltage would be applied in the usual way by means of a coupling loop either within the cathode resonator or grid resonator, if desired.

The modulated electron beam in passing across the gap 58 excites the output resonator by induction in a manner described in my patent referred to above. In the present case I employ a novel coupling arrangement for extracting energy from the output resonator and matching the load impedance to the tube impedance. As pointed out above, and referring to Figure 1, by moving the rod 72 with respect to the tubular member 68 the degree of coupling between the resonator and the coaxial line may be changed. In effect this is similar to changing, for example, a tap on the conventional coil of the conventional tank circuit to include more or less

turns to increase or decrease the coupling and the amount of power taken from the tank circuit. By moving the rod 72 into the tubular member 68 the coupling may be increased but this at the same time may vary the inductance and capacity of the coupling circuit. In order to match the impedance of the transmission line by the load, such as an antenna, to the tube impedance, a matching condenser 73 is used. This condenser 73 acts like a common coupling impedance between the portion of the line coupled into the resonator and the portion coupled to the load. The position of the condenser 73 on the line 71—69 can be varied by moving insulating rod 73' attached to condenser 73. Thus, the position of rod 72 determines the degree of coupling, and the proper positioning of condenser 73 neutralizes the reactive component of the coupling line 71. Thus, by proper matching maximum power output can be generated and delivered to the useful load.

Thus by means of my invention I have provided an electron discharge device which is particularly useful at ultra high frequencies and in which the effect of lead inductance and inter-electrode capacitances have been neutralized to permit control of the operation of the device at high frequencies. By means of my invention restrictions which were placed upon lead arrangements are removed and it is possible by individually tuning each of the circuits connected to the grid, cathode and accelerator to obtain the optimum performance. By means of my invention I have also eliminated the necessity for coaxial feed lines between the different circuits and the necessity for providing special phasing arrangements in the feedback coaxial lines. I have also provided by means of my invention a novel and effective means for coupling the output of the resonator to a load for maximum transfer of energy.

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 a cathode, a control electrode, and another electrode all in the order named and disposed along a linear axis, a first cavity resonator having one side coupled to said control electrode and adjustable tuning means in said first cavity resonator for tuning said cavity resonator off resonance, a second cavity resonator having one side coupled to said other electrode, and a common conductor having substantially no reactance and electrically connecting the other sides of said cavity resonators together, said second cavity resonator surrounding said first cavity resonator.

2. An electron discharge device having a cathode, control electrode, accelerating electrode and means for collecting electrons, all in the order named, a first cavity resonator having one side coupled to said control electrode and means included with said first cavity resonator for tuning said first cavity resonator off resonance, a second cavity resonator having one side coupled to said accelerating electrode, and a common

conductor having substantially no reactance electrically connecting the other sides of said cavity resonators together.

3. An electron discharge device having a cathode, control electrode, accelerating electrode and a collector, all in the order named, and a first cavity resonator coupled to said cathode, a second cavity resonator having one side coupled to said control electrode, and means included with said first cavity resonator for tuning said first cavity resonator, a third cavity resonator having one side coupled to said accelerating electrode and a common conductor electrically connecting the other side of said second and third cavity resonators together.

4. An electron discharge device having a cathode, control electrode, accelerating electrode and means for collecting electrons, all in the order named, a first cavity resonator having one side coupled to said control electrode, and means included with said first cavity resonator for tuning said first cavity resonator, a second cavity resonator having one side coupled to said accelerating electrode, and a common conductor electrically connecting the other sides of said first and second cavity resonators together, and means surrounding the electron path for inductively extracting energy from electrons passing from said cathode to said collector.

5. An electron discharge device having a cathode, control electrode, accelerating electrode and means for collecting electrons, all in the order named, a coaxial line resonator connected to said control electrode and means included with said coaxial line resonator for tuning said coaxial line resonator, and a cavity resonator connected between said accelerating electrode and said coaxial line cavity resonator.

6. An electron discharge device having a cathode, control electrode, accelerating electrode and means for collecting electrons, all in the order named, a first cavity resonator coupled to said control electrode, a second cavity resonator coupled to said cathode, and means included with said second cavity resonator for tuning said second cavity resonator, and a third cavity resonator coupled to said accelerating electrode, and conducting means common to and electrically connected to each of said first and third cavity resonators.

7. An electron discharge device having a cathode, control electrode, accelerating electrode, and collector, all in the order named, a first coaxial line resonator coupled to said cathode, a second coaxial line resonator coupled to said control electrode and a cavity resonator coupled between said accelerating electrode and the coaxial line resonator connected to said control electrode, and means included with the control electrode coaxial line circuit for tuning the coaxial line circuit connected to said control electrode.

8. An electron discharge device having a cathode, control electrode, accelerating electrode and collector in the order named, a first resonator having one side coupled to said cathode, a second resonator having one side coupled to said control electrode and means included with said second resonator for tuning said second resonator, a third resonator having one side coupled to said accelerating electrode, and a common conductor electrically connecting the other sides of said resonators together.

9. An electron discharge device having a cathode, control electrode, accelerating electrode and collector, all in the order named, a first coaxial

line resonator connected to said cathode, and a second coaxial line resonator connected to said grid, and conducting means surrounding said coaxial line resonators and extending toward but spaced from said control electrode, and a cavity resonator coupled between said accelerating electrode and said conducting means.

10. An electron discharge device having a cathode, control electrode, accelerating electrode and collector, all in the order named, a first coaxial line resonator coupled to said cathode, and a second coaxial line resonator coupled to said grid, and conducting means surrounding said coaxial line circuits and extending toward but spaced from said control electrode, and a cavity resonator coupled between said accelerating electrode and said conducting means included with said second coaxial line resonator, and means for tuning said second coaxial line resonator.

11. An electron discharge device having a cathode, control electrode, accelerating electrode and collector, all in the order named, a first coaxial line resonator connected to said cathode, and a second coaxial line resonator connected to said grid, and conducting means surrounding said coaxial line resonators and extending toward but spaced from said control electrode, and a cavity resonator coupled between said accelerating electrode and said conducting means and including a tubular conductor surrounding said conducting means and connected thereto, and means included with said second coaxial line resonator for tuning said second coaxial line resonator.

12. An electron discharge device including an envelope having in the order named a cathode, control electrode and a third electrode, a first coaxial line resonator coupled to said cathode, and a second coaxial line resonator coupled to said control electrode, and a cavity resonator coupled to said third electrode and surrounding said first and second coaxial line resonator, and means included with the second coaxial line resonator for tuning the second coaxial line resonator and means for collecting electrons from said cathode.

13. An electron discharge device including an envelope having in the order named a cathode, control grid, accelerating electrode and collector, leads positioned in a semi-circle extending through the end of said envelope and connected to said cathode, oppositely disposed leads positioned in a semi-circle and connected to the grid electrode, a coaxial line resonator, the inner conductor of which is coupled to said cathode leads, and a second coaxial line resonator, the inner conductor of which is coupled to said grid leads, said coaxial line resonators being parallel to each other, a tubular conducting member surrounding said coaxial line resonators and said cathode and grid leads and extending toward said grid, and a cavity resonator surrounding said tubular conducting member and coupled to said accelerating electrode and said tubular conducting member, and means for tuning the coaxial line resonator connected to said grid leads.

14. An electron discharge device including an envelope having in the order named a cathode, control grid, accelerating electrode and collector, leads positioned in a semi-circle extending through the end of said envelope and connected to said cathode oppositely disposed leads positioned in a semi-circle and connected to the grid electrode, a coaxial line resonator, the inner conductor of which is coupled to said cathode leads, and a second coaxial line resonator, the inner conductor of which is coupled to said grid leads,

said coaxial line resonators being parallel to each other, a tubular conducting member surrounding said coaxial line resonators and said cathode and grid leads and extending toward said grid, and a cavity resonator surrounding said tubular conducting member and coupled to said accelerating electrode and said tubular conducting member, and means for tuning the coaxial line resonator connected to said grid leads, and a longitudinally extending shield positioned between said coaxial line resonators and contacting said tubular member on the interior thereof.

15. An electron discharge device including an envelope having in the order named a cathode, control grid, accelerating electrode and collector, a lead extending through the end of said envelope and connected to said cathode, a lead extending through said envelope and connected to said grid electrode, a first coaxial line resonator with one end coupled to said cathode lead, a second coaxial line resonator parallel to said first coaxial line resonator and coupled to said grid lead, a first tubular conducting member surrounding said coaxial line resonators and said leads and extending toward said control grid and close to said envelope, a second tubular conducting member surrounding said first tubular conducting member and forming therewith a cavity resonator, said cavity resonator being coupled to said accelerating electrode, and a cavity resonator positioned between said accelerating electrode and said cathode, and means for tuning the coaxial line resonator connected to said control grid lead.

16. An electron discharge device including an envelope having in the order named a cathode, control grid, accelerating electrode and collector, a lead extending through the end of said envelope and connected to said cathode, a lead extending through said envelope and connected to said grid electrode, a first coaxial line resonator with one end coupled to said cathode lead, a second coaxial line resonator parallel to said first coaxial line resonator and coupled to said grid lead, a first tubular conducting member surrounding said coaxial line resonator and extending toward said grid and close to said envelope, a second tubular conducting member surrounding said first tubular conducting member and forming therewith a cavity resonator, said cavity resonator being coupled to said accelerating electrode, and an output cavity resonator positioned between said accelerating electrode and said collector, and means for tuning each of the coaxial line resonators and said cavity resonator coupled to said accelerating electrode.

17. A cavity resonator including means for coupling said cavity resonator to a load, said means including a coaxial line, the outer conductor of said coaxial line communicating with the interior of said resonator, the free end of the inner conductor of said coaxial line extending within the space within the resonator, and hollow conducting means extending outside of said resonator, and oppositely disposed to the outer conductor of said coaxial line receiving the free end of the inner conductor when said inner conductor is adjusted to extend through the space within said resonator.

18. A cavity resonator including means for coupling said resonator to a load, said means including a coaxial line, the outer conductor of said coaxial line communicating with the interior of said resonator, the free end of the inner conductor of said coaxial line extending within the space within the resonator, and hollow conducting means extending outside of said resonator, and oppositely disposed to the outer conductor of said coaxial line receiving the free end of the inner conductor when said inner conductor is adjusted to extend through the space within said resonator, and means within said coaxial line and movable longitudinally of the coaxial line for tuning said line.

19. An electron discharge device having a cathode, a cup-shaped control grid surrounding said cathode, an accelerating electrode and collector, a first coaxial line circuit having its inner conductor connected to said cathode, a second coaxial line circuit parallel to said first coaxial line circuit and having its inner conductor connected to said grid, a first tubular conducting member surrounding said coaxial line circuits and extending toward but spaced from said grid, a second tubular conducting member surrounding said first tubular conducting member and forming therewith a cavity resonator coupled between said accelerating electrode and said first tubular conducting member, and an output cavity resonator surrounding the path of the electrons from said cathode to said collector, and means for coupling said output cavity resonator to a load and comprising a coaxial line, the inner conductor of which has a free end extending into said output cavity resonator, said inner conductor being movable longitudinally of said output cavity resonator and adjustable tuning means in said last coaxial line for tuning said last coaxial line.

ANDREW V. HAEFF.

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Disclaimer

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Hereby enters this disclaimer to claim 5 of said patent.

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