May 21, 1946. A. V. HAEFF 2,400,752

ELECTRON DISCHARGE DEVICE

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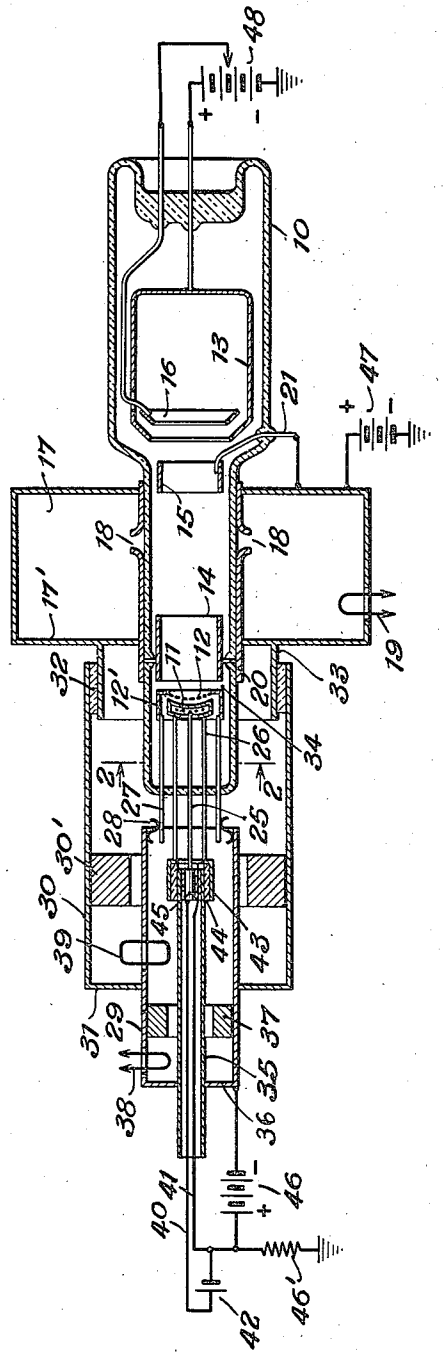


Fig. 1.

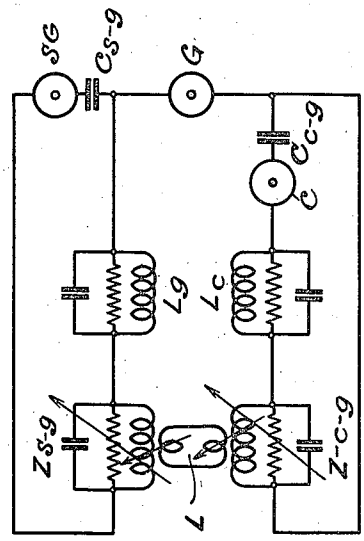


Fig. 3.

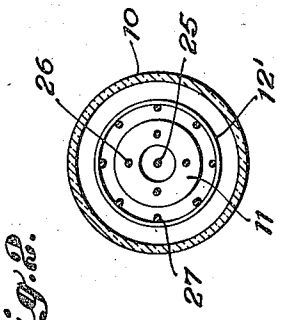


Fig. 2.

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ELECTRON DISCHARGE DEVICE

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16 Claims. (Cl. 250—27.5)

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 capacitance between leads and between the electrodes and associated circuit elements become factors materially affecting operation of tubes and circuits. These factors may cause undesirable and uncontrolled coupling between input circuits and other circuits associated with the electrode system.

There has recently come into use, particularly for high frequency operation, electron discharge devices utilizing a controlled beam of electrons. In these devices the electron beam is controlled either by a conventional grid electrode or by means of an electrode which is an integral part of a wall of a resonant cavity and the energy is extracted from the modulated beam by projecting the beam through one or several resonant cavities.

In one form of such tube an evacuated elongated envelope has positioned at one end a cathode and control grid and at the other end a collector. Between the grid and collector are positioned two accelerator electrodes and a resonant cavity output tank circuit through which the electron stream passes on its way from the cathode to the collector. A concentric line input circuit is connected between the cathode and the control grid and this concentric line is in turn surrounded by another resonant cavity circuit terminating at the control grid and the first accelerator electrode. The grid and cathode leads extend through the envelope and are electrically connected to the concentric conductors forming the concentric line input circuit. With this arrangement, however, the grid leads may provide a common coupling impedance between the input, or cathode-control grid circuit, and the circuit associated with the accelerator electrode, so that energy interchange may take place between the two circuits through this common impedance. Depending upon the phase relationship between the input signal voltage and the voltage fed back to the input circuit from the accelerator circuit, regeneration or degeneration may take place, causing either unwanted oscillations or excessive positive or negative damping of the input circuit.

Tubes of the kind described are primarily designed to eliminate or to control input loading and to reduce ohmic and radiation losses by the use of concentric line and resonant cavity circuits. However, as the higher frequencies are approached the lead impedances which are common to two circuits and the inter-electrode capacitances may cause excessive coupling between the circuits and thus become the limiting factors in the operation of such devices. Therefore, for satisfactory operation of these devices it is essential that the coupling between circuits and thus the energy feedback be under substantially absolute control.

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

Another object of my invention is to provide such a device in which the electrode lead impedance and the inter-electrode capacitance can be neutralized or substantially eliminated to insure operation of the device at ultra high frequencies.

More specifically it is an object of my invention to provide such a device utilizing concentric lines and resonant cavity tank circuits in which the electrode leads are merged into the tank circuits to eliminate the effects of a common lead impedance and capacity between electrodes and the tank circuits.

A still further object of my invention is to provide such an electron discharge device and associated circuit in which the transfer of energy to the input circuit from following circuits can be controlled so as to control the input loading as well as regeneration or degeneration present in the device.

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 schematic longitudinal section 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 showing details of the lead arrangement of the device, and Figure 3 is a schematic diagram representing the equivalent circuit of the device shown in Figure 1.

Referring to Figure 1, I provide an evacuated elongated envelope 10 having at one end an indirectly heated cathode 11, control grid 12 and at the other end a collector 13. Positioned between the grid and collector is a screening and accelerating electrode 14 and accelerating electrode 15, a suppressor 16 being provided within

the collector for suppressing secondary electron emission from collector 13.

Surrounding the envelope and the discharge path between the cathode and collector is the resonant cavity output tank circuit 17 provided with a gap 18 surrounding the discharge path. Energy is delivered to this resonant cavity tank circuit when a modulated stream of electrons passes across this gap as described in my Patent No. 2,237,878. Energy is fed to an output by means of coupling loop 19. The accelerating electrode 14 may be electrically connected to the tank circuit 17 by means of radial leads 20 and the accelerator 15 may be connected to the tank circuit by means of the lead 21.

In accordance with my invention, in order to prevent undesirable coupling between other circuits and the input circuit connected to the cathode 11 and control grid 12, the grid 12 is provided with a collar 12' to which is secured a plurality of leads 27 which form a screen around the cathode 11, and the cathode leads 26 and the heater lead 25 arranged as is shown in Figure 2. The grid leads act to shield the cathode leads, and the cathode leads in turn shield the heater lead from the grid-cathode circuit to prevent undesirable coupling therebetween and thus eliminate the necessity for providing by-passing condensers.

Closely adjacent the end-wall of the tube envelope and surrounding the cathode and heater leads and their extensions is the tubular member 29 electrically connected to the grid leads 27 by means of the connecting clips 28. The resonant circuit connected between the grid 12 and accelerating electrode 14 is completed by means of outer tubular member 30 electrically connected to member 29 by means of the end disc 31. The open end of the tubular member 30 is capacitively coupled to an extension 33 on the resonant cavity tank circuit 17. This member 33 extends from the vertical wall 17' and the open end of member 30 is electrically insulated therefrom by insulating collar 32. The resonant circuit between grid and accelerator electrodes thus comprises collar 12', grid leads 27, connectors 28, tubular member 29, disc 31, tubular member 30, collar 33, wall 17' connections 20 and electrode 14. R.-F. voltages and currents induced within this resonant cavity circuit confine themselves to the inner surfaces forming the chamber of the resonant cavity and the surface of the grid leads facing the interior of the chamber. If the grid leads do not sufficiently screen the cathode-grid circuit to be described, their number may be increased so that the coupling between the inner chamber of the resonant cavity and the grid-cathode circuit is practically nil. This resonant cavity may be tuned by means of the collar-like conducting member or shorting condenser 30' movable longitudinally within the resonant cavity.

The grid-cathode or input tank circuit comprises the outer tubular member 29 and the inner tubular member 35 capacitively coupled to the cathode leads 26 by means of the cup-shaped cap 43 insulated from the tubular member 35 by means of insulating collar 44. Member 29 is closed by means of the disc 36. The concentric line circuit formed by conductors 29 and 35 is tuned by means of the longitudinally moving collar 37. Desired input may be fed into cathode-grid circuit by means of coupling loop 38. The heater lead is by-passed for R. F. by means of plunger member 45 insulatingly supported within the tubular member 35.

The cathode heating current is supplied by means of the leads 40—41 connected to the potential source 42 and, if desired, the grid may be biased with respect to cathode by means of the potential source 46 and by means of a biasing resistor 46' or by either alone. It is noted that the insulating collar 32 permits high voltage (with respect to cathode and grid) to be applied to tank circuit 17 from the voltage source 47, the collector and suppressor voltages being supplied by source 48. The collector is usually maintained at a lower potential than the tank circuit and the suppressor ring 16 at a still lower potential.

Because of the concentric arrangement of the control grid leads which form part of the walls of the concentric line circuits, the inherent inductive coupling between the screen electrode-control grid circuit and the control grid-cathode circuit is reduced to a negligible value even though the physical length of the control grid leads is long compared to operating wavelength. Coupling due to capacitance between cathode and screen can be reduced to any desired value by using a high mu grid and a sufficient number of grid leads. The position of the heater leads and grid leads serves to minimize coupling from the grid-cathode circuit to the heater circuit and thus obviates the necessity of using internal by-pass condensers between the heater and the cathode leads. The concentric arrangement thus eliminates undesired coupling due to the lead impedance. The feedback of the energy from the screen grid circuit to the cathode circuit is accomplished by means of controllable coupling loop 39.

Thus in accordance with my invention by the use of a concentric lead arrangement for the cathode and grid and by merging these leads into the concentric type resonant cavity tank circuits proper, it is possible to eliminate common lead impedance between the input circuit and the screen grid or first accelerator electrode circuit, thus preventing undesired coupling. Control of the regeneration or degeneration is provided for by means of an adjustable coupling device between the input circuit and other circuits and by means of tuning arrangements permitting individual tuning of the circuits involved.

Figure 3 discloses an equivalent circuit diagram of the tube shown in Figure 1. Elements C, G and SG represent, respectively, cathode, grid and screen and accelerating electrodes, capacitances C_{s-g} and C_{c-g} represent the capacitances between the screen grid and the control grid and between the control grid and the cathode. The impedances L_g and L_c represent the grid lead impedance and the cathode lead impedance connected in series with Z_{s-g} representing the impedance of the tank circuit between the screen grid and control grid and Z_{c-g} representing the impedance of the tank circuit connected between the cathode and control grid, the coupling element L representing the coupling element 39 for controlling energy feedback between the control grid-screen electrode tank circuit and the cathode-control grid tank circuit.

In operation electrons furnished by the indirectly heated cathode pass through the grid 12 in the form of a beam to be modulated by the grid, are accelerated through the screen and accelerating electrode 14, pass gap 18 in the resonant cavity tank circuit 17, through the accelerator-screen 15, and are finally collected by collector 13. Secondary electrons are prevented from leaving the collector by means of suppressor ring 16 maintained at a lower potential than collector 13.

The concentric line input tank circuit connected between the cathode and grid and comprising the tubular members 29 and 35 closed by plate member 36 is energized by means of the coupling loop 38. The alternating voltage resulting between the grid 12 and cathode 11 modulates the electron stream prior to its passage through the screen and accelerating electrode 14, the energy being extracted from the modulated stream as the electrons pass the gap 18 in manner, now well known, by inductive action. The action which takes place is described in more detail in my Patent No. 2,237,878 issued April 8, 1941. The high frequency field resulting from excitation by means of loop 38 is confined within the concentric line resonant cavity tank circuit, the grid leads 27 and the cathode leads 26 forming continuations of the wall of the tubular members 29 and 35 forming part of the resonant cavity.

The arrangement shown at 45, 44 and 43 permits capacity coupling for R. F. between the cathode and the tubular member 35 but at the same time permits direct voltages to be applied to the cathode heater for heating the same.

Tuning of the input circuit is accomplished by means of the tuning cylinder 37, the position of which along the line is adjusted for optimum operating conditions. In passing across the gap between the control grid 12 and accelerator electrode 14, sufficient energy may be extracted to maintain the resonant cavity tank circuit coupled between the control grid and accelerator electrode excited. The R. F. voltage appearing across 12 and 14 may serve to further modulate the stream and the energy can be fed through 39 to provide the desired degree of regeneration. The resonant circuit between 12 and 14 may be tuned to resonance for optimum conditions by means of the tuning collar 30'. Because of the comparatively complete shielding between the cathode and accelerating electrodes, there is no common coupling except for the small coupling due to capacity of cathode 11 and accelerating electrode 14, which can be compensated for by proper tuning of the circuits. Control of transfer of energy between the input circuit and the screen-control grid circuit can then be accomplished by means of a coupling coil 39, the position of which may be varied to control the amount of coupling. The by-pass condenser formed by collar 33 and insulating collar 32 permits the tubular members 30, 29 and 35 all to be maintained at a direct current potential different from the potential of the tank circuit 17 and collector 13, while at the same time providing a low impedance path for radio frequency currents.

It will be observed that the grid leads 27 form a common wall between the two resonant cavity tank circuits. Since radio frequency voltages and currents of each cavity are confined within the cavity, this common wall although formed by leads closely spaced substantially completely shields the two resonant cavities from each other and prevents a common coupling. Proper and sufficient shielding is accomplished by the use of a sufficient number of grid leads.

The grid 12 is maintained at a negative potential with respect to the cathode by means of the voltage source 46 and in operation the grid is maintained at ground R. F. potential while the cathode is swung with respect to the grid to produce modulation of the electron stream. The output is taken from the resonant cavity 17 by means of the coupling loop 19 and can be fed to a transmission line for amplification purposes or may be fed directly into the antenna.

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 envelope containing a cathode for supplying electrons, a control grid electrode and another electrode in the order named, a conductor for said cathode extending through said envelope, said grid electrode having a shielding surface to shield said cathode from the other electrode and provided with conducting and supporting means extending through said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said other electrode, and including a conducting member coaxial with said control grid electrode and contacting said conducting and supporting means close to the outside wall of said envelope, said conducting and supporting means forming a continuation of the wall of said cavity resonator, and a cathode-grid circuit connected between said cathode and grid, and feedback means coupling said resonator with said circuit for controlling the energy feedback from said cavity resonator to said cathode-grid circuit.

2. An electron discharge device having an envelope containing a cathode for supplying electrons, a control grid electrode and another electrode in the order named, a conductor for said cathode extending through said envelope, said control grid electrode having a shielding surface to shield said cathode from the other electrode and provided with conducting and supporting means extending through said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said other electrode, and including a conducting member coaxial with said control grid electrode and contacting said conducting and supporting means close to the outside wall of said envelope, said conducting and supporting means forming a continuation of the wall of said cavity resonator, and a cathode-grid circuit connected between said cathode and grid.

3. An electron discharge device having an envelope containing a cathode for supplying electrons, a control grid electrode and another electrode within said envelope in the order named, a lead for said cathode, said control grid electrode having a shielding surface to shield said cathode and cathode lead from the other electrode and provided with conducting and supporting means extending through said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said other electrode and including a conducting member coaxial with said control grid electrode, and contacting said conducting and supporting means close to the outside wall of said envelope, said conducting and supporting means forming a continuation of the wall of said cavity resonator and a control grid electrode-cathode cavity resonator coupled between said cathode and control grid electrode, and means coupling said resonators

together for controlling the energy transferred from one cavity resonator to the other cavity resonator.

4. An electron discharge device having an envelope containing a cathode for supplying electrons, a control grid electrode and another electrode within said envelope in the order named, a conductor for said cathode extending through said envelope, said control grid electrode having a shielding surface to shield said cathode from the other electrode and provided with conducting and supporting means extending through said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said other electrode and including a conducting member coaxial with said control grid electrode, and contacting said conducting and supporting means close to the outside wall of said envelope, said conducting and supporting means forming a continuation of the wall of said cavity resonator and a control grid electrode-cathode cavity resonator coupled between said cathode and control grid electrode, said cavity resonator coupled between the cathode and grid comprising a concentric line having the inner conductor coupled to said cathode conductor and the outer conductor connected to said grid, and means coupling said resonators together for controlling the energy transferred from one cavity resonator to the other cavity resonator.

5. An electron discharge device having an envelope containing a cathode for supplying electrons, a control grid electrode and another electrode within said envelope in the order named, a conductor for said cathode extending through said envelope, said control grid electrode having a shielding surface to shield said cathode from the other electrode and provided with conducting and supporting means extending through said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said other electrode and including a conducting member coaxial with said control grid electrode, and contacting said conducting and supporting means close to the outside wall of said envelope, said conducting and supporting means forming a continuation of the wall of said cavity resonator and a control grid electrode-cathode cavity resonator coupled between said cathode and control grid electrode, said cavity resonator coupled between the cathode and control grid electrode comprising a concentric line having the inner conductor coupled to said cathode conductor and the outer conductor connected to said control grid electrode.

6. An electron discharge device having an envelope containing a cathode for supplying electrons, a control grid electrode and another electrode within said envelope in the order named, conducting and supporting means for said cathode extending through said envelope, said control grid electrode having shielding surfaces to shield said cathode from the other electrode and provided with conducting and supporting means extending through said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said other electrode and including a conducting member coaxial with said control grid electrode and contacting said control grid electrode conducting and supporting means close to the wall of said envelope, said conducting and supporting means forming a continuation of the wall of said cavity resonator, and a control grid electrode-cathode circuit comprising a cavity resonator coupled between said cathode and control grid electrode, and means coupled between said resonators for controlling the energy transferred from one cavity resonator to the other cavity resonator, said other electrode and said cavity resonator coupled thereto being insulatingly separated to permit different direct voltages to be applied to said other electrode and to the cavity resonator coupled to said other electrode.

7. An electron discharge device having an envelope containing a cathode for supplying electrons, a control grid electrode and an accelerating and screening electrode, and a collector electrode within said envelope in the order named, a lead for said cathode, said control grid electrode having a shielding surface to shield said cathode and cathode lead from said screen and accelerating electrode and provided with conducting and supporting means extending through said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said accelerating and screen electrode, and including a conducting member coaxial with said control grid electrode and contacting said conducting and supporting means close to the wall of said envelope, said conducting and supporting means forming a continuation of the wall of said cavity resonator and a cathode-control grid electrode circuit coupled between said cathode and control grid electrode and feedback means coupling said resonator with said circuit for controlling the energy fed back from said cavity resonator to said cathode-control grid electrode circuit.

8. An electron discharge device having an envelope, a cathode, control grid electrode, accelerating electrode and collector electrode within said envelope and positioned in the order named, and a lead for said cathode, said control grid electrode enclosing said cathode and cathode lead and having a lead construction extending outside said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said accelerating electrode, and including a tubular member coaxial with said grid and electrically coupled to said grid lead construction close to the wall of said envelope, said grid lead construction forming a continuation of the wall of said cavity resonator, a cathode-grid cavity resonator connected between said cathode and grid, said tubular member forming a common wall between said cavity resonators, and feedback means coupled between said resonators for controlling the energy transfer between said cavity resonators.

9. An electron discharge device having an envelope, a cathode, control grid electrode, accelerating electrode and collector electrode within said envelope and positioned in the order named, and leads for said cathode, said control grid electrode enclosing said cathode and cathode leads and provided with leads extending outside said envelope, a cavity resonator surrounding said envelope and coupled between said control grid electrode and said accelerating electrode, and including a tubular member coaxial with said grid and electrically coupled to said grid leads close to the wall of said envelope, said grid leads forming a continuation of the wall of said cavity resonator, and a cathode-control grid cavity resonator connected between said cathode and control grid electrode, said last cavity resonator including a conducting member coaxial with and inside said tubular member and electrically coupled to said cathode leads, and conducting means positioned

between said tubular member and said coaxial member and movable longitudinally thereof for tuning said cathode-control grid electrode cavity resonator.

10. An electron discharge device having an elongated envelope containing a cathode, control grid and a screen electrode, and a collector electrode in the order named, said cathode being provided with a plurality of leads mounted in a circle and extending through the end of said envelope, said control grid having a plurality of leads lying in a circle surrounding said cathode leads for shielding said cathode leads, a radially extending conducting support connected to said screen electrode and extending through the wall of said envelope, a tubular member coaxial with the longitudinal axis of said envelope and extending close to the envelope wall and electrically connected to the radially extending conducting support, a cavity resonator coupled between said screen electrode and said tubular member, and a circuit connected between said tubular member and said cathode.

11. An electron discharge device having an elongated envelope and having at one end a cathode, control grid and accelerating electrode in the order named, and a collector in the other end of said envelope, said cathode being provided with leads extending from the end wall of the envelope, and said grid having a lead construction surrounding the cathode leads and extending through the wall of the envelope of said device, said accelerating electrode having a radially extending conducting and supporting means extending through the wall of the envelope, a cavity resonator having a gap surrounding the discharge path between the accelerating electrode and the collector, a cavity resonator surrounding said cathode and grid and coupled between said accelerating electrode and said grid and having an inner member concentric and coaxial with the longitudinal axis of the envelope and electrically connected to the grid lead construction adjacent the wall of the envelope, whereby said control grid lead construction forms a continuation of the wall of the cavity resonator last mentioned, and circuit means connected between the cathode and said inner member providing an input circuit connected between the cathode and the control grid, and feedback means coupling the accelerating electrode-control grid cavity resonator with the circuit connected between the control grid and cathode.

12. An electron discharge device having an elongated envelope and having at one end a cathode, control grid and accelerating electrode in the order named, and a collector in the other end of said envelope, said cathode being provided with leads extending from the end wall of the envelope, and said control grid having a lead construction surrounding the cathode leads and extending through the wall of the envelope, said accelerating electrode having radially extending conducting and supporting means extending through the wall of the envelope, a cavity resonator having a gap surrounding the discharge path between the accelerating electrode and the collector, a cavity resonator surrounding said cathode and grid and coupled between said accelerating electrode and said control grid and having an inner tubular member concentric and coaxial with the longitudinal axis of the envelope and electrically connected to the control grid lead construction adjacent the wall of the envelope, whereby said grid lead construction forms a continuation of the wall of the cavity resonator last mentioned, and a conducting member coaxial and within said inner tubular member and electrically coupled to said cathode, and means connecting said inner tubular member and the conducting member within said inner tubular member providing a cavity resonator connected between the cathode and the grid, and means coupling the accelerating electrode-control grid cavity resonator and the cavity resonator connected between the control grid and cathode.

13. An electron discharge device having an elongated envelope and having at one end a cathode, control grid and accelerating electrode in the order named, and a collector in the other end of said envelope, said cathode being provided with leads extending from the end wall of the envelope, and said control grid having a lead construction surrounding the cathode leads and extending through the wall of the envelope, said accelerating electrode having radially extending conducting and supporting means extending through the wall of the envelope, a cavity resonator surrounding said cathode and grid and coupled between said accelerating electrode and said control grid and having an inner tubular member concentric and coaxial with the longitudinal axis of the envelope and electrically connected to the grid lead construction adjacent the wall of the envelope, whereby said grid lead construction forms a continutaion of the wall of the cavity resonator last mentioned, and a conducting member coaxial and within said inner tubular member and electrically coupled to said cathode and means connecting said inner tubular member and the conducting member within said inner tubular member providing a cavity resonator connected between the cathode and the control grid, means within said accelerating electrode control grid resonator for tuning said accelerating electrode-control grid resonator, and other means within said control grid-cathode resonator for tuning said control grid-cathode resonator.

14. An electron discharge device having an envelope and containing a cathode, control grid, screen electrode and a collector electrode in the order named, said cathode being provided with a lead system extending through the end wall of the envelope, said control grid being provided with a lead construction lying in a circle around the cathode lead system, a cavity resonator having a gap surrounding the discharge path between the screen electrode and the collector electrode, and a radially extending conducting and supporting means for said screen electrode extending through the wall of the envelope, a first tubular member coaxial with said envelope and extending closely adjacent the envelope wall around said control grid lead construction and electrically coupled thereto, and a second tubular member surrounding said first tubular member and providing therewith a concentric line circuit, coupled between the control grid and the screen electrode through said radially extending conducting and supporting means, the control grid lead construction forming part of the wall of the concentric line circuit, and a conducting member coaxial with and inside said first tubular member and electrically coupled to said cathode lead system, and forming with said first tubular member an input cavity resonator connected between the control grid and the cathode.

15. An electron discharge device having an envelope and containing a cathode, control grid, screen electrode and a collector electrode in the

order named, said cathode being provided with a lead system extending through the end wall of the envelope, said control grid being provided with a lead construction lying in a circle around the cathode lead system, a cavity resonator having a gap surrounding the discharge path between the screen electrode and the collector electrode, and a radially extending conducting and supporting means for said screen electrode extending through the wall of the envelope, a first tubular member coaxial with said envelope and extending closely adjacent the envelope wall around said control grid lead construction and electrically coupled thereto, and a second tubular member surrounding said first tubular member and providing therewith a concentric line circuit coupled between the control grid and the screen electrode through said radially extending conducting and supporting means, the grid lead construction forming part of the wall of the concentric line circuit, and a member coaxial with and inside said first tubular member and electrically coupled to said cathode lead system, and forming with said first tubular member an input cavity resonator connected between the control grid and the cathode, and means within said concentric line circuit and means within the cathode-control grid cavity resonator for individually tuning the screen electrode-control grid circuit and the cathode-control grid cavity resonator.

16. An electron discharge device having an envelope and containing a cathode, control grid, screen electrode and a collector electrode in the order named, said cathode being provided with a lead system extending through the end wall of the envelope, said grid being provided with a lead construction lying in a circle around the cathode lead system, a cavity resonator having a gap surrounding the discharge path between the screen electrode and the collector electrode, and a radially extending conducting and supporting means for said screen electrode extending through the wall of the envelope, a first tubular member coaxial with said envelope and extending closely adjacent the envelope wall around said control grid lead construction and electrically coupled thereto, and a second tubular member surrounding said first tubular member and providing therewith a concentric line circuit coupled between the control grid and the screen electrode through said radially extending conducting and supporting means, the grid lead construction forming part of the wall of the concentric line circuit, and a conducting member coaxial with and inside said first tubular member and electrically coupled to said cathode lead system, and forming with said first tubular member an input cavity resonator connected between the control grid and the cathode, and means coupling said screen electrode-control grid concentric line circuit with said control grid-cathode cavity resonator for controlling the feedback of energy from the screen electrode-control grid concentric line circuit to the control grid-cathode cavity resonator.

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