Nov. 2, 1943. G. P. CHEVIGNY 2,333,295

ULTRA-HIGH FREQUENCY ELECTRON DISCHARGE DEVICE

Filed June 5, 1941 3 Sheets-Sheet 1

FIG. 1.

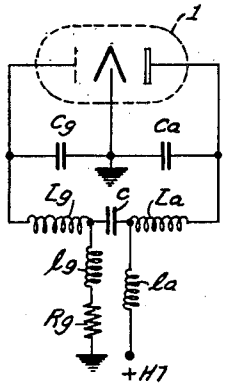


FIG. 2.

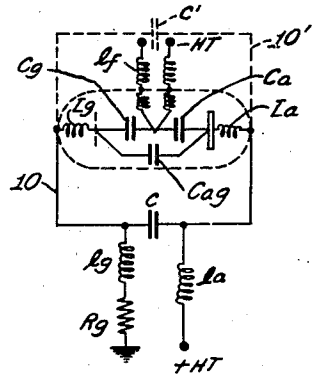


FIG. 3.

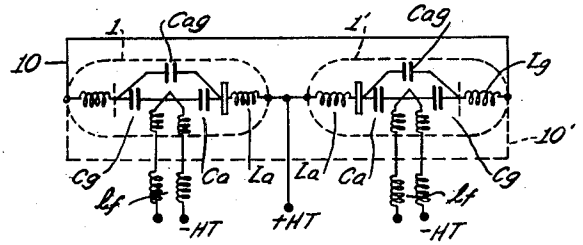


FIG. 4.

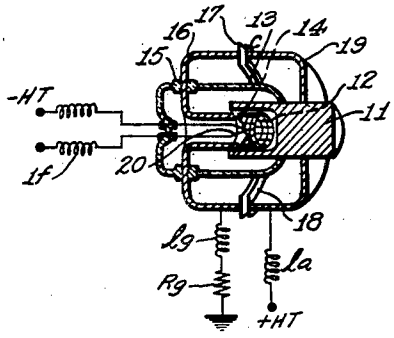
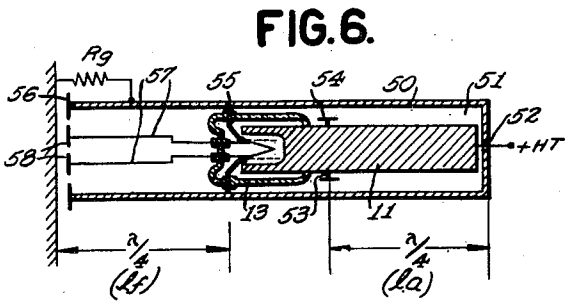


FIG. 6.



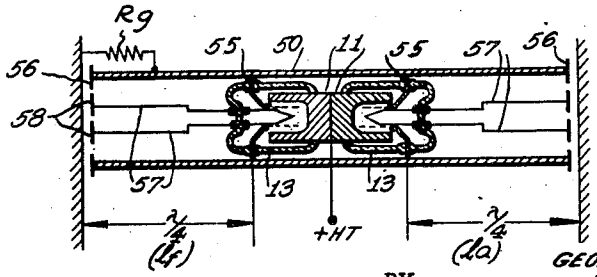


FIG. 7.

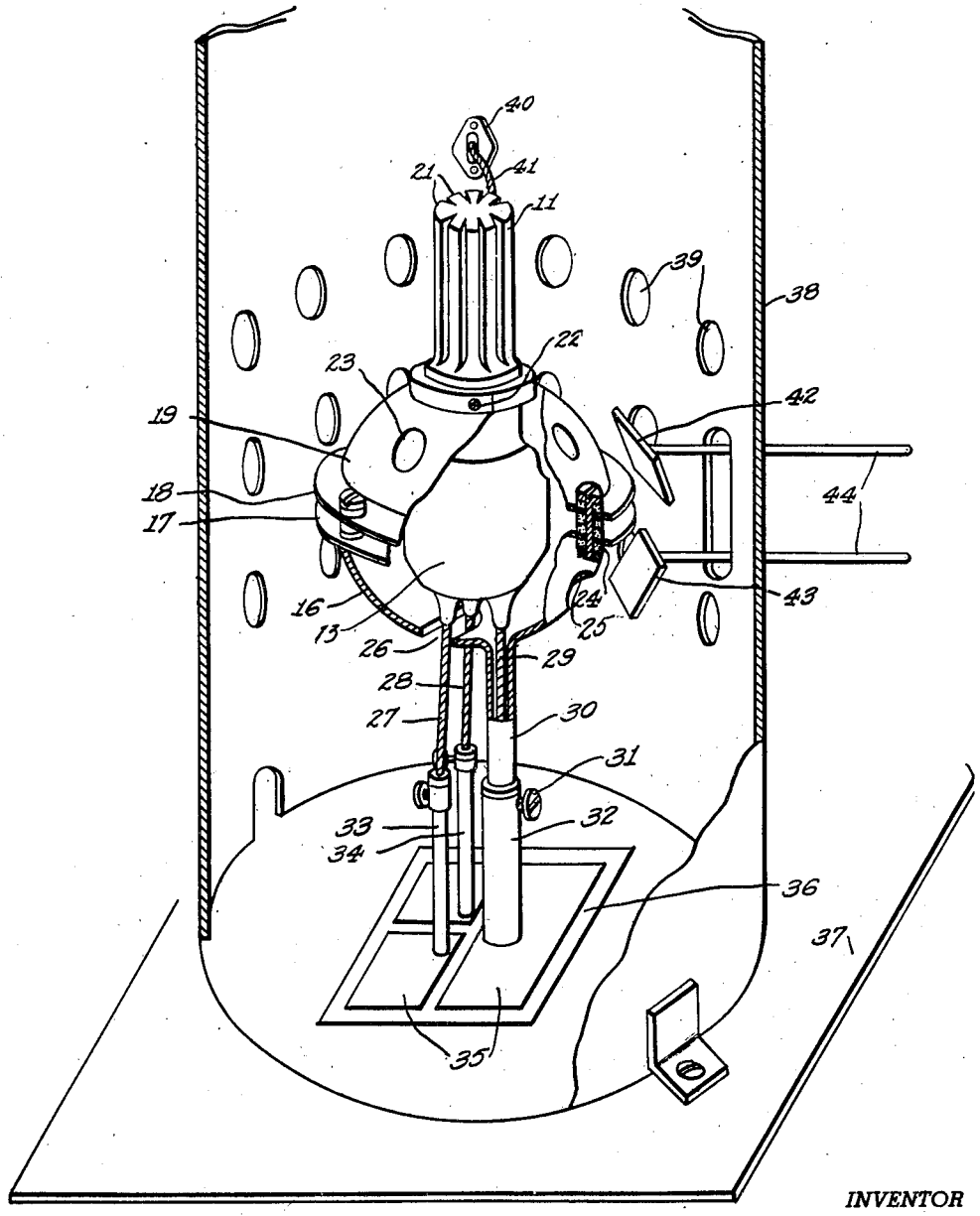
INVENTOR
GEORGES P. CHEVIGNY
BY
ATTORNEY

Nov. 2, 1943. G. P. CHEVIGNY 2,333,295

ULTRA-HIGH FREQUENCY ELECTRON DISCHARGE DEVICE

Filed June 5, 1941 3 Sheets-Sheet 2

FIG.5.



INVENTOR
GEORGES P. CHEVIGNY

BY

ATTORNEY

Nov. 2, 1943. G. P. CHEVIGNY 2,333,295

ULTRA-HIGH FREQUENCY ELECTRON DISCHARGE DEVICE

Filed June 5, 1941 3 Sheets-Sheet 3

FIG.8.

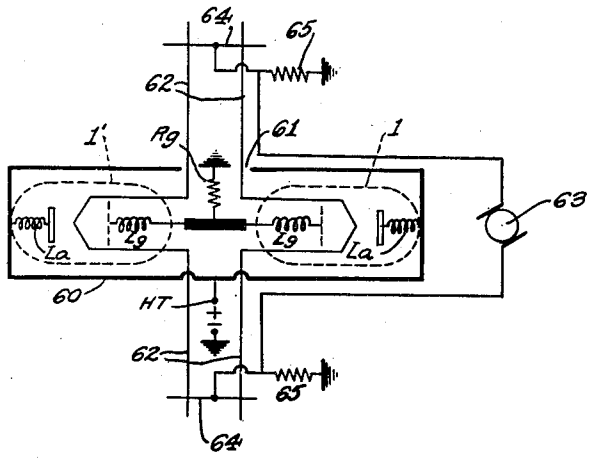
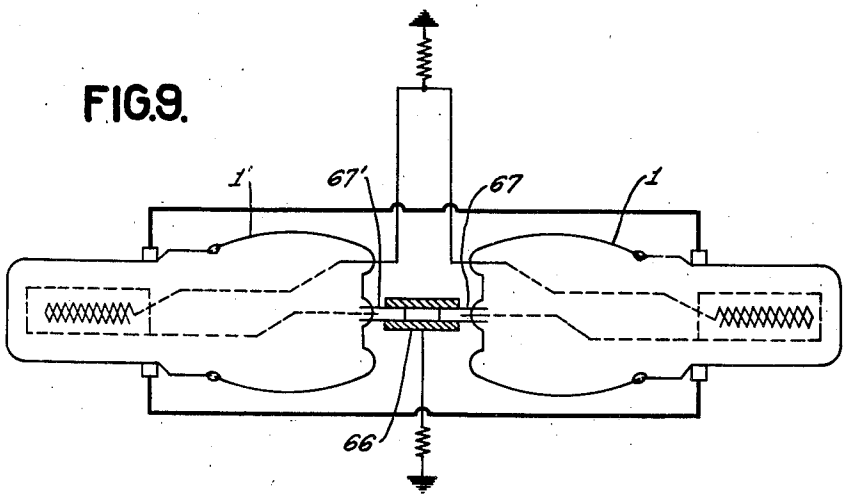


FIG.9.



INVENTOR
GEORGES P. CHEVIGNY

BY

ATTORNEY

Patented Nov. 2, 1943

2,333,295

UNITED STATES PATENT OFFICE

2,333,295

ULTRA HIGH FREQUENCY ELECTRON DISCHARGE DEVICE

Georges Paul Chevigny, New York, N. Y., assignor to International Standard Electric Corporation, New York, N. Y., a corporation of Delaware

Application June 5, 1941, Serial No. 396,656
In France December 26, 1940

16 Claims. (Cl. 250—27.5)

The present invention relates to oscillatory circuits for very short waves and particularly to oscillatory circuits for very high frequency electron discharge tubes which make use of impedances of the tube itself.

It is an object of the invention to provide an improved form of electron discharge device for operation at very high frequencies.

It is another object to provide an improved form of electron discharge device having low resistance losses and radiation characteristics.

Another object of the invention is to provide means for making a given tube operate at the highest possible frequency as determined by its structure.

It is another object of the invention to provide improved oscillatory circuit structures in which the electron discharge tube or tubes employed are contained within the circuit structure, so that lead-in connection impedances are minimized.

Other objects and further features of novelty and invention will hereinafter become apparent from a reading of the following specification in conjunction with the drawings included herewith. In said drawings,

Fig. 1 represents a well known Colpitts oscillator circuit;

Fig. 2 represents a form of the same circuit for operation at its highest frequency limit;

Fig. 3 represents a symmetrical oscillating circuit incorporating features of the circuit of Fig. 2;

Fig. 4 represents schematically and in partial section a preferred form of oscillating circuit in accordance with certain features of the invention;

Fig. 5 is a more detailed broken-away perspective showing of the oscillating circuit of Fig. 4;

Fig. 6 shows schematically another form of oscillating circuit incorporating features of the invention;

Fig. 7 represents a symmetrical arrangement of oscillating circuit similar to that of Fig. 6;

Fig. 8 represents another form of oscillating circuit incorporating features of the invention; and—

Fig. 9 represents a more detailed showing of the circuit of Fig. 8.

In the familiar Colpitts oscillator circuit of Fig. 1 the grid circuit of an electron discharge tube 1 includes on the one hand a grid capacity to earth C_g and on the other hand a grid inductance L_g which latter itself may be grounded through a coil l_g and a resistance R_g. The plate circuit of tube 1 includes on one hand a capacity to earth C_a and on the other an inductance L_a, which latter is connected to high voltage supply HT through a coil l_a. The two circuits just described are interconnected by the capacitance C inserted between the ends of inductances L_g and L_a remote from the electrodes, thus assuring a coupling between the two circuits. Such a circuit is well known and operates in accordance with well-known principles.

Now, in order to obtain higher operating frequencies, any external impedances for compensating for inter-electrode and lead-in impedances at high frequencies must be further reduced so that the upper operating frequency limit circuit is approached. Theoretically, this limit may be reached when the grid and plate inductances consist solely of inter-electrode and lead-in inductances and when the oscillating circuit capacitance is merely the inter-electrode capacity of the tube.

Fig. 2 shows a full development of such a theoretical circuit for operating at its upper frequency limit, reference characters for the various elements being the same as in the case of Fig. 1. The external circuit includes a simple connection 10 having a capacitance C for blocking continuous current. The internal grid-to-plate capacitance of the tube is indicated diagrammatically at C_{ag}, and the grid-to-filament capacitance and plate-to-filament capacitances as C_g and C_a, respectively. The filament may be supplied through independent coil or other means l_f.

Even though the external connection 10 represents a minimum of inductance in the form shown, this inductance may be too much if the upper oscillating frequency limit for the tube structure is to be obtained. In order further to reduce this inductance, features of the invention provide alternate means for more nearly approaching this limit by employing a conductive tubular screen about the axis of the tube element (or elements of the tubes if more than one are used) instead of line 10 and condenser C as above described. Such an embodiment is shown schematically with dotted lines in Fig. 2, by the line 10' and the capacitative coupling C', which represents the capacitance extending about this tubular screen. The screen 10' is preferably symmetrical about the axis of the electrode structure, extending longitudinally thereof. The impedance of the connection (C, 10) is thereby materially reduced since, as is well known, the impedance of a coaxial structure or a substantially coaxial structure is less than the impedance of a structure having substantially parallel elements, and further, since we may consider the closed circuit obtained in this manner as a coaxial structure.

A two-tube oscillatory circuit may also be made in accordance with these considerations as shown in Fig. 3 in which two tubes 1 and 1' are shown with their plate circuits interconnected and arranged end-to-end within a tubular screen 10. With this multiple arrangement the capacitative coupling (corresponding to C or C') is not em-

ployed since the tubular screen is only connected to grids. The plate and filament supply circuits must traverse the screen 10', and it is accordingly considered preferable to supply filaments through relatively high impedances. Such a tube circuit arrangement will have very slight energy dissipation because of its reduced resistance and its negligibly small radiation—hence, it is considered particularly adaptable to use at very high frequencies.

The invention thus provides oscillatory circuits the structure of which comprises a combination of an extended conductor, constituting a physically closed circuit from an electrical point of view, and tubes the active portions of which are arranged within the space thus defined and enclosed, the electrical connections being made in such a way that the circuit oscillates at its high frequency limit.

In the embodiment schematically shown in Fig. 4, the electron discharge tube comprises an anode 11, which may or may not be cooled, having a reentrant cavity 12 within which the other electrodes are arranged, and an insulating envelope 13 sealed to this anode 11. In a preferred form, the anode is generally cylindrical and symmetrical about a longitudinal axis. The connection to the grid electrode 14 is shown extending generally radially outwardly and is sealed to the insulating envelope 13 at 15. In the form shown the grid connection extends conductively outside the tube by means of a conductive shell 16 surrounding the tube for a portion of its length. The shell 16 may be terminated with a flange 17 which, together with a flange 18 associated with another and similar shell 19, forms a capacitance C, the latter shell 19 surrounding the other portion of the tube and being directly and conductively connected to the anode 11. The filament 20 may be supplied by appropriate means I_f, energy so supplied being passed through insulating envelope 13 at the grid end of the tube. Other electrodes if desired may also be supplied in this manner, the leads-in being preferably coaxial.

In the external circuit comprising the two shells 16 and 19 and each side of the capacitative coupling 17—18, one side is connected to ground through a coil I_g and resistance R_g, and high voltage is supplied to the other side through a coil I_a.

It will be appreciated that operation of the oscillating circuit just described is analogous to that of Colpitts oscillator of Fig. 2. For that reason, no operating details are considered necessary.

Fig. 5 is a perspective and partly broken away view of a preferred embodiment of an oscillator constructed in accordance with considerations which have been indicated as desirable. Reference characters designating corresponding elements are repeated throughout Figs. 4, 5, 6 and 7.

Viewing the electron discharge device of Fig. 5 from the outside a portion of the anode 11 may be seen extending outside the glass envelope 13. This portion of the anode 11 may be divided into a number of longitudinally extending fins, such as 21, for natural or other cooling of the anode. The shell 19, shown securely connected through the anode, for example by clamping means 22, is preferably of substantially hemispherical form and includes apertures 23 which, in making for lighter construction, permit better cooling of the tube. The flange 18 of the shell 19 is spaced from the flange 17 of shell 16 so that the two flanges may cooperate to form a capacitative coupling which will block continuous current. A uniorm spacing is preserved by insulator spacers 24, one of which is shown in cross section on the drawings. The substantially hemispherical shell 16 may likewise be provided with similar venting opening 25, and further includes an opening 26 to permit the free entrance of connections 27 and 28 to the filament. The portion of shell 16 enclosing the grid connection 29 of the tube is provided with a tubular extending shielding member 30. It will be observed that this member 30 is necessary since the output from the grid of the tube does not extend coaxially and circumferentially, but rather parallel to the filament leads. However, a direct connection from the grid to the shell 16 may be made at the end of this tubular extending member, for example, by means of a collar or clamp 31 which rigidly secures the tubular member 30 within a conducting tube 32. This tube 32, in conjunction with tubes 33 and 34, which are connected in a similar way for feeding the filament, serves as a transmission line and may therefore replace the coils I_f and I_g of Fig. 4 by being made equal, say, to a quarter wave length.

These tubes, which are substantially a quarter wave length or a multiple thereof, may be mounted on plate members 35 separated by an insulating plate member 36, which may be a portion of a base 37, and from the external shielding means 38 to which the insulation is fixed by clamping means. The shield 38 is shown partly broken away in Fig. 5; it must be closed at its upper end and includes ventilation holes 39 in order to permit cooling of the circuit structure. An insulated part 40 is provided as shown to enable connection to be made to the anode 41 through the shield. The shield is also pierced at other portions to permit coupling plates 42 and 43 respectively to be capacitatively connected to the grid and plate circuits of the oscillator and also connection to load line 44.

Another embodiment is shown schematically in Fig. 6, in which a conductor tube 50, of copper for example, coaxially surrounds a tube having an electrode arrangement similar to that of Fig. 4, the anode 11 extending a quarter wave-length or multiple thereof from the sealing connection to the envelope 13. This extension when considered with the corresponding portion of a copper tube 50, which is coaxial with the anode and hence with the general structure of the tube, constitutes a transmission line equivalent to coil I_a. The conductor tube 60 at the anode end 51 is provided with an aperture 52 to permit high voltage supply to the anode. The anode 11 is capacitatively coupled to the copper tube 50 in the immediate vicinity of the envelope-anode seal by means of a circular conductive plate 53 directly connected to the anode, by soldering or brazing for example, and is provided with an annular flat flange 54 which with the corresponding portion of tube 50 constitutes a capacitance. The grid lead, which is preferably circular, may be directly and conductively connected to the tube 50, as shown at 55. At this grid end, the tube 50 is extended from the connection 55 a length equal to substantially a quarter wave length of the operative frequency or a multiple thereof. The tube 50 is terminated with a circumferentially extending flange 56 which may be capacitatively associated with ground, as shown. If desired, the flange 56 may be directly connected to earth by means of a resistance R_g shunting the earth-to-flange 56 capacitance. Within the tube 50 the filament

supply leads 57 may be similarly extended and coupled to earth as shown by the plates 58. These connections comprise, together with the portion of tube 50 which surrounds them, a high impedance line which may serve the purpose of the coil l_1 of the preceding drawings. In this way, the oscillating circuit of Fig. 6, is so proportioned that a high impedance line is formed between the filament and the grid and high voltage supply from the anode is made over a high impedance line. Such an arrangement makes for substantially reduced radiation or resistance losses and hence substantially improved impedance and voltage characteristics, while at the same time making a very simple circuit which will operate at ultra-high frequencies.

Another embodiment of an oscillating circuit which may provide the same advantages is shown in Fig. 7 in which two electron discharge tubes are shown having a direct common plate connection in order to connect them in push-pull. It is clear that a single tube may be provided having two electrode systems and a common anode, hollowed out at both ends, instead of the two tube structures shown. High voltage plate supply may be introduced laterally through a potential connection, while the conductive tube 50 may be extended on both sides a quarter wave length or odd multiple thereof. Grid bias may be provided for in a single resistance R_g.

In the arrangement of Fig. 7, which shows two tubes according to Fig. 6 arranged back to back, circuit symmetry is not necessary in order to obtain the highest frequencies of oscillation or to assure optimum stability. In this arrangement power may be doubled and the capacitative coupling C of the structures of Figs. 4, 5 or 54—50 of the structure of Fig. 6 diminished—an effect which substantially reduces danger of flash over at high voltage.

In another preferred form, double-tube circuits such as those shown by way of example in Figs. 8 and 9 may be employed. In Fig. 8, which represents schematically two tubes 1 and 1' having grids directly connected symmetrically with respect to earth and through common resistance R_g, the two anodes are at opposite ends of the structure and electrically connected to the extended cylindrical conductor 60 coaxial with the structures of the two tubes it surrounds. This cylinder may be provided with orifices 61 appropriately located to permit passage of a lead-in connection 62 to parallel filaments, these connections 62 preferably being in the form of transmission lines adjustably suppliable from a source 63 from points adjustably intermediate short circuit members 64. These intermediate points may be grounded through resistances 65. Such an arrangement represents a complete electrical circuit, one that is symmetrical, and one in which the connection impedances are reduced to a minimum as a result of the conductive envelope 60 being like a coaxial line and also as a result of the grid connection.

Fig. 9 represents an arrangement of two tubes having external anodes connected in a circuit similar to that of Fig. 8. The structure of these tubes is preferably such that the grid connections comprise a conductor coaxial with the conductive envelope 60, the length of which has been predetermined for the desired frequency of operation. It will be seen that the anodes of the tubes may project externally of the closed circuit and that they have practically no influence upon operation of the circuit, in other words, their dimensions are such as to have no effect on the oscillating circuit dimensions. This permits the said anodes to be cooled by any appropriate means. This arrangement then offers a preferred form of high power tube. Reference numerals in Fig. 9 are similar to those in Fig. 8. The grid connection may be made, as shown, by a conductive sleeve member 66 wired to the output conductor 67—67' of the grid. The filament supply is not shown in full, but may be analogous to that illustrate in Fig. 8.

Although external anode tubes have been shown in the embodiments illustrated in the drawings, it is apparent that the invention may equally well be applied in cases in which the tube envelope completely surrounds the tube elements; and an internal anode such as, for example, in tubes having an opposed grid and plate. Moreover, it is also applicable to multi-electrode tubes other than triodes.

For illustrative purposes, the invention has been described particularly in connection with the familiar Colpitts oscillator of Fig. 1. It is to be understood, of course, as not being limited thereto since features of the invention may be adapted to other known oscillator circuits, for example, those of the Hartley, tuned grid and plate, ultra-audion, dynatron, Meissner, etc., types.

What is claimed is:

1. An electron discharge device including coaxial electrode means including cathode means, grid means, and anode means, an envelope of insulating material sealingly surrounding said electrode means, electrodes of said electrode means being formed with coaxial portions extending externally of said envelope, and generally cylindrical resonator means coaxial with said electrode means, said resonator means including means capacitatively coupling said electrodes of said grid and anode electrode means together.

2. An electron discharge device comprising a cathode, a generally cylindrical control grid substantially coaxial with said cathode, a generally cylindrical anode extending coaxially about said grid and said cathode, said grid being formed with a flared portion integrally and coaxially throughout and extending radially outwardly, said anode also being formed with a flared annular portion integrally and coaxially throughout and extending radially outwardly, capacitative coupling means between both said flared portions, and means forming an envelope sealing off said cathode, said grid, and said anode.

3. An electron discharge device comprising concentric electrode means including two coaxial electrodes, an envelope sealed about said electrodes, one of said electrodes being formed with a flared generally coaxial annular portion extending radially outwardly from one end of said one of said electrodes, the other of said electrodes being formed with a flared generally coaxial annular portion extending radially outwardly through said envelope from the end of said other electrode opposite said first-mentioned flared portion, and coaxial coupling means between said flared portions.

4. An electron discharge device comprising electrode means including a cathode, a grid coaxial therewith, and an anode surrounding said cathode and said grid and coaxial therewith, an envelope sealingly surrounding said electrode means, said grid being formed with a coaxial portion extending externally of one end of said envelope, said anode being formed with a co-

axial portion extending externally of the other end of said envelope, a generally cup-shaped coaxial member conductively connected to said extended portion of said anode, a generally cup-shaped coaxial member conductively connected to said extended portion of said grid, the peripheral edges of said cup-shaped members being formed with integral annular flanged portions spaced from each other and forming a capacitative coupling therebetween, and capacitative output coupling means on each of said cup-shaped members.

5. An electron discharge device having electrodes including coaxial control grid and anode means, an envelope of insulating material sealingly surrounding said electrodes, said control grid and said anode means being formed with coaxial portions extending generally longitudinally and externally of said envelope, and generally cylindrical resonator means coaxial with said electrode means, said resonator means including means capacitatively coupling said control grid and said anode means together.

6. An electron discharge device comprising a sealed envelope of insulating material, an anode element consisting of a cylindrical conducting member having one end projecting within said envelope, said end having a hollow cylindrical cavity, cathode and grid elements mounted within said cavity, said grid element having a portion extending outwardly of said envelope, and means outside of said envelope forming a capacitative coupling between said grid and anode elements, said means including a shell mounted outside of and about said envelope, conductively connected to that portion of one of said elements outside of the envelope and capacitatively related to that portion of the other of said elements outside of said envelope.

7. The combination according to claim 6, in which said shell is connected to the portion of the grid element outside of said envelope.

8. The combination according to claim 6, in which said shell is connected to that portion of the grid element outside said envelope, and in which said last means includes a second shell connected to that portion of the anode element outside of said envelope, said shells being coaxial and spaced from one another in the longitudinal direction forming the capacitative coupling.

9. The combination according to claim 6, in which said one shell is formed as a hemispherical shell connected to that portion of the grid element outside of said envelope, and in which said last means includes a second hemispherical shell connected to that portion of the anode element outside of said envelope, said shells being coaxial with one another and having their outer peripheries spaced from one another to form the capacitative coupling.

10. The combination according to claim 6, in which said one shell is formed as a hemispherical shell connected to that portion of the grid element outside of said envelope, and in which said last means includes a second hemispherical shell connected to that portion of the anode element outside of said envelope, said shells being coaxial with one another and having their outer peripheries spaced from one another to form the capacitative coupling, said hemispherical shells being provided with venting openings.

11. The combination according to claim 6, in which said one shell is formed as a hemispherical shell connected to that portion of the grid element outside of said envelope, and in which said last means includes a second hemispherical shell connected to that portion of the anode element outside of said envelope, said shells being co-axial with one another and having their outer peripheries spaced from one another to form the capacitative coupling, said last means also including a conducting tube connected to said grid element outside of said envelope, and a tubular member formed as an integral extension of said second shell rigidly and conductively supported in said conducting tube.

12. The combination according to claim 6, in which said one shell is formed as a hemispherical shell connected to that portion of the grid element outside of said envelope, and in which said last means includes a second hemispherical shell connected to that portion of the anode element outside of said envelope, said shells being coaxial with one another and having their outer peripheries spaced from one another to form the capacitative coupling, said last means also including a conducting tube connected to said grid element outside of said envelope, and a tubular member formed as an integral extension of said second shell rigidly and conductively supported in said conducting tube, in combination with a pair of further conducting tubes parallel to the first conducting tubes, and means connecting the cathode element to said pair of conducting tubes, all of said tubes having a length equal to $\lambda/4$.

13. An electron discharge device comprising a sealed envelope of insulating material, an anode element consisting of a cylindrical conducting member having one end mounted in said envelope, said end having a hollow cylindrical cavity, cathode and grid elements mounted within said cavity, a tubular shell open at one end and closed at its other end, positioned about said envelope with its closed end about said cylindrical anode element, and means extending through said envelope conductively connecting said grid element to said shell.

14. The combination according to claim 13, with a ground positioned adjacent the open end of said shell, and in which the distance from the point of connection of said shell with said grid element to said ground equals $\lambda/4$.

15. The combination according to claim 13, with a ground positioned adjacent the open end of said shell, and an annular flange attached to the open end of said shell adjacent said ground, and in which the distance from the point of connection of said shell with said grid to said ground equals $\lambda/4$.

16. The combination according to claim 13, with a ground positioned adjacent the open end of said shell, an annular flange attached to the open end of said shell adjacent said ground, and an annular flat flange attached to said cylindrical anode element outside of said envelope, the distance from the point of connection of said shell with said grid to said ground and the distance from said flat flange to the closed end of said shell each being equal to $\lambda/4$.

GEORGES PAUL CHEVIGNY.