

Aug. 30, 1938.

W. DÄLLENBACH
VACUUM DISCHARGE TUBE

2,128,237

Filed Dec. 23, 1935

2 Sheets-Sheet 1

Fig. 1

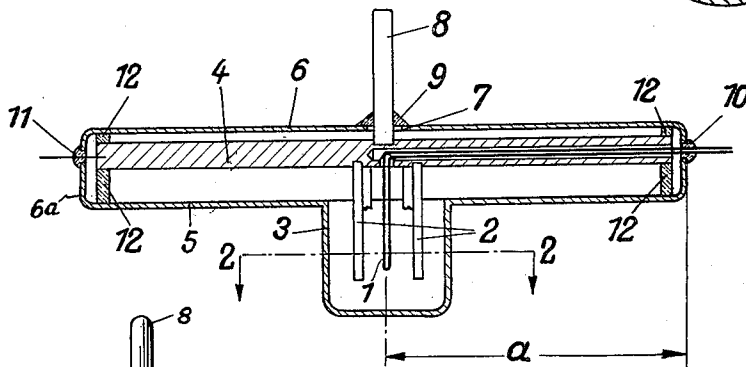


Fig. 2.

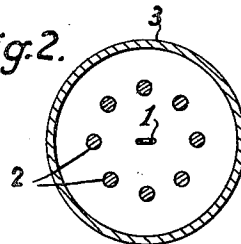


Fig. 3.

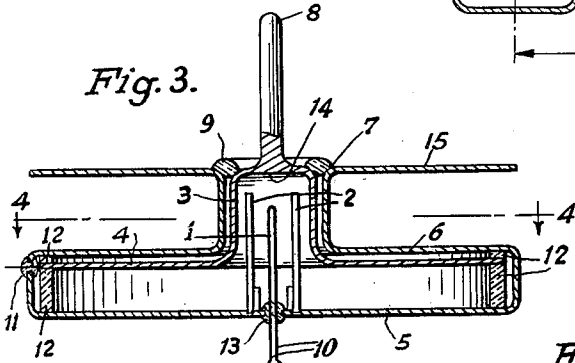


Fig. 6.

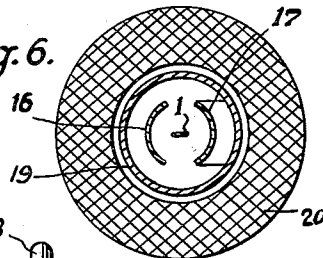


Fig. 5.

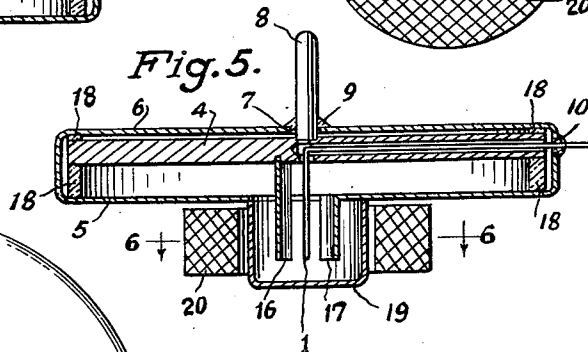
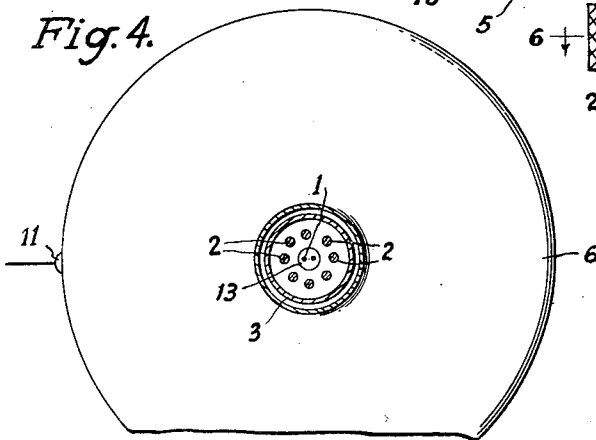


Fig. 4.



Inventor:
Walter Dällenbach
Attorneys:
Bailey & Hanson

Aug. 30, 1938.

W. DÄLLENBACH

2,128,237

VACUUM DISCHARGE TUBE

Filed Dec. 23, 1935

2 Sheets-Sheet 2

Fig. 7

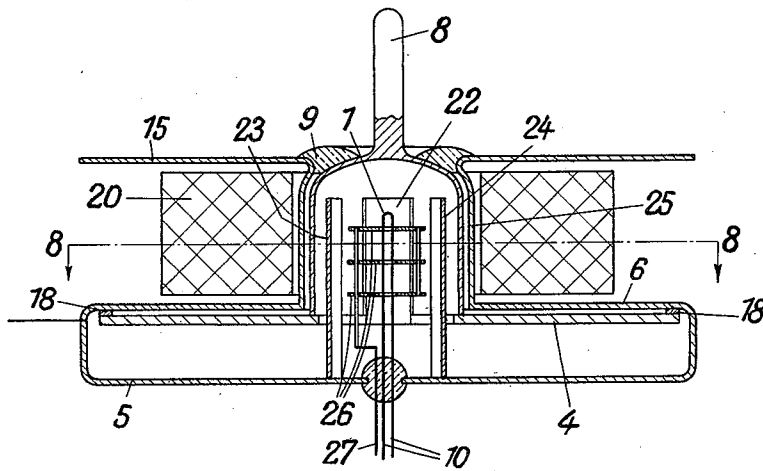
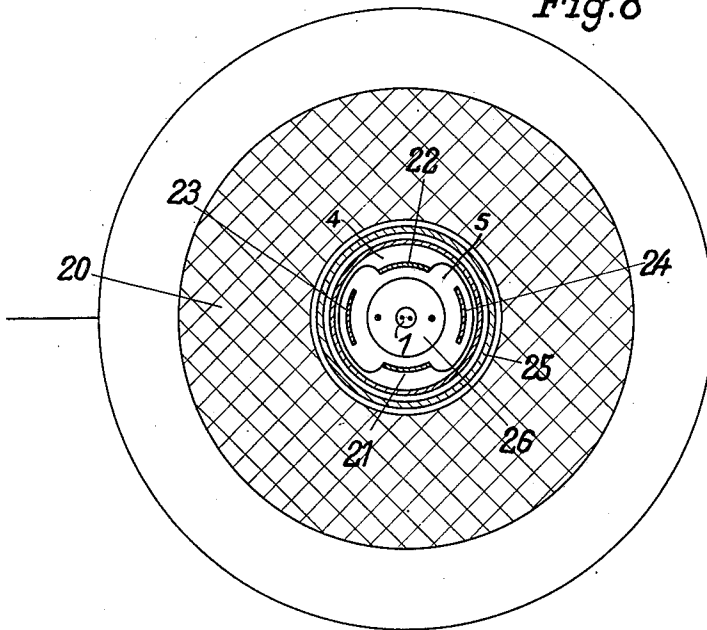


Fig. 8



Inventor:
Walter Dällenbach
Attorneys:
Bailey & Pearson

UNITED STATES PATENT OFFICE

2,128,237

VACUUM DISCHARGE TUBE

Walter Dällenbach, Berlin-Charlottenburg, Germany, assignor to Julius Pintsch Kommanditgesellschaft

Application December 23, 1935, Serial No. 55,885
In Germany December 24, 1934

19 Claims. (Cl. 250—27.5)

My invention relates to a vacuum discharge tube. More specifically it relates to a vacuum discharge tube for stimulating ultra-high frequency electro-magnetic oscillations. By the term stimulating I refer particularly to generating, amplifying or receiving such oscillations.

Generally speaking the essential parts of an ultra-short wave tube are the electrode system, the frequency determining resonator combined therewith, and the load resistance, for example, an aerial, connected with the resonator.

The present invention relates to a tube of the type in which the resonator is constructed as a plate condenser, and broadly resides in disposing the electrodes substantially perpendicular to the condenser plates. The tube is preferably provided with an incandescent cathode co-axial with the plate condenser, the cathode in turn being encompassed by other electrodes.

One object of my invention is to produce a superior ultra-short wave tube of the type in which the resonator is constructed as a plate condenser.

The invention has for another object the production of a tube which provides excellent stimulation while at the same time heat is readily radiated off without difficulty. It is also my desire to eliminate the defects in prior tubes.

Other objects and advantages of the invention will be more apparent from the following description and accompanying drawings, in which:

Fig. 1 is a cross-section of a tube showing one example of my invention as constructed for a braking field connection.

Fig. 2 is a cross section on the line 2—2 of Fig. 1.

Fig. 3 is a cross-section showing another embodiment of my invention as constructed for a braking field connection.

Fig. 4 is a cross section on the line 4—4 of Fig. 3.

Fig. 5 is a cross-section of another embodiment of my invention as constructed according to the magnetron principle.

Fig. 6 is a cross section on the line 6—6 of Fig. 5.

Fig. 7 is a cross-section of an example of my invention as constructed according to the magnetron principle and employing a grid.

Fig. 8 is a cross section on the line 8—8 of Fig. 7.

Referring now to Figs. 1 and 2, it will be noted that a hairpin-shaped wire cathode 1 is provided in the vertical axis of the arrangement. This cathode 1 is encompassed concentrically by a grid 2 the rods of which are parallel to the axis and approximately the same length as the cathode itself. Surrounding the grid 2 and co-axial

with the grid and the cathode is a hood-like solid wall electrode 3.

The reference numeral 4 indicates a circular plate of a plate condenser. At least the surface of this plate should be of a good conductive material. The cathode 1 and the rods of the grid 2 are inserted in the plate 4 to be supported thereby.

The plate 4 is surrounded and enclosed or encompassed by the metal walls 5 and 6. The metal wall 5 is provided with a central opening, the edge of which is connected with the solid wall electrode 3. The solid wall electrode 3 and the wall 5, however, may be made integral. The metal wall 6 is conductively connected at its edge with the metal wall 5 as indicated at 6a.

At the axis of the metal wall 6 an opening 7 is provided for the aerial 8. The aerial 8 is inserted in and supported by the plate 4. If the opening 7 is closed off by means of a glass insulator 9, the metal walls 5 and 6 together with the solid wall electrode 3 will form a vacuum receptacle.

The current leads for the cathode 1 may enter the arrangement at the point 10, for example, through a glass-metal fusion, and then extend insulated into the interior of the plate 4 to the axis thereof at which point they are connected with the cathode elements proper.

The lead to the grid 2 may enter the arrangement at the point 11, and it is then conductively connected with the plate 4.

The reference numeral 12 indicates insulated supports, preferably of ceramic material. These supports retain the plate 4, and, consequently, the grid 2 in rigid concentric position relative to the cathode 1, the electrode 3, and the receptacle walls 5 and 6.

The arrangement operates in a braking field connection in the following manner. The grid 2 receives a relatively high positive potential with respect to the cathode 1. The solid wall electrode 3 receives a negative potential in the vicinity of zero. The electrons emitted from the cathode 1 pass through partly between the rods of grid 2 into the space between the grid 2 and the solid wall electrode 3, wherein they reverse their direction under the influence of the braking field and then, after a forward and backward movement, are caught up by the grid 2. Now if a high frequency field is maintained between the grid 2 and the solid wall electrode 3, it will exert a controlling action on the electrons which penetrate from the cathode into the braking field chamber or space between the grid and the electrode 3,

whereby the electrons are capable of giving off oscillatory energy to the connected resonator.

The grid 2 and the electrode 3 are connected respectively with the plate 4 and the wall 5, which plate and which wall form a plate condenser. If the distance between the plate 4 and the wall 5 is great, and particularly considerably greater than that between the plate 4 and the wall 6, the plate condenser which is formed by the chamber or space between the plate 4 and the wall 6 acts as a short circuit capacity for the condenser formed by the space between the plate 4 and the wall 5 which acts as a resonator so that, thereby, a current bulge and a potential node can arise at the margin of the plate 4. A potential bulge occurs at the center, that is, in the vicinity of the axis of the plate condenser. Connected to this potential bulge is the solid wall electrode 3 serving as the braking electrode, and the grid 2, so that between these two electrodes, as is known, there may arise a high frequency alternating field of maximum amplitude.

The function of the condenser space between the plate 4 and the wall 6 is not only to form a short circuit capacity for the resonator space between the plate 4 and the wall 5, but also at the same time to receive and maintain adjacent the base of the aerial 8 an alternating field of small but suitable amplitude which acts to set the aerial 8 in oscillation. The aerial 8 is connected at its lower end in a tunable manner to the resonator space between plate 4 and wall 5 over the plate condenser formed by the members 4 and 6.

The frequency determining system of the tube is really the condenser which is formed by the plate 4 and the wall 5, and it oscillates in its basic oscillation, as stated, so that a potential node arises at its edge but a potential bulge at its center. The high frequency potential increases from the edge of this condenser to the center continually. The current from the edge to the center decreases continually. If neither the braking electrode 3 nor the grid 2 were connected to this condenser at the center, thus in the vicinity of the axis, the diameter of the condenser would be in simple ratio to the wave length, that is

$$\frac{2\pi \cdot a}{\gamma} = 2.405$$

where a designates the radius of the condenser, γ the wave length, and the number 2.405 the first zero point of the Bessel function of zero order. This formula is not strictly fulfilled since the cylindrical condenser formed by the grid 2 and the braking electrode 3, which is connected with the plate condenser 4, 5, has an additional capacity which results in lowering the frequency and thus in increasing the wave length.

The cylindrical condenser formed by the grid 2 and the electrode 3 may, of course, be shorter, especially considerably shorter than $1/4$ of the wave length, so that it may be considered as an aperiodic structure connected to the resonator space between the members 4 and 5.

The aerial 8 may be tuned in any known manner, or, to moderate the most favorable load of the generator, may be more or less tuned out with respect to resonance. The aerial extends above the plate formed by the wall 6 like a Marconi aerial over the earth's surface.

The principal advantage of the present arrangement with respect to previous arrangements consists chiefly in that the cathode 1 as well as the grid 2, which form the parts which

become the hottest, are heat-conductively connected with a good conducting metal mass 4 so as to provide excellent cooling for the parts subjected to the greatest thermal strains.

Moreover, a plate condenser such as described possesses an advantage over a concentric Lecher system, for example, in that the dimensions are greater so that when short wave lengths are to be produced the tube will possess sufficient dimensions to permit their production.

Finally the plate condenser of the present invention is of advantage in that, if the space between the plate 4 and the wall 5 is not too small, the so-called fly-wheel moment of the resonator, as compared with an oscillatory circuit consisting of a concentric capacity C and a concentrated self-induction L of the magnitude

$$Z = \sqrt{\frac{L}{C}}$$

is relatively large. This condition is very favorable for the production of stable oscillations.

In the embodiment disclosed in Figs. 3 and 4, the reference numeral 1 again represents the cathode, 2 the grid disposed around it, and 3 the damping or braking electrode. The embodiment differs from that disclosed in Figs. 1 and 2 in that the connections of the grid and the solid wall electrode are interchanged. That is, the grid 2 is connected to an outer wall 5, and the electrode 3, on the contrary, is connected to the plate 4 disposed within the tube. The advantage of this arrangement is that the cooling of the grid 2, at which the main energy is realized, is still better, since the grid 2 is connected with the plate 5 and the latter is in direct communication with the atmosphere.

The operation of this embodiment of the invention is the same as that of the embodiment disclosed in Figs. 1 and 2. The plate condenser formed by the plate 4 and the wall 5 together with the cylindrical condenser formed by the grid 2 and the electrode 3 (which is considerably shorter than $1/4$ of a wave length), serve as a resonator. Here again, a potential node line is formed at the margin of the plate condenser, when the condenser formed by the elements 4 and 6 are given a relatively small wave resistance with respect to the resonator space limited by the elements 4 and 5. The condenser space between 4 and 6 thus serves on the one hand as a short circuit capacity for the formation of a potential node at the margin of the condenser, and on the other hand as a high frequency lead to which the aerial 8 is connected in a relatively loose fashion. The aerial 8 is a direct prolongation of the cylinder 3 which serves as the braking electrode. If the aerial is not solid, it is preferable to provide a separating wall as at 14, which wall prevents the inner space of the aerial from exerting any action on the tuning of the resonator proper.

In addition to the improved heat conduction furnished by this embodiment, the arrangement is of advantage because of the convenient location of the cathode leads.

The reference numeral 15 indicates a plate screen which forms the horizontal of the aerial 8. The reference numeral 12 again indicates insulating plates which retain the condenser plate 4 to which the electrode 3 and the aerial 8 are attached co-axially, in rigid position.

The tubes disclosed in Figs. 5 to 8 in their fundamental construction are comparable with those disclosed in Figs. 1 to 4 described above.

However, they possess certain modifications which make them suitable for use in magnetron connection.

In Figs. 5 and 6 the reference numeral 1 represents the cathode, while the reference numerals 16 and 17 indicate the two halves of a so-called cleft or split anode. The half 16 is connected to the plate 4 secured within the interior of the receptacle, while the half 17 is connected to the receptacle wall 5. If there is an alternating potential between 16 and 17 the result is, insofar as the frequency of this alternating potential approximates that of the resonator, that the condenser formed of the members 4 and 5 passes into oscillation. The short circuit capacity of this condenser is in this embodiment as in the previously described embodiments formed by the space between the plate 4 and the wall 6 to which the aerial is connected through the opening 7 in known manner. Insulating supports 18 retain the plate 4 in position.

It will be noted that the cathode 1 and the two halves 16 and 17 of the cleft or split anode are encompassed by a hood-like cylindrical conductor 19 which is conductively connected with the wall 5 and serves as a screen against the escape of loss radiation as well as the portion of the wall of the vacuum receptacle. The electrode system is encompassed by a magnetic coil 20 which produces the axial magnet field necessary for magnetron stimulation.

The advantage of the magnetron arrangement is that there is no grid and that the two parts of the cleft anode have the same relative potential relative to the cathode. All parts of the arrangement thus have the same direct potential with the exception of the cathode which is held at a negative potential with respect to these parts. Since the plate 4 and the walls 5 and 6 have the same direct potential, the support insulators provided in the vicinity of the node line may be replaced by direct metallic supports 18, which are disposed as closely as possible to the node line.

In Figs. 7 and 8 an embodiment is disclosed which is somewhat similar to that disclosed in Figs. 3 and 4 but in which a magnetron connection is used and the cleft anode is comprised of more than two parts, for example, of four parts. It is to be understood, however, that the embodiment disclosed in Figs. 5 and 6 may also be provided with a cleft anode consisting of more than two parts or halves. In Fig. 7 the cathode 1 is encompassed by four parts or segments, 21, 22, 23 and 24, of the cleft anode. This will perhaps be more apparent from Fig. 8 which is a cross-section on the line 8-8 of Fig. 7. The parts 21 and 22 of the anode are in direct connection with the plate 4 which is secured within the receptacle, while the parts 23 and 24 are secured to the wall 5. The plate 4 is provided with notches or recesses to permit the parts 23 and 24 to pass through to the wall 5. Another function of these recesses, which appear clearly in Fig. 8, is to permit the parts 23 and 24 to pass through the plate 4 with the lowest possible capacity. The short circuit capacity 4, 6, is again connected to the margin of the resonator where the potential node line extends, and this short circuit capacity at the same time serves as an energy lead to the aerial 8, which extends from the horizontal. In this embodiment, as in the embodiment previously described, all of the parts with the exception of the cathode can be maintained at the same positive potential rela-

tive to the cathode. It is thus possible in this embodiment also to retain the member 4 within the resonator by means of metallic supports 18.

Instead of a cleft anode consisting of four parts, the anode may be comprised of six or eight parts whereby all of the even numbered parts are connected to the plate 4 and all uneven numbered parts to the wall 5 in the same manner as shown for the four parts in Figs. 7 and 8. The magnetic coil 20 for producing the axial magnetic field is mounted above the lead 25 of the ultra-high frequency conductor.

Other electrodes can be introduced in the magnetron arrangement for modulating the load efficiency. For example, in the space between the cathode and the cleft anode a wire-shaped or otherwise formed electrode can be provided which, through a suitable charge, will control the emission of the electrons and thereby the load on the ultra-short wave tube. It is likewise possible to dispose this control electrode outside of the cleft anode so that it influences the capacity emission between the individual parts of the cleft anode.

The magnetron tube illustrated in Figs. 7 and 8 is provided with such a control electrode for modulating emission. In this embodiment the control electrode consists of metal discs 26 which are disposed perpendicular to the tube axis between the cathode and the cleft anode and are connected to a common lead 27. The control electrode may be given a positive or a negative preliminary potential. In both cases, with superposed control alternating potential, a modulation of the electron flow, and consequently of the load efficiency of the tube, can be effected.

While I have described several examples of my invention, I do not wish to be limited thereto since obviously changes can be made therein without departing from the spirit of the invention.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A vacuum discharge tube comprising a plate condenser composed of a first condenser plate and a second condenser plate, a conductor adjacent the outer side of said first condenser plate and conductively connected with the edge of said second condenser plate, and electrodes disposed substantially perpendicular to said condenser plates, said second condenser plate and said conductor forming walls of a hollow body, said walls sealing said tube against radiation losses.

2. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, a circular conductor adjacent the outer side of said first condenser plate and conductively connected with the edge of the second condenser plate, the centers of said circular condenser plates and said circular conductor lying on a common axis, and electrodes in the vicinity of said axis and disposed substantially perpendicular to the condenser plates, said second condenser plate and said conductor forming walls of a hollow body, said walls sealing said tube against radiation losses.

3. A vacuum discharge tube as in claim 1, said electrodes forming an oscillating system having an autofrequency higher than, and aperiodic to, the autofrequency of said condenser.

4. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, a circular conductor adjacent the outer side of

said first condenser plate and conductively connected with the edge of said second condenser plate, said second condenser plate and conductor forming walls of a hollow body, said walls sealing
 5 said tube against radiation losses, said conductor forming with said first condenser plate a short circuit condenser, an aerial disposed co-axially with respect to said plate condenser and connected to said first condenser plate, and electrodes
 10 in the vicinity of the center of the plate condenser and disposed substantially perpendicular to the condenser plates.

5. A vacuum discharge tube comprising a circular plate condenser consisting of a first condenser plate and a second condenser plate, a
 15 conductor adjacent the outer side of said first condenser plate and conductively connected with the edge of said second condenser plate, electrodes disposed substantially perpendicular to
 20 said condenser plates, and vacuum-tight seals on said second condenser plate and the conductor connected therewith, both of said members combining to form the vacuum receptacle.

6. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, a circular conductor adjacent the outer side of one of
 25 said condenser plates and conductively connected with the edge of the other condenser plate, said other condenser plate having a central opening therein, a cylindrical hood-shaped conductor closing
 30 off said opening, and electrodes disposed co-axially within said hood-shaped conductor and substantially perpendicular to the condenser plates.

7. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, a circular conductor adjacent the outer side of said
 40 first condenser plate and conductively coupled with the edge of the second condenser plate, said conductor forming with said first condenser plate a short circuit condenser and a high frequency lead of small wave resistance, an aerial disposed
 45 co-axially with respect to said plate condenser and connected to said first condenser plate, said conductor having a central opening through which the aerial passes, a seal of insulation material closing off said opening vacuum tight, and
 50 electrodes in the vicinity of the axis of said circular plates and connected to said first and second condenser plates and substantially perpendicular thereto.

8. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, a circular conductor adjacent the outer side of said
 55 first condenser plate and conductively coupled with the edge of the second condenser plate, said conductor forming with said first condenser plate a short circuit condenser and a high frequency lead of small wave resistance, an aerial disposed
 60 co-axially with respect to said plate condenser and connected to said first condenser plate, said conductor having a central opening through which the aerial passes, a seal of insulation material closing off said opening vacuum tight, a
 65 cathode disposed co-axially with respect to the plate condenser, and leads for said cathode passing radially through said first condenser plate.

9. A vacuum discharge tube comprising a circular plate condenser comprising a first condenser plate and a second condenser plate, said
 75 second plate being provided with a central opening, a conductor adjacent the outer side of said

first condenser plate and conductively connected with the edge of said second condenser plate, a cylindrical hood-shaped conductor closing off the
 opening in said second condenser plate and forming a solid wall electrode, a cylindrical grid dis-
 5 posed co-axially within said solid wall electrode and connected with the first condenser plate, and a cathode at the axis of said grid.

10. A vacuum discharge tube comprising a circular plate condenser comprising a first condenser plate and a second condenser plate, said
 10 second plate being provided with a central opening, a conductor adjacent the outer side of said first condenser plate and conductively connected with the edge of said second condenser plate, and
 15 forming therewith a metallic housing, an aerial disposed co-axially with respect to said plate condenser and connected with said first condenser plate and passing through a central opening
 20 in said conductor, a seal of insulating material closing off said opening in a vacuum-tight manner, said second condenser plate having a central opening therein, a cylindrical hood-shaped
 25 electrode closing off the opening in said second condenser plate, said hood-shaped electrode being co-axial with said plate condenser, a cylindrical grid composed of axio-parallel rods disposed
 30 within said hood-shaped electrode and conductively connected to said first condenser plate, a cathode disposed co-axially within said grid, insulating members at the edge of said first
 35 condenser plate supporting the same within the housing, leads to said grid and said cathode passing through said housing at the periphery thereof, and seals of insulating material closing off
 the lead inlets into the housing in a vacuum-tight manner.

11. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, a circular
 40 conductor adjacent the outer side of said first condenser plate and conductively connected with the edge of the second condenser plate, a split anode disposed co-axially with respect to the plate condenser and provided with a plurality
 45 of segments, the even number segments of said anode being connected with one of the plates of the plate condenser and the uneven number segments of the anode being connected to the
 50 other plate of said plate condenser, and a cathode disposed so-axially within said split anode.

12. A vacuum discharge tube as defined in claim 11 having metallic members which support one condenser plate at the edge and in potential nodes, and a magnetic field coil disposed
 55 about said tube in substantially coaxial position.

13. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, a circular conductor adjacent the outer side of said
 60 first condenser plate and conductively connected with said second condenser plate to form a metallic housing, an aerial disposed co-axially with respect to said conductor and connected to said
 65 first condenser plate and passing through an opening in said conductor, a seal of insulating material closing off said opening in a vacuum-tight manner, a split anode disposed co-axially
 70 within said tube and consisting of a plurality of segments, the even number segments being connected to one of the plates of the plate condenser and the odd number segments to the other,
 a cathode disposed coaxially within said split anode, metallic members supporting the first condenser plate at the edge against the housing and

in potential nodes, leads passing through the housing at the periphery thereof to the cathode, and a magnetic field coil disposed substantially co-axial with respect to the tube.

14. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, one of said condenser plates having a co-axial opening therein, a cylindrical hood-shaped conductor closing off said opening outwardly, electrodes within said hood-shaped conductor and disposed substantially perpendicular to said plate condenser, a circular conductor approximately encompassing said hood-shaped conductor and the condenser plate connected therewith, said circular conductor being conductively connected with the second condenser plate at its edge, an aerial connected to said hood-shaped conductor, and a metal plate connected with said circular conductor and disposed perpendicularly to the axis of the tube.

15. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, said first condenser plate having a co-axial opening therein, a cylindrical hood-shaped electrode closing off said opening outwardly, a grid disposed co-axially within said hood-shaped conductor and conductively connected with said second condenser plate, a cathode disposed co-axially within the grid and passing through said second condenser plate at its axis and insulated therefrom, a vacuum-tight seal at the entrance point of said cathode, a lead to said cylindrical hood-shaped conductor, said lead being connected at the edge of said first condenser plate, a circular conductor approximately encompassing said hood-shaped conductor and the condenser connected therewith, said circular conductor being conductively connected with said second condenser plate at its edge, an aerial connected with said hood-shaped conductor, and a metal plate connected to said circular conductor and disposed perpendicular to the axis of the tube, and insulating

members at the edge of and supporting said first condenser plate in potential nodes against said circular conductor.

16. A device as defined in claim 15, wherein said grid consists of axio-parallel rods.

17. A vacuum discharge tube comprising a circular plate condenser composed of a first condenser plate and a second condenser plate, one of said condenser plates having a co-axial opening, a cylindrical hood-like conductor closing off said opening outwardly, a split anode consisting of an even number of segments and disposed within said hood-like electrode, the even number segments being connected with the first condenser plate and the odd number segments being connected with said second condenser plate, a cathode disposed co-axially within said split anode and passing through said second condenser plate from which it is insulated, a vacuum-tight seal at the inlet point of said cathode, a circular conductor approximately encompassing said hood-like conductor and the condenser plate connected therewith, said circular conductor being conductively connected with said second condenser plate at the edge, an aerial connected with said hood-like conductor, and a metal plate connected to said circular conductor and disposed perpendicular to the axis of the tube.

18. A vacuum tube as defined in claim 17, wherein said split anode consists of four segments, metallic members at the edge of and mutually supporting the condenser plates in potential nodes, seals at the juncture points of the circular conductor and said aerial closing off the interior of the tube in a vacuum-tight manner.

19. A vacuum discharge tube comprising a plate condenser consisting of a first condenser plate and a second condenser plate, a conductor conductively connected with the edge of said second condenser plate, split anodes and a cathode disposed substantially perpendicular to said condenser plates, and a control electrode between the split anode and the cathode.

WALTER DÄLLENBACH.