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ELECTRON DISCHARGE DEVICE

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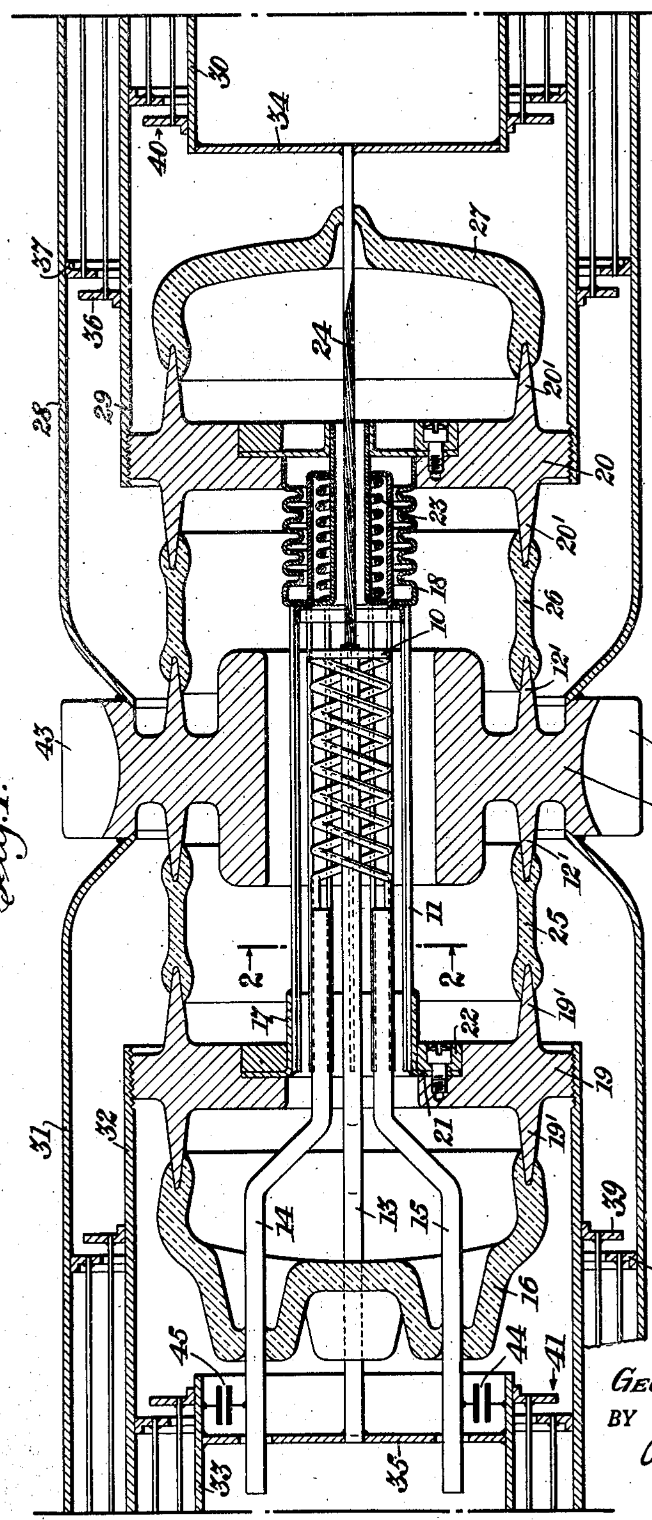

Fig. 1.

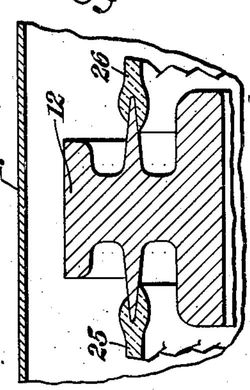

Fig. 3.

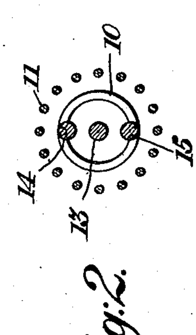

Fig. 2.

INVENTOR.
GEORGES P. CHEVIGNY
BY
Paul R. Adams
ATTORNEY

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ELECTRON DISCHARGE DEVICE

Georges P. Chevigny, New York, N. Y., assignor to Federal Telephone and Radio Corporation, a corporation of Delaware

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6 Claims. (Cl. 250—27.5)

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This invention relates to electron discharge devices and circuits and more particularly to such apparatus adapted to operate at ultra high frequencies. It has for its object to improve the operating performance, and increase the frequency and the power output at which such devices may be made to operate effectively. A related object is to provide a simple compact construction, by which an efficient operation is obtained. A further related object is to provide an improved form of such devices which will be readily adaptable for operation with co-axial line structures.

There have heretofore been provided vacuum tubes having resonant cavity type circuits arranged to establish ultra high frequency resonance. At these frequencies, in order to avoid large inductances and distributed capacities, the size of the electrodes should be made small in order that a substantial transfer of energy of the ultra high frequency may be made effective over the electrode areas. Furthermore, it is desired that the electrical impedance of the elements coupling the resonant circuits with the tube electrodes should be made small in order to reduce the power loss across them.

In accordance with this invention there is provided a compact symmetrical arrangement of the component parts of the tube and cavity circuits, which reduces the effective size of the electrodes to half their actual size, and thereby permits a high energy output at a very high frequency. A feature is an arrangement of the cavities symmetrically with respect to the central section of the electrodes so that the tube operates as two tubes, one on either side of the central section. A further feature is the formation of the electrodes and the tube in such a manner that two separate resonant circuits may be provided between grid and anode and two further tuning means may be provided between cathode and grid circuits. In this manner, one tube may be made to do the work of two and increased power and higher operating frequencies may be obtained.

Other objects and further features of novelty and invention will hereinafter be pointed out or will become apparent to those skilled in the art from a reading of the following specification in connection with the drawing annexed hereto. In said drawing—

Fig. 1 depicts a partly sectionalized and broken away elevation of an electron discharge device and its associated circuits in accordance with features of the invention;

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Fig. 2 is a sectional view taken substantially in the plane 2—2 in Fig. 1; and

Fig. 3 is an alternative embodiment of a portion of the device shown in Fig. 1.

The device shown in the drawing is a simple triode having its output connection so provided that it may be readily connected in a co-axial transmission line. The arrangement further permits provision of a pair of resonant cavities between the grid and anode and between cathode and grid. The tube as shown comprises a double-helix cathode 10 concentrically surrounded by a grid 11 and then by an anode 12. For feeding cathode heating voltage to cathode 10 symmetrically about the electrical mid-point thereof, a rigid lead-in wire 13 is connected rigidly to one end of cathode 10 (at the right in the drawing). Lead-in 13 thus serves to support that end of the cathode. The other respective ends of the cathode helices are supported by two further rigid lead-in conductors 14, 15, and all the cathode lead-in conductors 13, 14, and 15 are brought out of the evacuated envelope of the device through a glass press 16.

Grid 11 comprises a plurality of longitudinally extending rods or wires (see also Fig. 2) rigidly fixed at one end to a collar 17 and at the other to a bellows 18, whereby changes in length of the grid due to heating in operation may be absorbed by the device without displacing the grid with respect to cathode 10 and anode 12 so as to impair performance of the device. In order that connection may be made to the grid from both sides of the anode, two annular lead-in members 19, 20 are provided. Members 19 and 20 include longitudinally extending flanges 19′ and 20′ to aid in sealing them to insulating portions of the envelope. At the end of the device where the grid is held fixed, collar 17 is provided with a radially extending flange 21 by means of which collar 17 is rigidly fixed by bolting a ring 22 and flange 21 to the annular member 19.

As mentioned above, the other end of grid 11 is connected to annular member 20 through a bellows 18. The purpose of bellows 18 is to take up with relative ease changes in length of the grid in operation, and it also serves to provide a highly efficient conductive surface for direct connection to annular member 20. It is accordingly preferable that bellows 18 offer the least possible resistance to changes in length of grid 11 and, accordingly, that it be made of very thin metal. If desired, the disposition of all elements of grid 11 may be still more securely maintained by providing spring means 23 within bellows 18 whereby all the wires of grid 11 are constantly under a certain amount of tension.

It will be noted that the arrangement thus far described permits provision of an additional lead-in 24 for the mid-point of cathode 10 whereby cathode output from a radio frequency point of view may be taken symmetrically from both ends of the tube as is also the case for grid connections. Inasmuch as lead-in 13 supporting the electrical mid-point of cathode 10 may extend due to heating during operation, it is preferable that lead-in 24 include a flexible (e. g. stranded) portion, whereby no stresses will be set up during operation.

Anode 12 has a rather extensive operating surface concentrically surrounding the grid 11 and extending a substantial distance therealong. In the form shown, anode 12 further includes flanged portions 12′ similar to flanges 19′ and 20′ on the annular grid lead-ins. The evacuated portion of the discharge device thus comprises press 16, annular grid lead-in 19, insulating collar 25 sealed to flanges 19′ and 12′, anode 12, a further insulating collar 26 sealed to flanges 12′ and 20′, grid lead-in 20, and a further press 27 sealed to the other flange 20′, as will be clear.

It will be seen that I have described a relatively simple structure for use in connection with coaxial transmission lines and resonant circuits of the transmission line type. In the form shown, a concentric line comprising three cylinders 28, 29, 30 may be connected to one end of the tube and another concentric line comprising tubular conductors 31, 32 and 33 may be connected to the other end thereof. Lines 28 and 31 are shown directly connected to anode 12, lines 29 and 32 are connected directly to the grid leads-in 20 and 19 respectively, and lines 30 and 33 are provided with end-plates 34 and 35 for symmetrical connection to the electrical mid-point of cathode 10. By-pass condensers 44, 45 are shown linking the outer ends of cathode leads-in 14, 15 with the cathode line 33.

If desired, tuning means may be provided to tune any of the grid-anode and cathode-grid circuits described. In the form shown, one side of the grid-anode circuit may be tuned with slideable capacitative tuning elements 36, 37 and the other side with a similar pair 38, 39. These elements may be of known form and slideable longitudinally between lines 28 and 29, and 31 and 32, as the case may be. These tuning means are shown as capacitatively separated so that high B-supply voltages may be placed on the anode without affecting grid potentials, as will be clear. If preferred, a relatively fixed capacitative connection could be made between line 28 and anode 12 and between line 31 and anode 12 so that a more rigid single conductive tuning element could be used instead of elements 36, 37, 38 and 39. Connections of this latter nature are shown in the copending application Serial No. 431,134 filed February 14, 1942 of E. Labin and myself. Further tuning means, which may be similar to that used in connection with the grid-anode circuit, may be provided adjustably to tune the respective cathode-grid circuits. These further tuning means, designated generally 40, 41, are shown as adjustably slideable between lines 29 and 30, and 32 and 33, as the case may be.

It will be seen that I have provided an extremely useful form of high frequency discharge device wherein a single tube may be employed effectively to deliver the power that would be expected of two former devices. Although there is only a single cathode, the effect of the symmetrical construction of the electrodes and resonant circuits is to cause the half of the apparatus to the right of a center section through anode 12 to operate as one device, and the other half as another device in parallel, as will be clear. Furthermore, inasmuch as the elements constituting the active electron discharge portions of the tube may be designed with relative compactness, a higher operating frequency may be obtained. The relatively efficient disposition of the several resonant circuits gives a maximum of access of outer portions of the anode to cooling media; and in order to increase effectiveness of such cooling, the outer periphery of anode 12 may be provided with cooling fins, which in the form shown, have been milled out, as at 42 and 43.

Fig. 3 illustrates another embodiment of the above-described tube. In this embodiment a single cylindrical line 47 surrounds anode 12 and is coextensive with grid lines 29 and 32 as lines 28 and 31 were with the same grid lines in Fig. 1. This arrangement thus provides a single tank extending between both grid leads 19 and 20 and anode 12. Coupling capacity between the tank and the anode may be provided by appropriately spacing that part of line 47 adjacent anode 12 therefrom. High anode potential is supplied in a well-known manner (not shown) through a glass bead insulator in the surface of line 47 and in this way these high potentials are kept off external elements of the device. If desired, the anode may be cooled by providing longitudinally extending slots or other apertures (also not shown) in line 47 and a draft forced therethrough.

It is to be noted that I have described a completely symmetrical device wherein the half to one side of a midsection normal to the axis of the device may function symmetrically and concurrently with the other half. In other words the device could, from an electrical point of view, be considered as two separate devices formed by dividing along the midsection of the anode. The ability to tune both cathode-grid and grid-anode circuits symmetrically about this midsection permits all circuits to operate at more elevated frequencies that would otherwise be unattainable. The arrangements described possess the further advantage over two separate tubes in parallel and intended for operation at the same frequencies that the additional inductive and capacitative reactance that would necessarily be introduced by so connecting two separate tubes would materially impair ability to reach those frequencies—at least with electrodes of the size possible in accordance with the invention.

Although I have described my invention in detail in connection with the preferred form shown, it is clear that many modifications, additions and omissions may be made within the scope and spirit thereof as defined in the appended claims.

What is claimed is:

1. An ultra high frequency electron discharge device comprising concentrically mounted cathode, grid and anode electrodes, the anode being the outer of said electrodes, an evacuated envelope enclosing said cathode, said grid and a portion of said anode, an annular member of conducting material passing through a portion of said envelope on one side of said anode, a further annular member of conducting material passing through a portion of said envelope on the other side of said anode, both said annular members being co-axially disposed with respect

to said electrodes and conductively connected with said grid, and cavity resonator means extending across outer portions of said annular members and outer portions of said anode.

2. An electron discharge device according to claim 1, wherein said cavity resonator means includes a first cavity resonator connected between said first-mentioned annular member and said anode and a second cavity resonator connected between said further annular member and said anode, said cavity resonators being generally symmetrically disposed longitudinally with respect to each other and also being symmetrical co-axially with said electrodes.

3. An electron discharge device according to claim 1, wherein said grid electrode is directly connected at one end to one of said annular members and wherein flexing means are provided on the other end thereof and connected to the other of said annular members.

4. An electron discharge device according to claim 1, wherein said grid electrode is connected at one end directly to one of said annular members and wherein the other end thereof is connected to the other of said annular members through a bellows.

5. An electron discharge device comprising a centrally positioned, longitudinally extending cathode, a tubular grid surrounding said cathode, a tubular anode about said grid, means supporting said electrodes, said means including a pair of longitudinally spaced plates, means rigidly attaching one end of said grid to one of said plates and a flexible bellows forming a continuous conductive connection and a longitudinally extensible support interconnecting the other end of said grid with the other plate, and means forming a sealed envelope about said electrodes.

6. The combination according to claim 5, in combination with a tension spring inside of said bellows attached at one end to the other end of said grid and at its other end to the other plate to maintain said grid under tension.

GEORGES P. CHEVIGNY.