United States Patent [19]

Gerlach et al.

[11] **3,742,292**

[45] **June 26, 1973**

[54] **ELECTRONIC TUBES SUCH AS TETRODES FOR VERY HIGH-FREQUENCY OPERATION**

[75] Inventors: **Pierre Gerlach; Gerard Sire,** both of Paris, France

[73] Assignee: **Thomson-CSF,** Paris, France

[22] Filed: **Nov. 30, 1971**

[21] Appl. No.: **203,360**

[30] **Foreign Application Priority Data**

Dec. 4, 1970 France 7043740

[52] **U.S. Cl.** **315/39,** 331/101

[51] **Int. Cl.** **H01j 7/46,** H01j 19/80

[58] **Field of Search** 315/39; 331/101

[56] **References Cited**

UNITED STATES PATENTS

2,870,374	1/1959	Papp	315/39
2,289,846	7/1942	Litton	331/101 X
2,306,860	12/1942	Black	331/101 X
3,381,166	4/1968	Gerlach	315/39

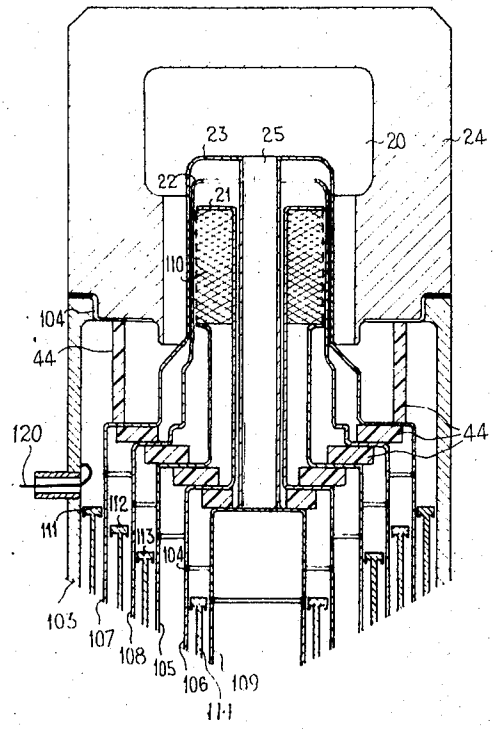
Primary Examiner—Rudolph V. Rolinec
Assistant Examiner—Saxfield Chatmon, Jr.
Attorney—John W. Malley, G. Lloyd Knight et al.

[57] **ABSTRACT**

Tetrode operating at very high frequencies according to a "grounded cathode" mode.

All the coaxial cylindrical electrodes are extended outside the exhausted enclosure, with cylindrical conductive walls forming coaxial cavities which are tunable by means of ring pistons. Furthermore, the screen-grid is connected to a central conductive cylinder passing through the cathode and extending , as the electrodes do, with a cylindrical conductive wall constituting with that one extending from the cathode a cavity which is tuned for ensuring a high frequency short-circuit between the cathode and the screen-grid.

4 Claims, 2 Drawing Figures



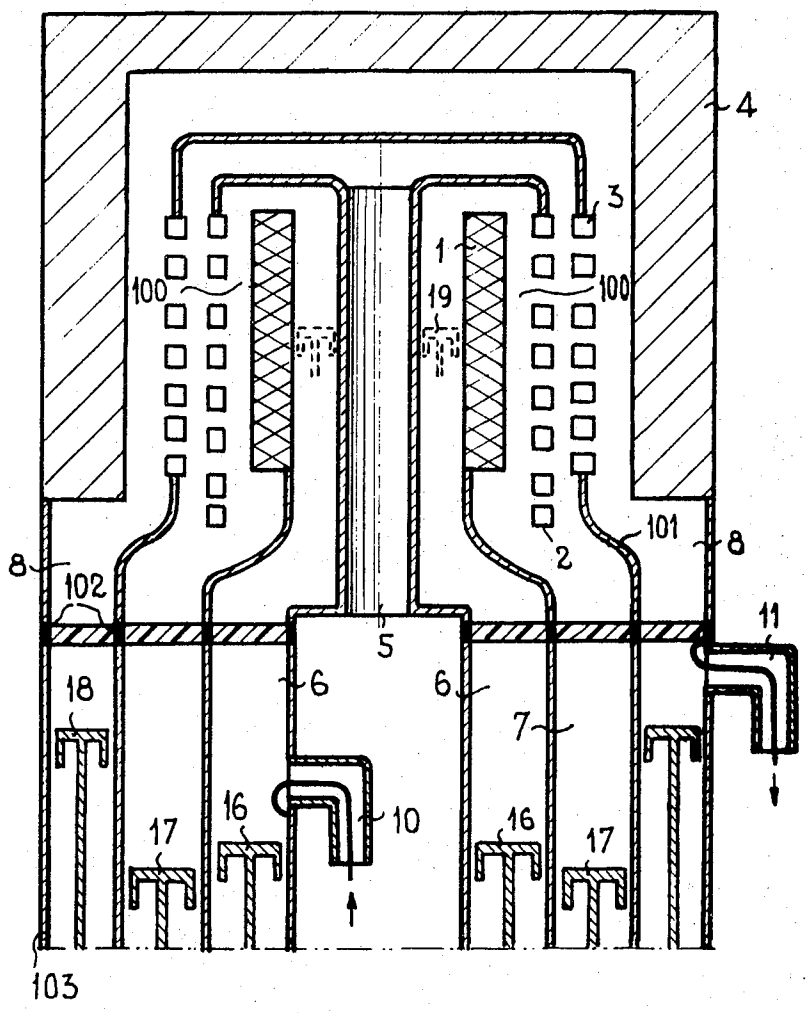


FIG. 1

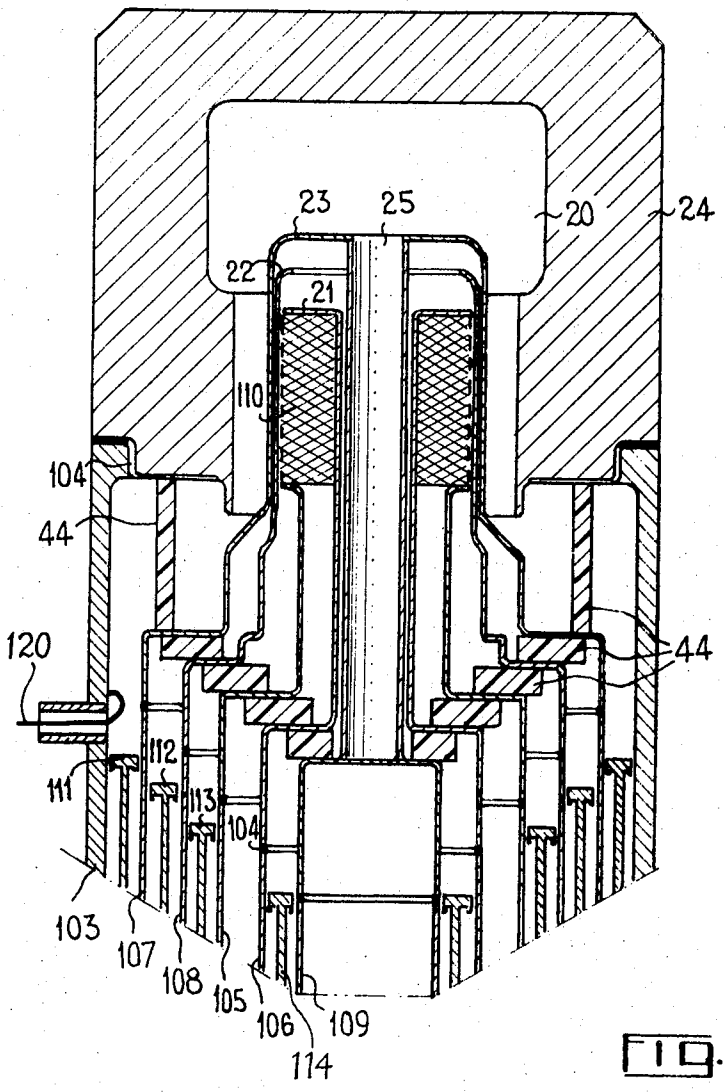

23
25
20
24
22
21
110
104
44
120
44
112
111
113
104
103
107
108
105
106
109
114

FIG. 2

ELECTRONIC TUBES SUCH AS TETRODES FOR VERY HIGH-FREQUENCY OPERATION

The present invention relates to electronic tubes for operation at very high frequencies, and in particular to tetrode tubes of high-gain and high-power type.

These very high-frequency tubes predominantly utilize coaxial cavities, the electrodes there more often than not being constituted by coaxial cylinders which respectively play the part of cathode, control grid, screen-grid and anode. They are prolonged with coaxial lines which are chiefly made by means of coaxial cylinders between which the cavities are located, said cavities being for example an input and an output one.

However, it is well known that the attainment of a high power gain is facilitated by arranging the tube in a "grounded cathode" circuit, in this case the input power simply having to control the grid courant.

However, in the case of the tetrode tubes most generally used, unless special modifications to the internal connections of the electrodes, of the kind described hereinafter, are made, the only kind of operation possible is the "grounded grid" system, in which the input power has to control the whole of the cathode current. The simplest explanation of this is provided by an analysis of the voltages at work in the conventional kind of circuit, that is to say the "grounded grid" one.

It is well known that a circuit diagram equivalent to a tetrode tube operating on microwave signals, according to a grounded grid mode, comprises a resistor in series with the cathode circuit. Considering the cathode high frequency potential as being the high frequency reference potential the other electrodes have a high frequency potential which cannot be zero.

A known solution to the increase of the power gain of a tetrode is, as has been mentioned hereinbefore, the modification of the arrangement of the electrode connections, in order to enable the grounded cathode system to be used, in which system the resistor of the equivalent circuit diagram is connected in the control-grid circuit and consequently wherein a high-frequency short circuit is provided between the cathode and the screen-grid. This modification can be effected inside the tube by crossing the connections of cathode and control-grid but has the drawback that it introduces a top limit on the operating frequency, which is due to parasitic coupling and increase in the inductances produced by these connections. It can equally well be achieved externally of the tube by using a special tube design of the double-ended kind, which, although it enables the aforesaid drawbacks to be overcome, necessitates a dismantleable cavity for the installation and replacement of the tube. Finally, it can be achieved by yet a third method, which consists in suspending the control grid from a support passing through the cylindrical cathode, this method not exhibiting the aforesaid drawbacks. However, the excessive length of the line in the input circuit, inside the tube, which results from this technique, brings about a considerable reduction in the effective passband, this as a consequence of a physical mechanism which is detailled hereinafter.

The present invention relates to a tetrode for microwave operation which can be operated in a grounded cathode system, in order to achieve a substantial power gain whilst avoiding the aforestated drawbacks by suitable assembly of the screengrid, the latter being arranged upon a support passing through the cathode and connected to the high frequency circuits of the tube through the medium of two connections. One of these connections contributes to the output for the amplified microwave power and is an element of the output line, at the same time producing an effective screen between the input and output circuits; the other connection satisfies the condition which must be met by the desired mode of operation, ensuring the production of a zero high-frequency potential in relation to the cathode.

The ensuing description will provide a better understanding of the invention and is based upon the attached figures in which:

FIG. 1 illustrates a schematic view of a known type of tetrode, for operation at very high frequencies;

FIG. 2 illustrates a microwave tetrode in accordance with the invention.

FIG. 1 provides a schematic view of a known kind of tetrode operating at very high frequency and arranged in a grounded cathode system, the illustration not being a scale one and having been given in fact purely by way of an example of the prior art.

The tetrode tube itself comprises four cylindrical electrodes, a cathode **1**, a control grid **2**, suspended at one of its ends from a central support **5** used as the grid connection, a screen-grid **3**, and an anode **4**.

The resonant cavities of the tube are constituted by cylindrical rings **6, 7** and **8**, composed of the intervals between conductive walls (**103** for example) extending the electrodes **2, 1, 3** and **4**, and constituting coaxial cylinders; these conductive walls are fixed to the electrodes by means of conductive collars (**101** for example) making possible the transition between the small distances between the electrodes and the distances necessary between the cylindrical wall for a convenient operation of the cavities.

The means for assuming the tightness of the exhausted enclosure for the electrodes are schematically represented on the figure between the cylindrical walls; they are for example constituted by ceramic rings tightly closing the cavities near the collars.

Pistons **16, 17** and **18**, of ring-form, are movable in the cavities **6, 7** and **8**.

Classical biasing means, not shown, are used for applying continuous convenient voltages onto the electrodes. The conductive walls are isolated from the continuous biasing voltages by electrically insulating means constituted for example by mica rings (**102** for example).

The high frequency power input and output are respectively assumed by microwave couplers **10** and **11**.

The operation of this kind of device is as follows:

The microwave input to the tube is effected through the coupler **10** into the cavity **6** between the cathode **1** and the control grid **2**; the output is through the coupler **11**, via the cavity **8** between the screen-grid **3** and the anode **4**. The pistons **16** and **18** assume the tuning of the input and output cavities.

The grounded cathode arrangement is rendered possible by the special disposition of the connections of the control grid **2**, inside the tube. In other words, with the help of the piston **17** it is possible to achieve a microwave short-circuit between the cathode **1** and the screen-grid **3**. In this fashion, the production of the grounded cathode arrangement is not accompanied by the aforestated drawbacks such as parasitic coupling or obligatory dismantling of the cavities on installation of the tube.

Nevertheless, the substantial length of the input circuit constituted by the cavity **6** and its extension between the electrodes up to the space **100** where is provided the interaction between the high frequency waves and the electron beam emitted by the cathode **1**, introduces a limitation upon the pass bandwidth, because of the following mechanism:

The tuning of the input circuit which is effected by the piston **16**, to the $\lambda/4$ mode for example can only be achieved for long wavelengths λ, that is to say relatively low frequencies, since the piston **16** cannot penetrate into the inside of the tetrode tube itself, and thus reach the position **19**, for example shown in dotted fashion. The higher order mode can then be used, this enabling the piston **16** to reach a viable position, albeit at the expense of the passband which, considering for example the $(3\lambda)/4$ mode, is reduced in the ratio of around **4**.

FIG. **2** illustrates a tetrode in accordance with the invention.

The continuous biasing voltages are applied onto the electrodes as earlier said in connection with FIG. **1**; the biasing means are not represented on FIG. **2** because they are similar to the classical ones.

The four electrodes themselves are arranged as electrodes of every microwave operating tetrode and for example tetrode of FIG. **1**.

An anode **24** having a cylindrical shape contains the tight exhausted enclosure **20** wherein are arranged the three other electrodes: cathode **21**, control-grid **22**, screen-grid **23**.

On the other hand, the connections of said electrodes and the cavities of the tube are realized in a new arrangement characteristic of the invention.

The electrodes are extended with conductive walls having an approximately cylindrical shape and constituting the beginning of the tube cavities. The electrical insulation of said walls and the tightness of the enclosure **20** are assumed by rings **44** made of a material being mechanically strong and electrically insulating, ceramic for example.

The resonant cavities are extended outside the exhausted enclosure **20** with conductive cylindrical walls, looking like those of FIG. **1** and being also electrically insulated from the continuous voltages appearing between the electrodes. by insulating rings **104** made of mica for example.

On FIG. **2**, two cylindrical walls **105** and **106** are extending from the cathode **21**. They are equivalent with regard to the high frequency signal and are only used for applying a small continuous heating voltage between the two ends of a cylindrical mesh **110** which is mounted onto the cathode **21** for heating it.

In accordance with the invention, the control-grid **22** is prolongated with a cylindrical wall **108** while the screen-grid **23** is carried by a cylindrical support **25** passing through the cathode **21**, whose walls are electrically conductive, constituting one of the two connections by means of which the screen-grid **23** is connected with the exterior, and on which is mounted a conductive cylinder **109**, the other connection of said screen-grid being prolongated with the cylindrical wall **107**. The anode **24** is prolongated with the cylindrical wall **103**.

This new arrangement of the electrodes connections and consequently of the associated cavities, makes possible using the tetrode in a grounded cathode mode while avoiding the aforementioned drawbacks by tuning the cavities by means of ring pistons schematically shown by **111**, **112**, **113** and **114**; said pistons being able to be moved in the cavities thus ensuring the adjustment of the electrical length of said cavities.

The high frequency wave is applied to the control-grid **22** by means of a coupling device entering for example into the input cavity delimitated by the walls **105** and **108** and their extensions towards the cathode and the control-grid. This coupling device is not shown on FIG. **2** which is a sectional view; it is indeed disposed in a zone of the pheriphery of the tube not encumbered with the pistons rods which rods are shown on the figure. Said input cavity is tuned by means of the piston **113**.

The extraction of the high frequency amplified wave is realized for example by means of a coupling device **120** entering into the output cavity of the tube which cavity is delimitated by the walls **107** and **103** extending towards the screen-grid **23** and the anode **24**. Said output cavity is tuned by means of the piston **111**.

The grounded cathode arrangement is easily obtained by adjusting the piston **114** which is movable in the cavity delimitated by the walls **106** and **109** and their extensions, is such a way that a high-frequency short circuit is established between the cathode **21** and the screen-grid **23**, that is to say between the cathode and the walls of the cylindrical support **25**.

At last, a piston **112** is movable in the cavity delimitated by the walls **107** and **108** and their extensions towards the screen-grid **23** and the control-grid **22**, and is adjusted in such a way that it brings about a quasi-infinite high frequency impedance between said two electrodes for avoiding production of disturbances in the tube operating due to said cavity.

As in the case of the preceding figure, there are none of the drawbacks referred to above, namely parasitic coupling, increase in inductance due to internal connections, or requirement for dismantling of cavities.

Moreover, the microwave input line between the cathode **21** and the control grid **22**, is of small length, contrary to the case of FIG. **1**, so that there is less limitation on frequency. Thus, the first connection of the screen-grid **23**, which connection is constituted by the wall of the support **25**, forms one of the elements of the cavity enabling a grounded cathode system to be produced; the second connection wall **107**, of the screen-grid **23** on the one hand achieved good screening between input and output microwaves, and on the other hand serves as an element of the output cavity.

The advantages introduced by the present invention are two-fold:

On the one hand, it is possible to use a grounded cathode arrangement and this yields a very substantial improvement in power gain; with this kind of circuit, said gain is in the order of 20 dB whereas with a grounded grid system it is not possible to achieve much in excess of 12 dB. On the other hand, it is possible to operate at frequencies in excess of 500 Mc/s, this with a passband of sufficient width for it to be applicable with advantage to television transmitters where it is then possible, thanks in particular to the improvement in power gain, to reduce the number of intermediate amplifier stages.

What is claimed is:

1. A high frequency operating tetrode comprising:

cylindrical electrodes arranged coaxially within a tight exhausted enclosure about the tube axis, in-

cluding successively from said axis, an electron-emissive cathode, a control-grid, a screen-grid and an anode,

input coupling means applying a high frequency input wave between said control-grid and said cathode,

output coupling means extracting an output high-frequency wave between said anode and said screen-grid,

tunable coaxial cavities including conductive cylindrical walls arranged coaxially about said axis and respectively connected to one extremity of the of the electrodes,

a central conductive cylinder coaxially arranged about said axis and passing through said cathode, said central cylinder having a first extremity extending from said cathode towards said cylindrical walls and a second extremity extending from the cathode opposite the first extremity,

a further conductive clyindrical wall establishing a coaxial cavity being coupled to said first mentioned extremity of the central cylinder and the second mentioned extremity of the central cylinder being coupled to the screen grid at one end and the opposite end of the screen grid being coupled to one of the cylindrical walls,

and ring pistons movable along said coaxial cavities for providing their respective tuning, the ring piston movable along one of said coaxial cavities between the cylindrical wall coupled to the cathode and the cylindrical wall coupled to the first extremity of the said central cylinder being adjusted for ensuring a high-frequency short-circuit between said cathode and said screen-grid.

2. A high frequency operating tetrode according to claim **1** wherein the coaxial cavity between the walls extending from said control-grid and said screen-grid is tuned for providing a quasi-infinite high frequency impedance between said control-grid and said screen-grid.

3. A high frequency operating tetrode according to claim **1** wherein said input coupling means is coupled between the cylindrical walls extending from said control-grid and said cathode forming the associated coaxial cavity.

4. A high frequency operating tetrode according to claim **1** wherein said output coupling means is coupled between the cylindrical walls extending from said screen-grid and said anode forming the associated coaxial cavity.

* * * * *