Aug. 20, 1957 G. DIEMER 2,803,782

TRIODE THERMIONIC TUBE

Filed Aug. 14, 1951 2 Sheets-Sheet 1

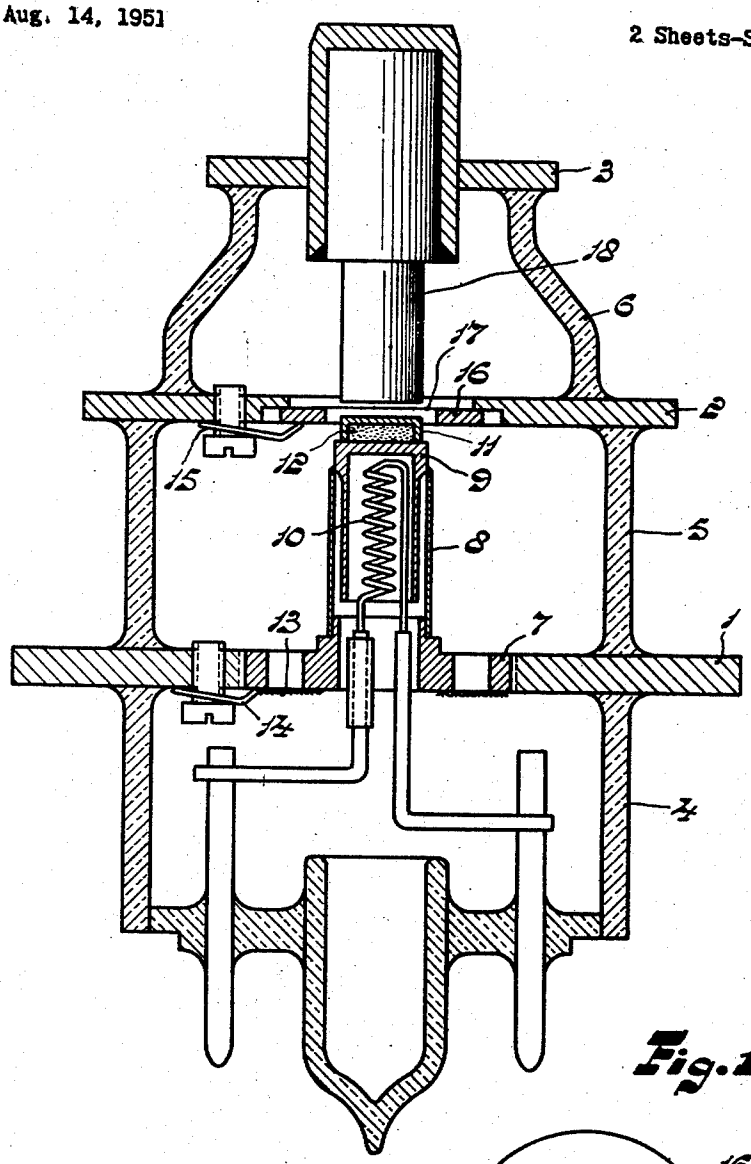



Fig. 1

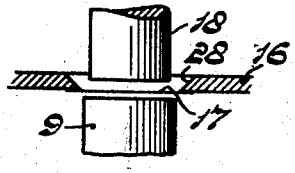



Fig. 6

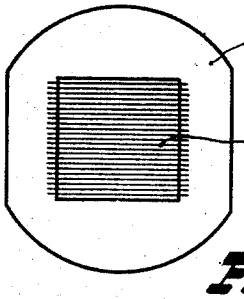



Fig. 2

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TRIODE THERMIONIC TUBE

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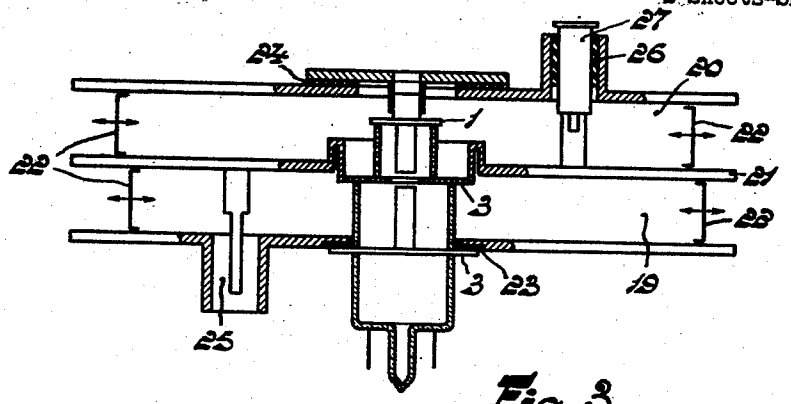



Fig. 3

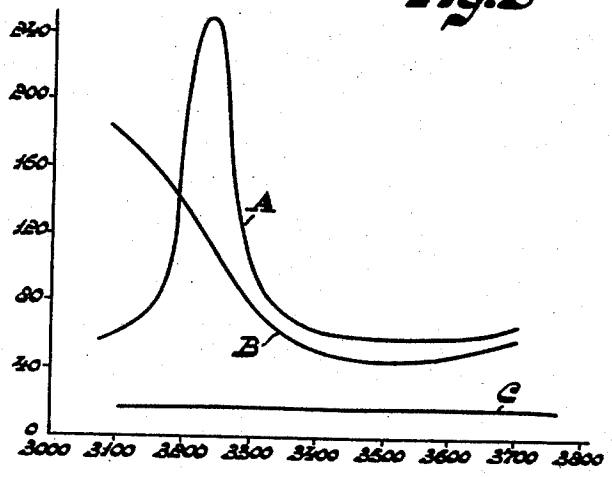



Fig. 4

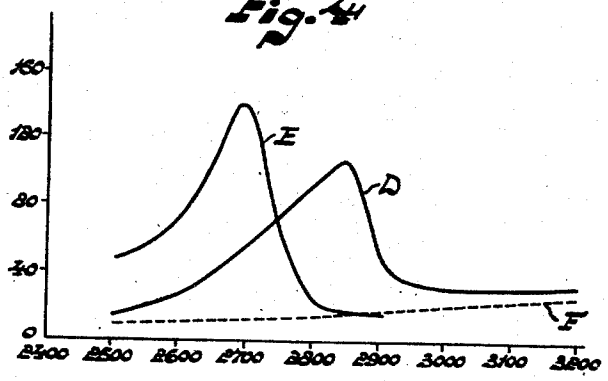



Fig. 5

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2,803,782

# TRIODE THERMIONIC TUBE

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Application August 14, 1951, Serial No. 241,796

Claims priority, application Netherlands September 22, 1950

2 Claims. (Cl. 315—40)

This invention relates to apparatus for operating at very high radio frequencies (1000 mc./s. and higher) comprising a triode having flat electrodes, wherein the grid consists of a plurality of parallel wires stretched over a hole provided in a conductive ring which is supported by a conductive disc sealed into the wall of the tube and separating the cathode space from the anode space. Furthermore the invention relates to triode tubes intended for such device.

It is known that in devices of the aforesaid type, the magnetic field of the grid wires gives rise to a reaction or feedback from the anode space to the cathode space.

Furthermore it is known that the self-inductance of the grid supply lead causes a similar reaction in a tube of rather classical construction.

It is held that this reaction involves an apparent increase in an anode-cathode capacity.

The present invention has for its object to utilize to advantage the aforesaid reaction due to self-inductance of the grid wires.

According to the invention, in apparatus for operating at very high radio frequencies comprising a triode having flat electrodes, wherein the grid consists of a plurality of thin parallel wires stretched over a hole provided in a conductive ring which is supported by a conductive disc sealed into the wall of the tube and separating the cathode space from the anode space, the self-inductance of the grid wires is such that the resultant reaction or feedback from the anode space to the cathode space entirely or substantially entirely corrects for the reaction due to the static capacity between the anode and cathode. In order to ensure optimum compensation as a result of the self-inductance of the grid wires, the device is adjusted in a range of frequencies about the angular frequency

$$\omega=\sqrt{\frac{C_{ac}}{C_{an}C_{gc}L_g}}$$

In a particular embodiment of the invention an inductance- and capacity-free resistor having a value of

$$\frac{1}{\omega^2 C_{ag}C_{gc}r_g}$$

is connected between the anode and the cathode.

It has, in effect, both theoretically and experimentally been found that the anode-cathode capacity approximately has the apparent value of

$$C_{ac}\left(1-\omega^2 L_g\frac{C_{ag}C_{gc}}{C_{ac}}\right)$$

wherein $C_{ac}$ denotes the static anode-cathode capacity, $C_{ag}$ the static capacity between grid and anode, $C_{gc}$ the static capacity between grid and cathode, $L_g$ the self-inductance, $r_g$ the resistance of the grid wires and $\omega$ the angular frequency.

An apparent resistance of

$$\frac{-1}{\omega^2 C_{ag}C_{gc}r_g}$$



is connected in parallel with the said apparent capacity. For the self-inductance of the grid wires practically only that part is of importance which is located between the point of attachment of the wires and their portion partaking in the discharge, the same holding for the resistance.

It appears that if

$$\omega=\sqrt{\frac{C_{ac}}{C_{ag}C_{gc}L_g}}$$

the reaction from the anode space to the cathode space is a minimum and may be designated by the aforesaid negative resistance, which may consequently be compensated by a positive resistance.

If the device is to be used in a large frequency range, more particularly above 5000 mc./s., it is advisable that the length of the grid wires between the ring and their portion partaking in the discharge should be reduced as much as possible. This is ensured by mounting the grid ring such that its non wire-stretched side faces the anode and by providing that the hole therein is not much larger than is necessary for the discharge, i. e. not more than 0.3 mm. at both sides, and by bevelling the hole in the ring.

In order that the invention may be readily carried into effect, an example will now be described in detail with reference to the accompanying drawings, in which:

Fig. 1 represents an electric discharge tube for use in a device according to the invention,

Fig. 2 shows the stretched grid ring for this discharge tube,

Fig. 3 represents a measuring arrangement with this tube,

Figs. 4 and 5 show the measuring results obtained with this tube, and

Fig. 6 represents a bevelled grid ring for this tube.

In Figs. 1 and 2, the reference numerals, **1**, **2** and **3** designate three chrome iron discs which, jointly with the substantially cylindrical glass parts **4**, **5** and **6**, constitute the discharge tube. Into a disc **1** is screwed a cathode ring **7** to which a molybdenum cylinder **9** is secured with the aid of a thin tantalum foil **8**. The cylinder contains a heater coil **10** and has welded to it a porous tungsten cap **11** containing barium strontium oxide **12**. The cathode ring is provided with three gauze-covered holes **13** and is held in place by means of three bolts **14** comprising clamping rings.

A grid ring **16** with wires **17** stretched thereon and soldered thereto is pressed against grid ring **2** by means of three bolts with clamping rings **15**. A copper anode **18** is soldered to the chrome iron disc **3**.

Fig. 3 shows how the tube depicted in Fig. 1 is arranged in a measuring arrangement constituted by two elongated wave guides **19** and **20** having a common wall **21**. Four pistons **22** provide for the tuning of the wave guides. The grid disc is clamped in the common wall **21** by a ring of resilient bent tags. A mica ring **23** is provided for insulation between the cathode disc and the lower wall of the wave guide **19**, a mica ring **24** for insulation being provided between the clamping means for the anode head and the upper wall of wave guide **20**. The end of the coaxial supply cable **25** extends into wave guide **19**. A crystal detector **27** is mounted in wave guide **20** so as to be insulated therefrom by a mica bush **26**. If a signal is sent into the lower wave guide through a cable **25**, this signal is detected to a greater or less degree in the crystal detector **27** in accordance with the reaction from the anode space to the cathode space. Thus the reaction from the cathode space to the anode space is actually measured, but this reaction is equal to that from the anode space to the cathode space. The measurements are invariably effected at such tube voltages that the cathode, when

heated, does not carry current. In the case of a cold cathode this additional step is not necessary. The higher the voltage required to be applied through cable **25** to the lower cavity resonator to detect a particular signal in the crystal detector **27**, the lower the reaction between anode space and cathode space.

In Fig. 4, this signal is plotted in an arbitrary measure along a vertical axis as a function of the frequency in m.c/s. and more particularly in curve A for a cold tube and in curve B for a cathode temperature of 600° C. For controlling purposes the curve C is shown with removed grid and a conductive rod provided between anode and cathode, so that the input electrode and the output electrode are directly connected through a short-circuit.

Fig. 5 shows the same for another tube, in curve D for a tube with a cold cathode and in curve E for a cathode temperature of 1000° C., curve F representing the control with the aforesaid short-circuit between inlet and outlet.

From these curves it is evident that the voltage required at inlet **25** as a function of the frequency has a maximum, so that in this case the reaction as a function of the frequency is a minimum. Furthermore, the frequency shift from minimum reaction towards lower frequencies at higher cathode temperatures appears from the drawing. This also fits with the expectations, since the arrangement is such that the grid-cathode capacity increases upon thermal expansion of the cathode. The structural details of the measured tubes are as follows: the hole in the grid ring is 4 mms. square, the molybdenum ring itself being 0.5 mm. thick. The cathode and the anode have a diameter of 3 mms. The tungsten grid wires are $10\mu$ thick and gold-plated to a thickness of $0.1\mu$. The distance of the cathode from the centre of the grid wires is $40\mu$, this being $250\mu$ for the anode. In the cold state of the tube the grid-cathode capacity is 1.1 $\mu\mu$f., it being 1.5 $\mu\mu$f. at a cathode temperature of 1050° C. The grid-anode capacity is 0.45 $\mu\mu$f. and the cathode-anode capacity amounts to $15\times10^{-3}$ $\mu\mu$f.

If for the self-inductance of the grid wires only the length between the ring and the active part thereof is taken and assuming them to be equispaced from the anode and from the cathode by this length, it is found that $L_g$ $0.10\times10^{-9}$ henries. By means of the aforesaid expression it can be calculated that the frequency of minimum reaction with a cold and hot cathode is 2900 and 2500 m.c/s. respectively which roughly fits with the curves measured.

The triode shown in Fig. 6 differs from that shown in Fig. 1 only in that the side of the grid ring **16** where the wires are stretched on it is remote from the anode. The circular hole in the ring has a bevelled edge **28** and is only slightly larger that the anode, viz. 0.3 to 0.4 mm. in diameter.

What I claim is:

1. An electron discharge device adapted for operation at a given frequency above 1000 mc./s. comprising an envelope, a cathode within said envelope having a flat electron emissive surface which includes a porous tungsten cap containing barium strontium oxide and which provides an electron beam of high current density; an anode within said envelope having a flat electron receiving surface disposed opposite said electron emissive surface; a conductive disc having an aperture therein for the passage of said electron beam interposed between said electron-emissive surface and said electron receiving surface, said disc being sealed into the wall of the envelope; a conductive ring supported by said disc; and a plurality of thin spaced parallel wires stretched over the ring constituting a grid, said wires having a length and spacing at which that part



of said wires between said ring and said electron beam has a given value of self-inductance $L_g$, said wires defining with the emitting surface and the receiving surface a cathode space and an anode space, respectively, the self-inductance $L_g$ of said wires having a value at which the coupling between the anode space and the cathode space due to the self-inductance $L_g$ of the wires substantially compensates for the feedback due to static capacity between the electron emissive surface and the electron receiving surface at said given frequency in a range about an angular frequency which lies

$$\omega=\sqrt{\frac{C_{ac}}{C_{ag}C_{gc}L_g}}$$

$C_{ac}$ denoting static anode-cathode capacity, $C_{ag}$ denoting static anode-grid capacity, and $C_{gc}$ denoting static cathode-grid capacity.

2. An electron discharge device adapted for operation at a given frequency above 1000 mc./s. comprising an envelope, a cathode within said envelope having a flat electron emissive surface which includes a porous tungsten cap containing barium strontium oxide and which provides an electron beam of high current density; anode within said envelope having a flat electron receiving surface disposed opposite said electron emissive surface; a conductive disc having an aperture therein for the passage of said electron beam interposed between said electron-emissive surface and said electron receiving surface, said disc being sealed into the wall of the envelope; a conductive ring supported by said disc; a plurality of spaced thin parallel wires stretched over the ring constituting a grid, said wires having a length and spacing at which that part of said wires between said ring and said electron beam has a given value of self-inductance $L_g$, said wires defining with the emitting surface and the receiving surface a cathode space and an anode space, respectively, the self-inductance $L_g$ of said wires having a value at which the coupling between the anode space and the cathode space due to the self-inductance $L_g$ of the wires substantially corrects compensates for the feedback due to static capacity between the electron emissive surface and the electron receiving surface at said given frequency, which lies in a range of frequencies about an angular frequency

$$\omega=\sqrt{\frac{C_{ac}}{C_{ag}C_{gc}L_g}}$$

$C_{ac}$ denoting static anode-cathode capacity, $C_{ag}$ denoting static anode-grid capacity, and $C_{gc}$ denoting static cathode-grid capacity, and an inductance- and capacity-free resistance having a value

$$\frac{1}{\omega^2C_{ag}C_{gc}r_g}$$

$r_g$ representing the resistance of the grid wires, connected between the anode and the cathode.


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