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TRAVELLING WAVE TUBES WITH CROSSED ELECTRIC AND MAGNETIC FIELDS

Filed June 25, 1956

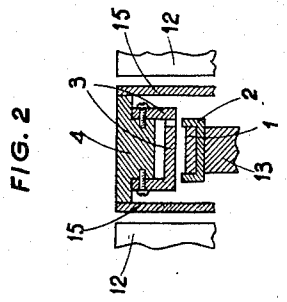


FIG. 2

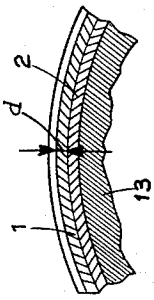


FIG. 3

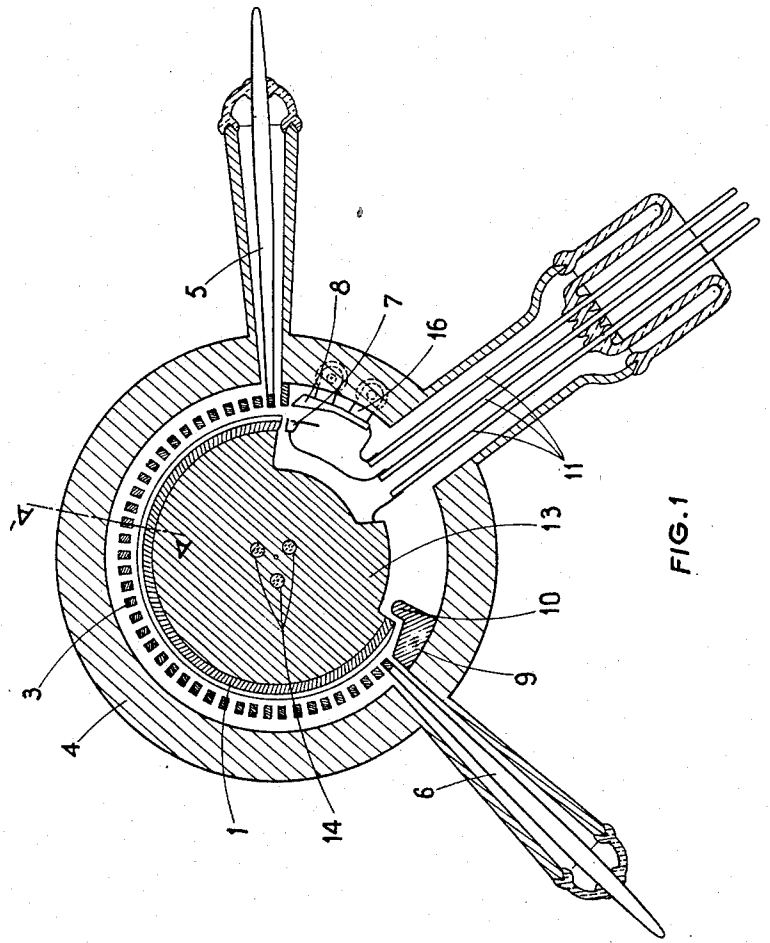


FIG. 1

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TRAVELLING WAVE TUBES WITH CROSSED ELECTRIC AND MAGNETIC FIELDS

Georges Guilbaud, Paris, France, assignor to Compagnie Generale de Telegraphie Sans Fil, a corporation of France

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8 Claims. (Cl. 315—3.5)

Travelling wave tubes with crossed electric and magnetic fields generally comprise a conductive delay line and a conductive negative electrode, generally known as a sole. The delay line and electrode bound what is called the interaction space, and the potential of the delay line is high with respect to that of the negative electrode. An electron beam is projected into the interaction space for propagation in a direction parallel to the delay line. A magnetic field is provided in this space, perpendicularly to the directions of the beam and of the electric field due to the potential difference between the delay line and the negative electrode.

As is well known, in tubes of this type, and more particularly in high power tubes, some of the beam electrons reach the negative electrode and give rise therein to an undesirable current which increases the noise in the tube.

It is an object of the present invention to provide a tube of the above described type which does not present this disadvantage.

The tube, according to the invention, has an interaction space of constant width and is provided with a negative electrode made of lossy material and with means for maintaining the whole of the negative electrode at the same continuous potential with respect to the delay line, in spite of the current due to the impact of the beam electrons on this electrode.

The invention will be better understood from the ensuing description, taken in connection with the appended drawing, wherein:

Fig. 1 represents a transverse section of a cylindrically shaped amplifier according to the invention;

Fig. 2 is a radial section along line AA' of Fig. 1;

Fig. 3 shows a detail of Fig. 1, on a larger scale.

In the tube shown by way of example in Fig. 1, a negative electrode 1 and a delay line 3, parallel to each other, and having a circular structure, are located in a cylindrical envelope 4, closed at its ends by flanges 15 (Fig. 2). The delay line is coupled to an input 5 and an output 6. A cathode 7 is located opposite a focusing electrode 8, which is insulated from the envelope 4 by supports 16. Cathode 7 is adjacent input 5 and is positioned for shooting an electron beam into the interaction space bounded by electrodes 1 and 3. This beam is collected at the end of its path by a collector 9, adjacent output 6. The collector 9 may be integral with a screen 10 which uncouples input 5 and output 6. Feeding connections 11 are provided for bringing cathode 7 to a negative potential with respect to envelope 4, delay line 3 and collector 9, for bringing electrode 1 to a negative potential with respect to delay line 3 and for bringing plate 8 to a suitable positive potential with respect to the cathode 7. Polar pieces 12, shown in Fig. 2, supply an axial magnetic field, which in fact is transverse to the direction of electron flow. All above mentioned elements are entirely conventional.

According to the invention, electrode 1 is built of a lossy material and is inserted into a peripheral groove

provided in the circularly shaped metal support 2, carried by a disc 13 secured on insulating cross-pieces 14, as may be seen in Figs. 1 and 2. The lossy electrode 1 presents a smooth continuous elongated strip-like surface substantially the width of the negative electrode structure and having its major dimension generally in the direction of the electron beam. Thus, not only is the current which may be caused to flow in the sole 1, under the impact of electrons, reduced to a small intensity because of the high resistivity of the material of this electrode 1, but also the whole of the sole 1 is kept at a constant electrical potential by the highly conductive support 2. Of course any other connections may be used to the same effect.

The thickness of the negative electrode 1 is of the order of one or several times the penetration depth of the ultra high frequency current into the material of which it is built.

This penetration depth d is given by the well known formula

$$d=2.89\sqrt{\frac{\rho\lambda}{\mu}}$$

where d is expressed in millimeters, the resistivity of the material ρ in ohms-cm., the wave-length λ in the free space of the wave propagating in the line in meters and the magnetic permeability μ in electro-magnetic units c.g.s.

If, for instance, $\lambda=0.10$ m., $\rho=50$ ohms-cm. and $\mu=1$, one obtains:

$$d=6.5 \text{ mm.}$$

i.e. the thickness of the negative electrode is of a few millimeters.

According to a theory developed by applicant, it has been established that the noise is generally reduced to a minimum when the resistivity ρ is tied to the respective values of the dielectric constant ϵ and of the angular velocity ω i.e. 2π times the frequency of the wave concerned, by the relation:

$$\rho=\frac{9.10^{11}}{\epsilon.\omega}$$

where ρ is in ohm-cms. and ϵ in c.g.s. units. This condition corresponds to a loss angle of 45°.

For instance, for the .1 m. wave length, which corresponds to

$$\omega=6.10^{9}\pi$$

and for $\epsilon=1$, $\rho=50$ ohm-cms.

It is obvious that the above formula is given only by way of example, and that the value of ρ may be varied within very wide limits.

Of course the tube described has been given by way of example only. The invention may be obviously applied to any traveling wave tube with crossed electric and magnetic fields, i.e. direct or backward travelling wave amplifiers or oscillators, of circular or linear type.

What I claim is:

1. A travelling wave tube, of the type in which an electron beam is used and which includes means for providing crossed electric and magnetic fields in the interaction space for the electron beam, comprising a delay line and an electrode parallel to said delay line and bounding therewith said space, having an elongated continuous strip-like surface of lossy resistive material with its major dimension generally in the direction of the electron beam, said surface extending substantially the width of said electrode, said material serving to reduce the noise within said tube normally produced therein by primary stray electrons of said electron beam when reaching said electrode during operation of the tube, said electrode including electrically conducting means

offsetting the effect of said resistive material for keeping the electric potential thereof constant all along this electrode.

2. A travelling wave tube comprising a smooth strip-like electrode made of a lossy material having at the operating wave frequency a loss angle of the order of 45°, a delay line parallel to said electrode and bounding therewith an electron and wave interaction space, means for producing in said interaction space transverse crossed electrostatic and magnetic fields, means for producing an electron beam propagating in said interaction space perpendicular to said crossed fields and means for maintaining a constant electrostatic potential all along said electrode.

3. A travelling wave tube comprising a smooth strip-like electrode made of a lossy material having at the operating wave frequency a loss angle of the order of 45°, a delay line parallel to said electrode and bounding therewith an electron and wave interaction space, means for producing in said interaction space transverse crossed electrostatic and magnetic fields, means for producing an electron beam propagating in said interaction space perpendicular to said crossed fields and a conductive support having a groove for supporting therein said electrode, said conductive support being brought to a constant negative potential with respect to said delay line.

4. A travelling wave tube comprising a smooth strip-like electrode made of a lossy material having at the operating wave frequency a loss angle of the order of 45°, a delay line parallel to said electrode and bounding therewith an electron and wave interaction space, means for producing in said interaction space transverse crossed electrostatic and magnetic fields, means for producing an electron beam propagating in said interaction space perpendicular to said crossed fields and a conductive support having a groove, said electrode being located in said groove and having a thickness of the order of skin depth at said operating frequency, said conductive support being brought to a constant negative potential with respect to said delay line.

5. A travelling wave tube according to claim 1, wherein said electrode has a longitudinal configuration of a circular arc and said last-mentioned electrically conducting means includes support means made of highly conductive material to support the portion of said electrode made of lossy material, said highly conductive material extending substantially throughout the circular arc defined by said strip-like surface of said electrode.

6. A traveling wave tube of the type comprising an anode shaped as a delay line, a smooth strip-like electrode made of lossy material and bounding with said delay line an electron and wave interaction space, means for producing in said interaction space transverse electrostatic and magnetic fields in essentially perpendicular relationship to one another, and means for producing an electron beam propagating through said interaction space essentially perpendicularly to said fields, said tube including means for maintaining substantially the entire surface of said lossy electrode at a constant negative potential with respect to said delay line, and said delay line being parallel to said lossy smooth electrode.

7. A tube in accordance with claim 6, including a conductive support in contact with substantially the whole face of said smooth electrode remote from said interaction space, and means for maintaining said conductive support at a constant negative potential with respect to said delay line.

8. A tube in accordance with claim 7, wherein said lossy electrode has a loss angle of the order of 45° at the operating wave frequency.

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