

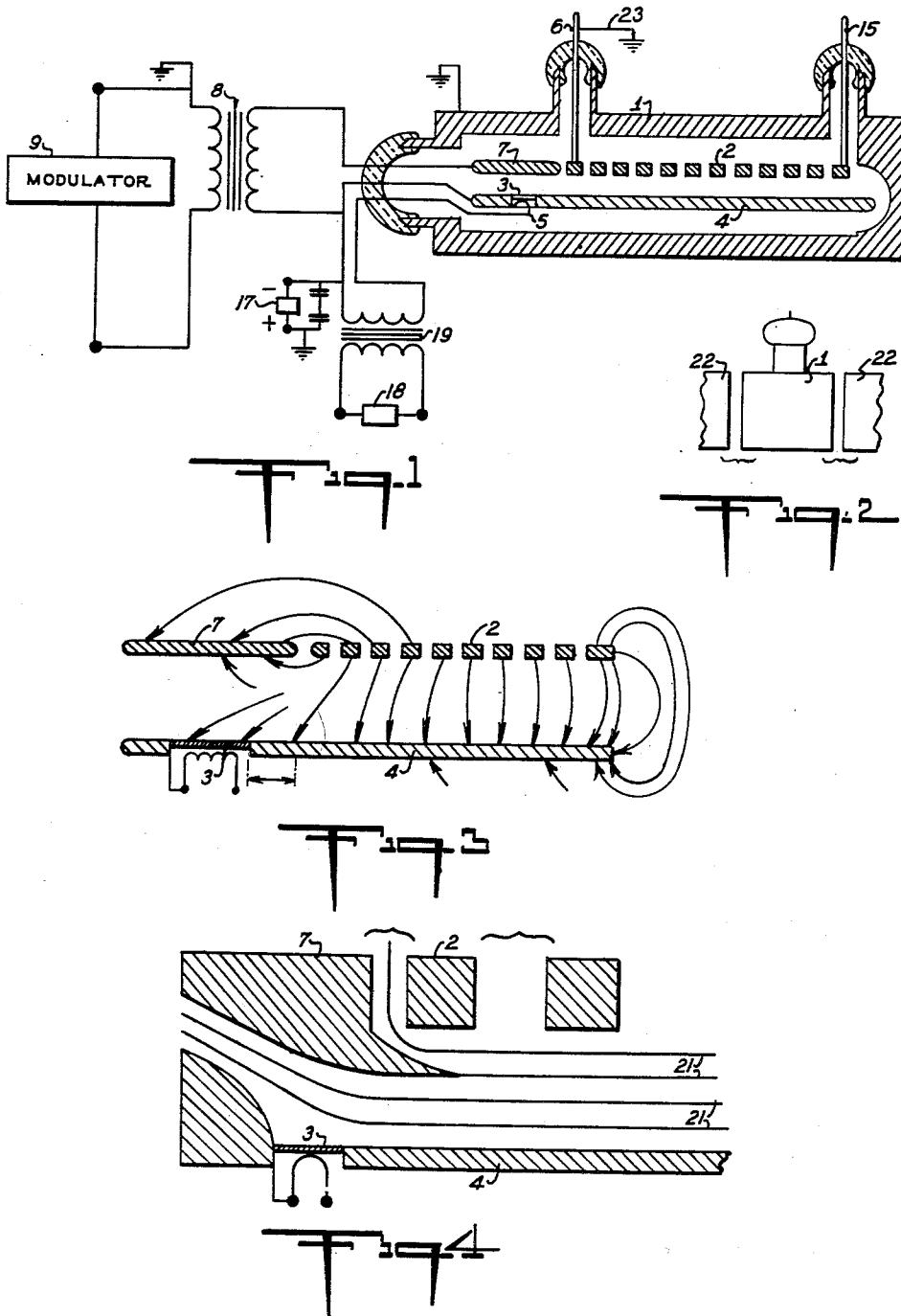
Feb. 15, 1955

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PULSE-MODULATED TRAVELING WAVE TUBE WITH
CROSSED ELECTRIC AND MAGNETIC FIELDS

2,702,370

Filed March 16, 1954

2 Sheets-Sheet 1



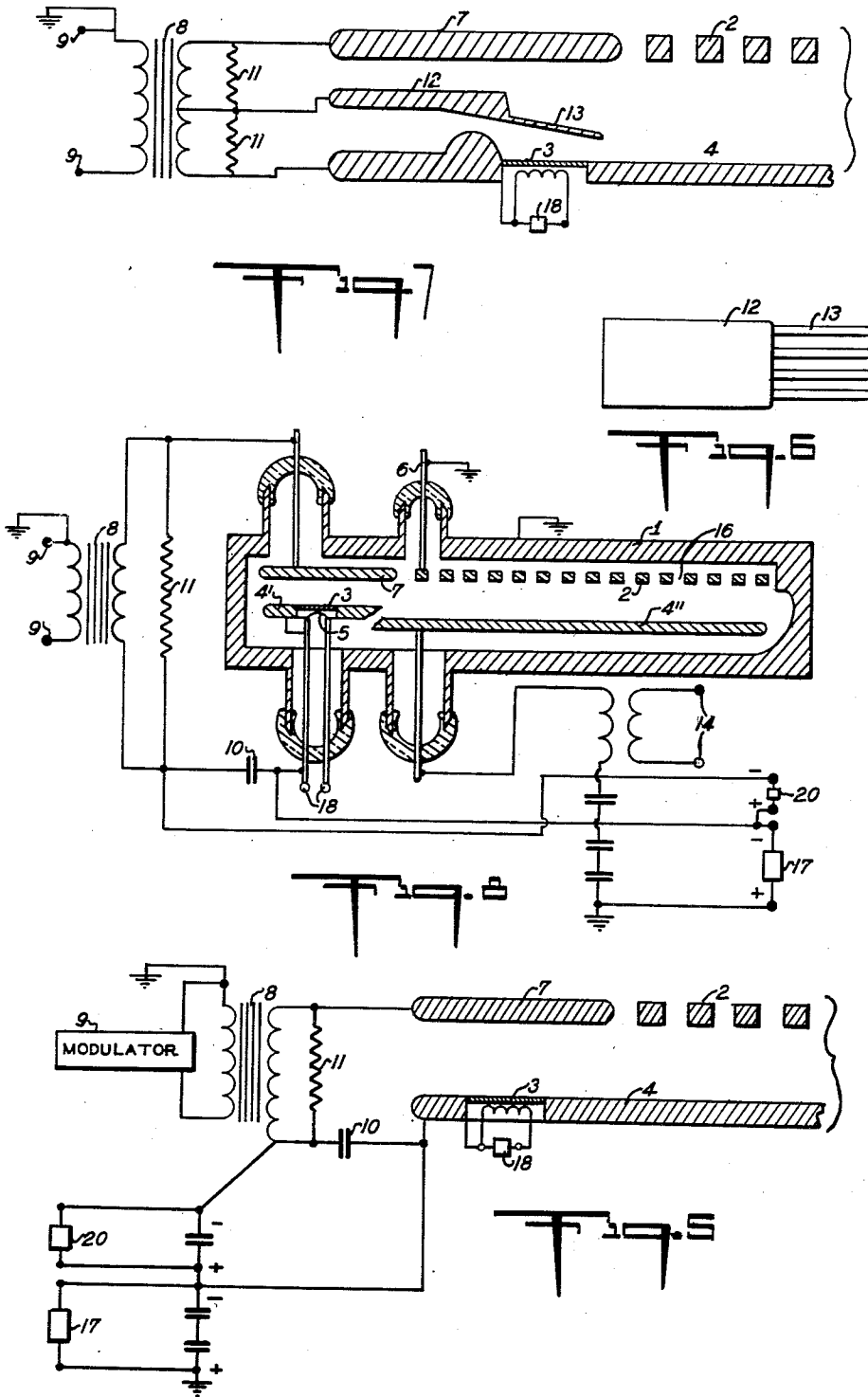
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PULSE-MODULATED TRAVELING WAVE TUBE WITH CROSSED ELECTRIC AND MAGNETIC FIELDS

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Claims priority, application France March 18, 1953

9 Claims. (Cl. 332-13)

The present invention relates to well-known amplifier, oscillator or multiplier ultra-high frequency tubes, in which an electron beam propagates at right angles with an electric and a magnetic field, the latter fields being perpendicular to each other. The electric field is established between two electrodes which are approximately parallel to the beam, the positive electrode, or anode, being in the form of a delay line. The two fields are so adjusted that the beam-velocity is equal to the phase velocity of a space harmonic of an ultra-high frequency wave propagating along the delay line.

When pulse-modulating the output delivered by such tubes, it would seem simplest to apply the modulating pulses to the negative one of said two electrodes, so that the electric field should prevail between the electrodes for the duration of these pulses only. However, given a constant value of the magnetic field, this type of tube will work properly for one value only of the electric field. It is therefore necessary that the pulses be as perfectly rectangular in shape as possible. Now, as is well known, power demand for raising pulse amplitude until crest value is attained, increases with the gradient of the pulse flanks. This increases the cost of the pulse modulating equipment.

It is an object of the present invention to provide a new embodiment of the above-mentioned tube, particularly suitable for pulse modulation.

It is another object of the invention to provide an assembly for pulse modulating the tube according to the invention.

According to the invention, an auxiliary electrode is provided in the tube, this electrode being separated from the anode and located opposite the cathode; this electrode is connected to said cathode, being brought thereby to potential thereof, or a biasing voltage is applied thereto, bringing it to an even higher negative potential than the cathode with respect to the anode, while modulating voltage is applied between the cathode and the auxiliary electrode to bring the latter, for the duration of the modulating pulses, to a potential approximating anode potential.

According to another embodiment of the invention, a grid is provided between the auxiliary electrode and the cathode, this grid being brought, for the duration of the modulating pulses, to a potential intermediate between auxiliary electrode and cathode potentials.

The invention will be best understood from the following description and the appended drawing wherein,

Fig. 1 shows a longitudinal section of an amplifier tube according to the invention;

Fig. 2 shows very diagrammatically an end view of the tube shown in Fig. 1;

Figs. 3 to 7 show various embodiments of the electrodes used according to the invention;

Fig. 8 shows an oscillator according to the invention.

Fig. 1 shows schematically a travelling wave amplifier of rectilinear structure, with crossed electric and magnetic fields. The tube comprises a delay line 2 and a parallel negative electrode 4. Line 2 may for example be brought to a potential equal to the potential of the envelope 1, which in the embodiment shown is grounded. Under these conditions, line 2 may also be grounded as shown at 23. An ultra-high frequency source (not shown) is feeding in the usual way an ultra-high frequency wave to the delay line 2 through the input 6 and the amplified energy is collected at the output 15. A cathode 3, which may for example be brought to a potential equal to that

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of electrode 4, is in the embodiment shown carried by the latter electrode, although this arrangement is not essential. The cathode is heated by a filament 5, an extremity of which is connected to the electrode 4. A magnetic field perpendicular to the plane of Figure 1 is provided within the tube, for example by a magnet 22 (Fig. 2).

An auxiliary electrode 7, separated from anode 2, is located opposite the cathode 3. The modulating voltage is supplied by a source 9, through a transformer 8 whose secondary winding is connected between electrodes 7 and 4. Electrode 4 is connected to the negative terminal of a high voltage power supply source 17, whose positive terminal is grounded. Filament 4 is heated by a source 18, through a transformer 19 whose secondary winding is connected between electrode 4 and filament 5.

When the tube is not being modulated, the electrode 7 is at cathode potential, since it is connected to the cathode through the secondary winding of the transformer 8. Whenever the source 9 supplies a pulse, the electrode 7 gains a positive potential, for instance substantially equal to the potential of the anode 2. This results in the cathode being unlocked. It will be noted that the modulating and bias supply circuits are independent of each other.

Any residual current which could subsist during the pulse intervals can be substantially eliminated by giving the electrode 7 such a length that it projects beyond the cathode 3 in the output direction by a certain amount (Fig. 3).

Further it is obvious that the auxiliary electrode does not need to be of the diagrammatic form shown, but may be a part of any suitable electronic optical system, as shown in Fig. 4, where equipotential level lines 21 may be seen.

In order to still decrease the residual current through the tube in the intervals separating the pulses, or when no pulses are fed to the tube, the electrode 7 can be brought to a potential which is more negative than that of cathode 3 with respect to the anode 2, as shown for instance in Fig. 5. According to this figure, the secondary winding of the transformer 8 is separated from the negative electrode by a capacitor 10 whose capacitance is large enough so as not to offer any appreciable impedance to the pulses. Resistor 11, which is in parallel with said secondary winding, is used for loading the modulator and stabilizing it in operation; this resistor of course may be dispensed with. Electrode 7 is brought to a negative voltage with respect to cathode 3, by means of an additional low output source connected to terminals 20.

According to another feature of the invention, the tube may be provided (Fig. 7) with a grid between the cathode 3 and the auxiliary electrode 7. The grid is brought to a potential intermediate between the potentials of these two electrodes and preferably corresponding to the equipotential level prevailing in the place occupied by the grid. Moreover, the grid should be of such a shape as to cause minimum disturbance of the equipotential levels. The grid which is shown in plan view in Fig. 6, consists of a block 12 supporting parallel rods 13 pointing in the direction of the beam. Such a grid is easily cooled and easily adaptable to the tube. In the example shown (Fig. 7), it is connected to a suitable tap on the secondary winding of the transformer 8, so that modulation takes place both on the grid 12 and the electrode 7. Furthermore, as an alternative to Figure 7, the grid could be brought to a more negative potential than the cathode D. C. potential.

Figure 8 shows the invention as embodied in the oscillator tube, described in the copending application, Serial Number 281,347, filed on April 9, 1942, and known as "Carcinotron," this word being a registered trade-mark. This tube differs from that shown in Figure 1 in that energy is collected at an output 6 arranged at the end of the line 2 which is nearest to the gun 3. At the other end of the line there is arranged an attenuator 16 which absorbs the spatial components of the ultra-high frequency wave which are propagating in the same direction as the beam. In the embodiment of Fig. 8, cathode 4' is separated from electrode 4''. Pulse modulation is applied between the cathode 4' and the auxiliary electrode 7 as in the case of Figure 4. The electrode 4'' is brought

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to a more negative potential than the cathode. In the example shown, an A. C. voltage, supplied by a source 14 through a transformer, is superimposed to the D. C. voltage applied between the delay line 2 and the electrode 4". As a result, the pulse-modulated oscillating energy provided by the tube is also frequency-modulated, since it is known that in this type of oscillators, frequency is dependent on the potential difference between the delay line 2 and the electrode 4". Any other means could of course be used for the purpose of frequency modulation: for instance the output of the source which feeds the terminals 17 could be varied.

What I claim is:

1. A travelling wave tube of the type including an anode in the form of a delay line, a negative electrode substantially parallel thereto, means for propagating an ultra-high frequency wave along said delay line, whereby an electric field is provided between said two electrodes, means for providing within said tube a magnetic field normal to said electric field, and a cathode for propagating an electron beam normally to both said fields, said tube comprising: an auxiliary electrode located substantially in front of said cathode and in prolongation of said anode; energized connections for negatively biasing said auxiliary electrode, whereby said cathode is normally blocked; and connections for applying modulating pulses, provided by a modulating source, between said auxiliary electrode and said cathode with positive potential of said pulses applied to said auxiliary electrode for causing said cathode to emit during each of said pulses.

2. A travelling wave tube of the type including an anode in the form of a delay line, a negative electrode substantially parallel thereto, means for propagating an ultra-high frequency wave along said delay line, whereby an electric field is provided between said two electrodes, means for providing within said tube a magnetic field normal to said electric field, and a cathode for propagating an electron beam normally to both said fields, said tube comprising: an auxiliary electrode located substantially in front of said cathode and in prolongation of said anode; energized connections for normally bringing said auxiliary electrode to the same negative potential as said cathode; and connections for applying modulating pulses, provided by a modulating source, between said auxiliary electrode and said cathode for causing said cathode to emit during each of said pulses.

3. A travelling wave tube of the type including an anode in the form of a delay line, a negative electrode substantially parallel thereto, means for propagating an ultra-high frequency wave along said delay line, whereby an electric field is provided between said two electrodes, means for providing within said tube a magnetic field normal to said electric field, and a cathode for propagating an electron beam normally to both said fields, said tube comprising: an auxiliary electrode located substantially in front of said cathode and in prolongation of said anode; energized connections for bringing said auxiliary electrode to a potential which is negative with respect to said cathode; and connections for applying modulating pulses, provided by a modulating source, between said auxiliary electrode and said cathode for causing said cathode to emit during each of said pulses.

4. A tube according to claim 3 further comprising a grid located between said cathode and said auxiliary

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electrode and a connection for bringing said grid, when modulating pulses are provided, to a potential intermediate between the respective potentials of said auxiliary grid and said cathode.

5. A tube according to claim 4 wherein said grid is constituted by a solid body having fingers extending in the direction of said anode.

6. A tube according to claim 1 wherein said auxiliary electrode is extending beyond said cathode in the direction of the anode.

7. In combination: a travelling wave tube, of the type including an anode in the form of a delay line, a negative electrode substantially parallel thereto, means for propagating an ultra-high frequency wave along said delay line, whereby an electric field is provided between said two electrodes, means for providing within said tube a magnetic field normal to said electric field, and a cathode for propagating an electron beam normally to both said fields, said tube further comprising an auxiliary electrode located substantially in front of said cathode and in prolongation of said anode; means for negatively biasing said auxiliary electrode whereby said cathode is normally blocked; and means for applying modulating pulses between said auxiliary electrode and said cathode for causing said cathode to emit during each of said pulses.

8. In combination: a travelling wave tube, of the type including an anode in the form of a delay line, a negative electrode substantially parallel thereto, means for propagating an ultra-high frequency wave along said delay line whereby an electric field is provided between said two electrodes, means for providing within said tube a magnetic field normal to said electric field, and a cathode for propagating an electron beam normally to both said fields, said tube further comprising an auxiliary electrode located substantially in front of said cathode and in prolongation of said anode; a source of direct current potential for negatively biasing said auxiliary electrode whereby said cathode is normally blocked; and a source of modulating pulses, applied between said cathode and said auxiliary electrode, for causing said cathode to emit during each of said pulses.

9. In combination: a travelling wave tube of the type including an anode in the form of a delay line, a negative electrode substantially parallel thereto, means for propagating an ultra-high frequency wave along said delay line, whereby an electric field is provided between said two electrodes, means for providing within said tube a magnetic field normal to said electric field, and a cathode for propagating an electron beam normally to both said fields, said cathode being electrically separated from said negative electrode, an auxiliary electrode located substantially in front of said cathode and in prolongation of said anode; energized connections for negatively biasing said auxiliary electrode whereby said cathode is normally blocked; connections for applying modulating pulses, provided by a modulating source, between said auxiliary electrode and said cathode for causing said cathode to emit during each of said pulses, and means for varying the direct current potential between said negative electrode and said delay line for frequency modulating the pulse modulated output energy of the tube.

No references cited.