# United States Patent [19]

**Guenard et al.**

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[54] **TRAVELLING WAVE TUBES**

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[73] Assignee: **Thomson-CSF**

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[51] **Int. Cl.** ..........................................**H03c 1/28**

[58] **Field of Search** ..........332/5, 13, 25, 58; 331/82; 315/3.5, 39.51, 39.53

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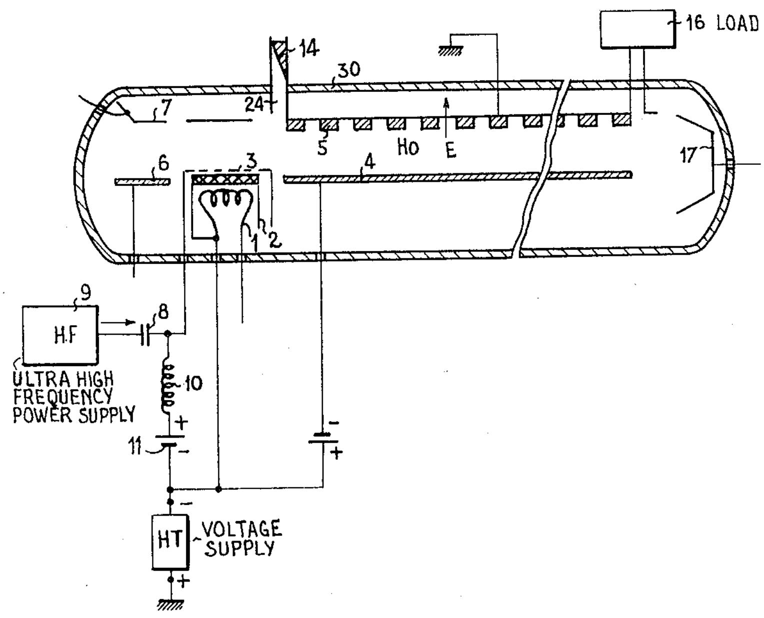
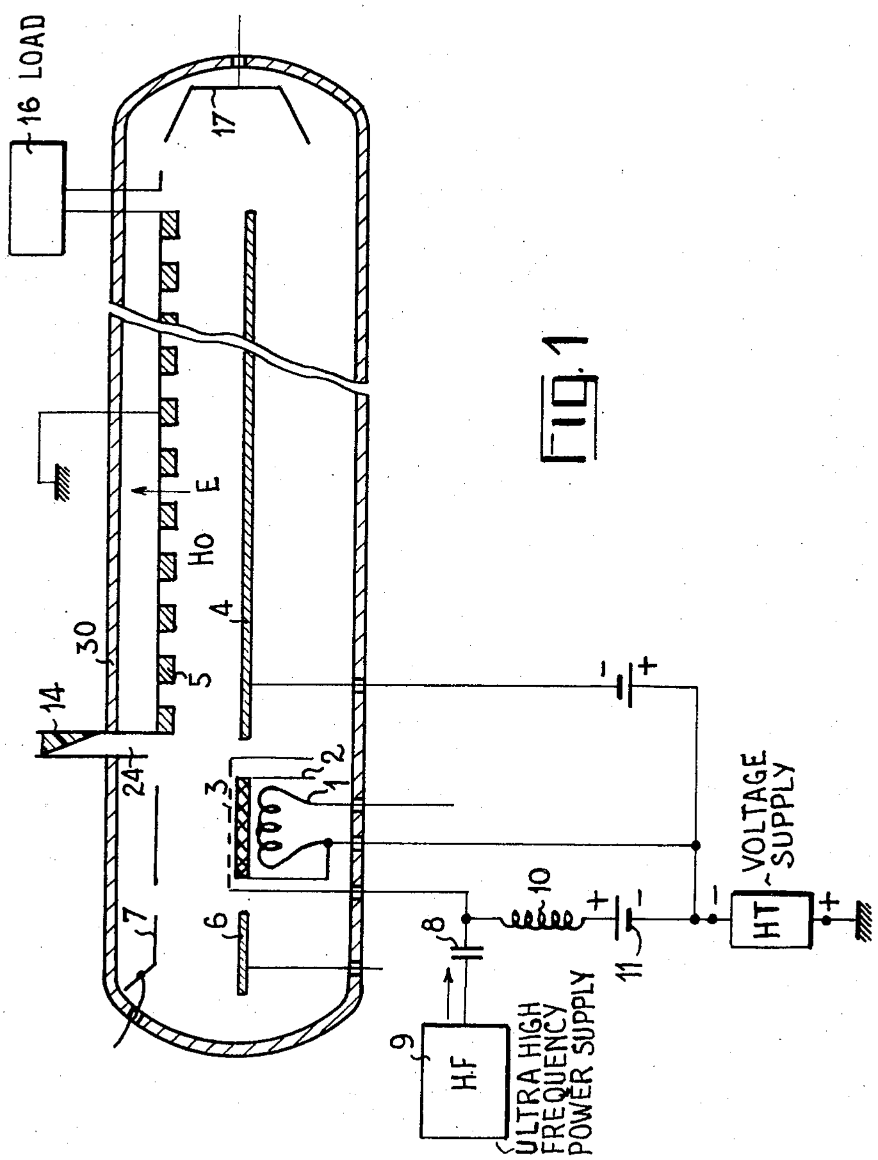
[57] **ABSTRACT**

An improvement in piloted amplifier or locked-oscillator travelling wave tubes of the "M" type, said improvement consisting in a high frequency device for directly modulating the beam in density at the cathode by a grid, this device, in a preferred embodiment of the invention, being constituted by coaxial waveguide of T - form, one of the branches of the T being terminated on the one hand by the cathode supported by the internal conductor of the coaxial section, and on the other hand by a grid supported by the external conductor, and the high frequency signal for modulating the beam being injected into said coaxial waveguide, and having a maximum amplitude in the neighborhood of the cathode.

**7 Claims, 2 Drawing Figures**




16 LOAD
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ULTRA HIGH FREQUENCY POWER SUPPLY
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VOLTAGE SUPPLY

FIG. 1

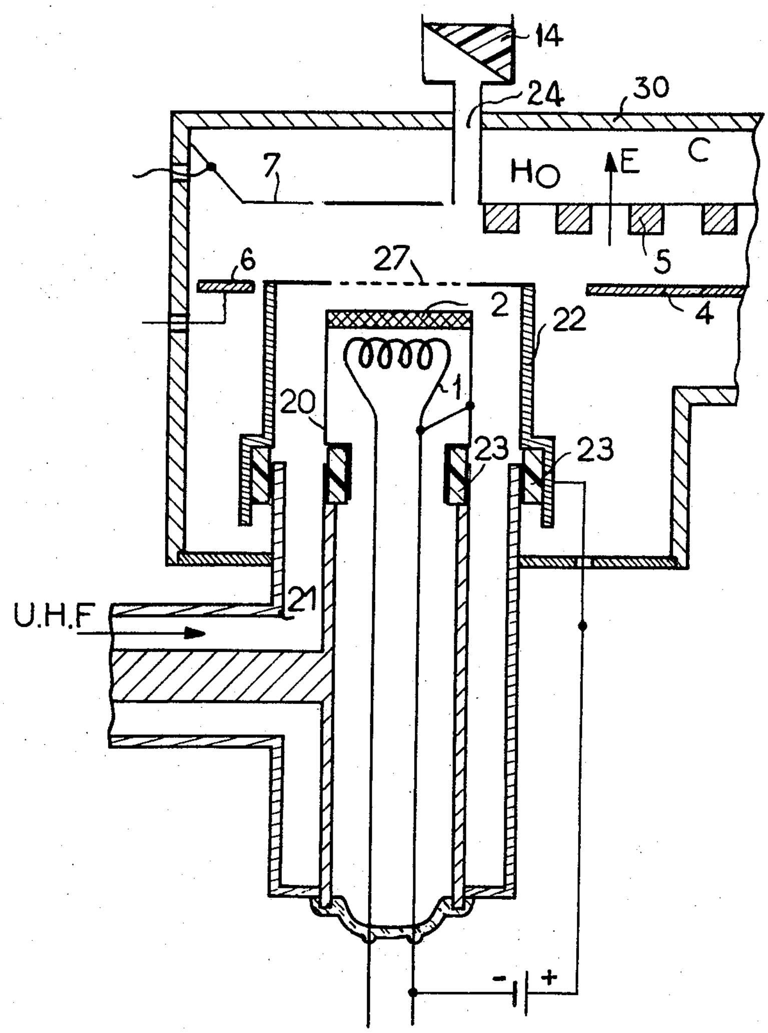


Fig. 2

## TRAVELLING WAVE TUBES

The present invention relates to travelling wave tubes, for ultra-high frequency, with crossed electric and magnetic fields, so-called "M" type tubes.

As is well known, an "M" type tube is a travelling wave tube (direct or backward) comprising, in addition to the elements present in other travelling wave tubes, an electrode, known as sole, and means for providing a magnetic field, perpendicular to the electric field prevailing between the delay line of the tube and this sole and to the direction of propagation of the wave and of the electron beam, in the space bounded by the delay line and the sole.

Furthermore, these tubes generally comprise microwave input and output, connected to the delay line at its ends.

There are numerous devices of such types, among which are to be cited, by way of example, travelling wave amplifiers, or "M" type TWT, and phase locked oscillators, such as the well-known "Carpitron" (Registered trade mark) operating on backward mode.

"M" travelling wave tubes, which are capable of very high performances, have up to now given rise to numerous studies and developments. However, with tubes, there is a well known drawback, namely a high noise level, due to the instability of the beam space charge in the space defined between the cathode and the beginning of the delay line, that is to say in the electron gun, wherein instability is attributed to the so called "Diocotron effect ". This "Diocotron effect" is an amplification mechanism which occurs in the body of the beam. Whatever may be the external circuits, even in the absence of any external circuit, when a magnetic field is applied in a direction perpendicular to the beam path, it amplifies every modulation component present in the beam, including the noise component normally associated with electron emission. This therefore necessitates the use of a high level input signal, so that the gain is very much reduced.

It is an object of this invention to overcome this drawback. This is achieved by carrying out density modulation of the electron beam at the cathode, using for that purpose the signal itself which is to be amplified, or the pilot signal itself, i.e., the ultra-high frequency signal involved in the operation of the tube.

Another outstanding feature of the present invention wherein, excellent results have been achieved by the applicants. For example on tubes in which the high frequency signal is applied only to the modulator device at the cathode, typically by a modulating grid, and nowhere else in the tube encouraging, results were realized relating to the low input power needed, and the low level of noise brought by the beam.

It is to be noted that the density modulation above referred to, has nothing in common with the usual modulation. Generally either in pulsed or in continuous operation, at very low frequencies, are applied to the electron beam of all kinds of electronic tubes, by means of a grid located in the vicinity of the cathode from which the electron beam emerges. For example triodes of the known art, operating at a wave length outside the microwave range, that is to say higher than 40 to 50 cm, among the devices, provided with periodic delay circuits to pick up the energy from the electrons of the beam.



In the triodes of this latter type there is also prevailing along the path of the electron beam a magnetic field; but the latter, as generally is substantially colinear to the electric field for focussing purpose. The magnetic field of the "M" type travelling wave tubes on the other hand is perpendicular to the electric field present along the same path, the role of which is fundamental in the energy transfer process through the tube.

In other words, the tubes with which the present invention is concerned substantially differ from all the tubes of the prior art, and even from those involving periodic structures.

A possible explanation of the results, at first sight surprising, obtained with the tubes modified in accordance with the present invention may essentially be due to the three following reasons:

a. The noise-reduction action of a grid located close to an emitting cathode is already known in the case of DC biased grids by respect of the cathode itself, even when this bias is zero, but is totally unsufficient to explain the results observed.

b. The low noise voltage level of the beam near the cathode, at the place where is injected the input useful signal. In fact, unlike what happens in the devices of the prior art, the ultra-high frequency signal is injected at high level in comparison with the cathode noise level, in a zone of the "M" type travelling tube where the Diocotron effect and the characteristic amplification of said noise is still low.

The signal-to-noise ratio resulting from this type of injection, with a noise already reduced by the first described noise reduction, thus exhibits an outstanding improvement.

c. The "diocotron effect," occurs in the remaining space of the electron gun extending between the grid and the beginning of the periodic delay structure of the tube. In this zone, the Diocotron effect appears in the beam, as already explained, achieving an amplification of the injected signal together with the noise signal. It is to be noted that there is no change, during this amplification, in the signal-to-noise ratio. The only and other outstanding result is the reduction in the input power needed to operate the tube at the rated output characteristics, this reduction due to the "Diocotron" gain.

According to the invention, there is provided an M-type microwave tube including a cathode, means for modulating the electron beam at the output of said cathode, and ultra-high frequency input means for feeding modulating ultra-high frequency energy to said modulating means.

The invention will be better understood from a consideration of the ensuing description and the accompanying drawings in which :

FIGS. 1 and 2 schematically illustrate, in partial section, two embodiments of a microwave tube in accordance with the invention, given in the case of an amplifier.

In these two figures, similar elements are marked with the same references.

The embodiment illustrated in FIG. 1 relates to a linear "M" type tube. It comprises an evacuated enclosure defined by an envelope 30 , an indirectly heated cathode 2 with a filament 1, a modulating grid 3 , a delay line 5 for example of the "vane" type, a sole 4 , a beam focussing electrode 6 and an electrode 7 for magnetically screening the beam. A magnetic field, not shown, is applied on the tube perpendicularly to the figure plane.

This tube differs from a conventional "M" type travelling wave amplifier tube equipped with a conventional current control electrode, in terms of the following features:

the input of the device for density modulating the beam (schematically illustrated by a wire in FIG. 1), is a microwave input;

the delay line terminates, at the electron gun end, in a matched load, in order to avoid any internal reflections, but has no localized absorbing attenuation or sever.

The matched load **14** which is here shown outside the envelope **30**, can equally well be located inside the evacuated enclosure. It may be of any conventional kind, a carbon charge, a water wedge, or, if it is inside the tube, an absorbing deposit at the end of the delay line which is located near the electron gun.

In the case of a matched load which is located outside the tube, the connection between the delay line and the load should be made extremely carefully in order to prevent any reflection phenomena; all the line has a uniform structure up to the high frequency output.

The operation of the tube will be explained by means of FIG. 1 in which it is simply the tube input connection arrangement which has been shown, the other supply arrangements being conventional. The base **4** carries a negative potential with respect to the cathode, while the delay line is earthed along with the positive terminal of the high-voltage source, the negative terminal of the source being taken to the cathode. The grid **3** is at a potential equal to or close to that of the cathode, thanks to an auxiliary voltage supply **11**. A choke **10** can be arranged in the circuit.

The microwave signal to the amplifier is produced by a microwave source, for example an oscillator **9**. The signal is applied to the grid **3** by means of a capacitor **8** which isolates the oscillator **9** from the high voltage applied to the grid **3**. At the cathode, the microwave input signal, the amplitude of which exceeds largely that of the parasitic signals or noise components present in the beam, modulates said beam in density. Then, this microwave signal experiences very substantial gain along the beam in the space defined between the grid and the delay line, this amplification, in accordance with the hypothesis set out hereinbefore being due to the Diocotron effect.

The beam subsequently induces its power into the delay line which supplies it to the useful load **16** in the same way as in a conventional "M" type travelling wave tube. A collector **17** finally picks up the beam.

The improvement in accordance with the invention, besides its features of gain and signal-to-noise ratio improvements has other advantages, namely:

suppression of localized attenuation or sever usually needed in conventional M-type amplifier tubes, with consequently a substantial reduction in the length of the delay line by the length of the localized attenuation arrangement, and by the necessary length of the line section preceding this attenuation, and finally a substantial reduction of the overall size of the tube;

excellent decoupling between tube low level input and power output.

Experiments on an improved "M" type travelling wave tube in accordance with the invention, have shown an improvement in gain of better than 10 decibels compared with the results obtained with the conventional "M" type travelling wave tube, this under the same voltage and current conditions, and have also indicated a very substantial reduction, of better than 10 decibels, in the noise component.

In FIG. 2, a variant embodiment of the improved "M" type travelling wave tube in accordance with the invention, is shown. In this variant embodiment, the device for density modulating the beam at the cathode, comprises a coaxial section **21** into which the high frequency signal is injected. Its end forms a T which is terminated on the one hand in a cathode **2**, the latter being carried by the internal conductor **20** of the coaxial section, and on the other hand in a grid **27** which is carried by the external conductor **22** of the coaxial section, a space separating grid and cathode; the length of the coaxial section is selected so that the microwave signal modulating the beam has a maximum amplitude at the cathode. U.H.F. traps **23** of $\lambda/4$ type ($\lambda$ being the wavelength of the high frequency signal modulating the beam), isolate the high voltage on cathode **2** and grid **27**, from the rest of the coaxial section.

Self-evidently, the invention is not limited to the embodiments described and illustrated here.

It will be observed in particular that it is possible to still further reduce the tube noise level and to improve the efficiency and bandwidth, by simultaneously injecting a microwave signal into a grid such as the grid **3** of FIG. 1, or into a coaxial section such as the coaxial section **21** of FIG. 2, and the input **24** of the delay line encountered in a conventional "M" type travelling wave tube. In this case, it is necessary to take careful precautions to ensure that the two modulating signals are in phase. However, decoupling between the high frequency input and output of the delay line is necessary, thus necessitating a sever or a localized attenuation.

On the other hand, the circuit in accordance with the invention is applicable to an oscillator circuit utilizing a "locked" "M" type tube of the backward-wave kind. In this case, the tube differs from a "Carpitron" equipped with a device for low-frequency modulation of the beam at the cathode, in that the input of the modulation device will be a microwave input, and in that at the collector end, the delay line is terminated not by the usual absorbing zone of limited attenuation of a Carpitron, which eliminates only partially the reflections at the end of the line, but by a matched load.

What is claimed is:

1. A traveling wave tube of the M-type including: a delay line, an electrode substantially parallel thereto and raised to a potential which is negative relative to the potential of the delay line whereby an electric field is provided between the delay line and the electrode, means for providing within said tube a magnetic field normal to the electric field, and a cathode for propagating an electron beam normal to both of the fields, said tube further comprising: means for modulating the electron beam being located at the immediate vicinity of the cathode and being energized both by a negative biasing potential and ultra-high frequency energy which is the energy to be propagated along the delay line.

2. The traveling wave tube of the M-type according to claim 1 wherein said modulating means comprises an ultra-high frequency input means for said tube.

3. The traveling wave tube of the M-type according to claim 2 comprising: further ultra-high frequency input means for feeding ultra-high frequency energy to the delay line.

4. The traveling wave tube of the M-type according to claim 3 wherein said ultra-high frequency input means and said further ultra-high frequency input are fed by a common ultra-high frequency source.

5. The traveling wave tube of the M-type according to claim 1, comprising: means for collecting ultra-high frequency energy at an end of said delay line which is remote from said cathode, and matched absorbing means coupled to the other one of said ends.

6. The traveling wave tube of the M-type according to claim 1, comprising: means for collecting ultra-high frequency energy at an end, of said delay line which is near said cathode, and matched absorbing means coupled to the other one of said ends.

7. The traveling wave tube of the M-type according to claim 1, wherein said means for modulating the electron beam at the cathode comprises a coaxial guide, one end thereof terminated by the cathode, supported by an internal conductor of the coaxial section separated from the cathode by a selected space terminating the other end thereof; and a grid supported by an external conductor of the coaxial section.

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