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[54] **TRAVELLING WAVE TUBE**

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[58] **Field of Search** 315/3.6, 39.3

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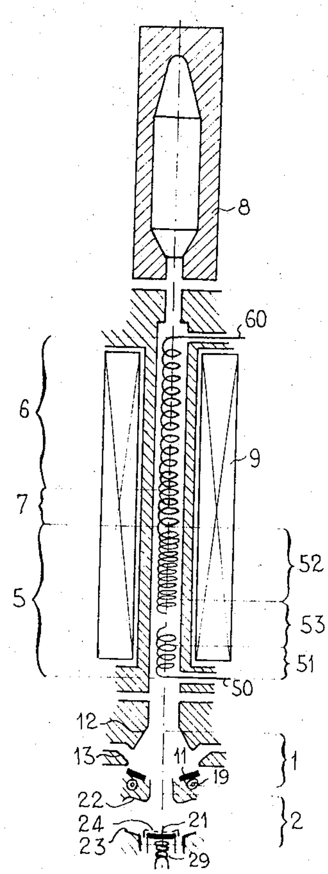
[57] **ABSTRACT**

A travelling wave tube for two operating conditions: continuous low-level operation and pulsed high-level operation.

This travelling wave tube comprises a double electron-gun 1 and 2 and a double HF structure 5 and 6 with a transition 7. Across the double delay line thus constituted, there is coaxially injected a double electron-beam, one cylindrical the other tubular, this under conditions which satisfy the generation of the two aforesaid operating conditions.

Tubes of this kind have a particulary significant application in countermeasure or transmission systems of multipurpose radars.

4 Claims, 2 Drawing Figures



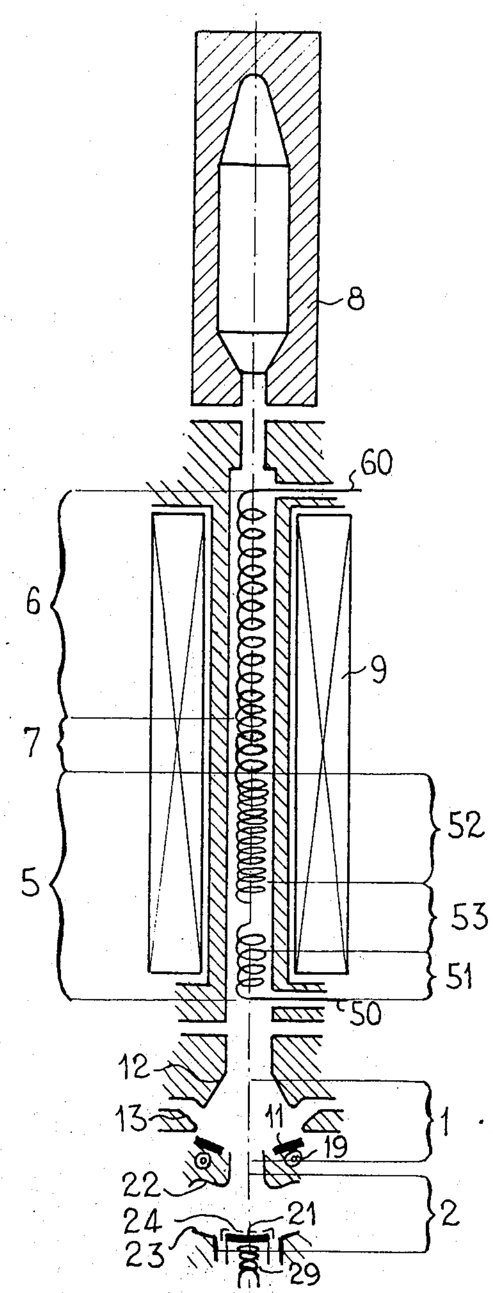


FIG. 1

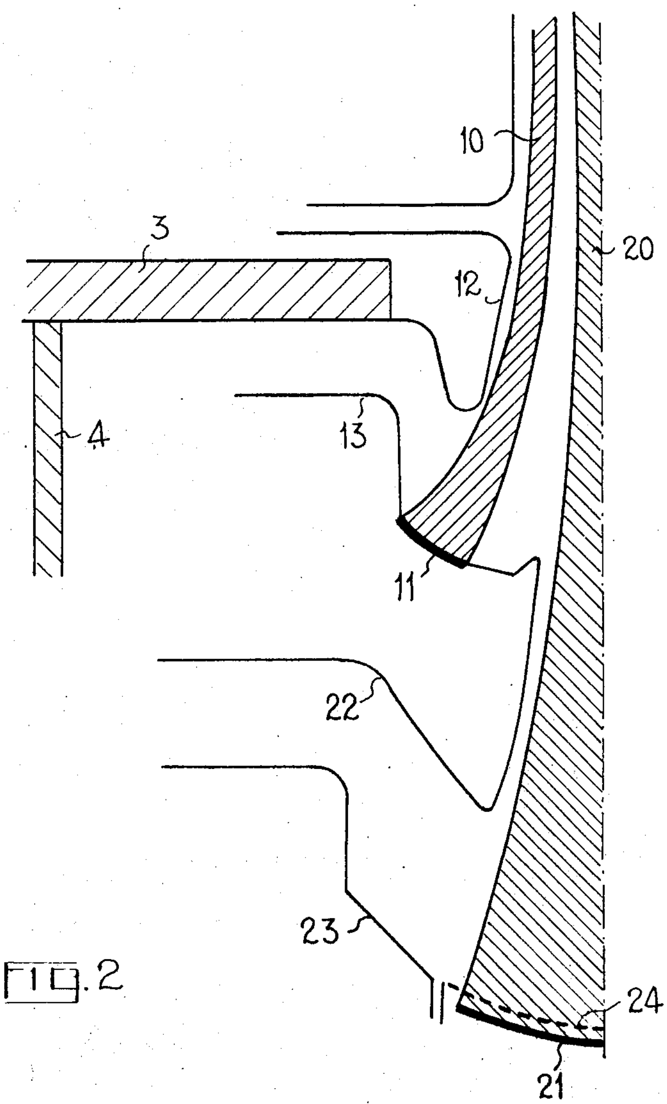


FIG. 2

TRAVELLING WAVE TUBE

The present invention relates to travelling wave tubes.

Those skilled in the art will appreciate that a travelling wave tube is an electron-beam tube comprising a delay line, in which tube an electron beam yields up energy to an electromagnetic wave injected at the tube input and whose velocity of propagation is very close to that of the electrons in the beam, said delay line being constituted by a linear network, of periodic structure, of cells or elements of various types, i.e., cavities, resonant or non-resonant slots, sections of line of more or less complex form, the simplest of which are helices, lines with interleaved elements known as interdigital lines, etc., etc.

The mode of operation of tubes of this kind is well known per se and can comprise either continuous operation or pulsed operation, in either case at different levels of excitation, that is to say at different levels on the part of the wave injected at the tube input.

The present invention relates more particularly to travelling wave tubes for dual-mode operation: low-power continuous lower-power mode and a pulsed higher power mode, this with the best possible efficiency in the two modes.

The prior art travelling wave tubes, which only employ one delay line and one beam, can only be made to satisfy this latter condition with some difficulty, since the transition from one mode to the other is generally achieved, in tubes of this kind, by varying the beam current, and since under these circumstances, it is difficult to optimise the efficiency for the two aforestated modes of operation. This kind of condition is, of course, even more difficult to satisfy if it is required to effect an instantaneous transfer from one power level to the other.

The travelling wave tube forming the subject of the invention enables all these conditions to be satisfied and achieves a variation of at least 10 dB between the selected two operating levels.

This is made possible by the fact that in the tube in accordance with the invention, there are two delay lines and two electron beams each of which latter can only interact with one of the lines. In a first mode of operation, at low level, only one of the beams is used, whilst in the second mode of operation, at high level, both beams are operating simultaneously, this under conditions which will be specified hereinafter.

This travelling wave tube comprises, between a double-electron source and a collector, a double HF structure: two separate electron beams on the same axis, the first, a tubular one, surrounding the second, a cylindrical one, and both beams being concentrically emitted by two separate electron-guns respectively constituted by a cathode of ring form, and an anode, and by a cathode of spherical cap form and another anode, the voltages of the two beams differing from one another in that the accelerating voltage of the tubular beam is lower than that of the cylindrical beam, and the double HF structure being constituted by a first delay line with a high delay factor and a second delay line with a lower delay factor and associated with the first through the medium of a variable-delay junction.

The present invention relates to a travelling wave tube for amplifying an HF wave, characterized in that it comprises:

- an electron source designed to produce either a first electron beam or simultaneously both said first electron beam and a second beam propagating in the same direction as the first but having a different propagation velocity and a higher energy;
- a first delay line receiving the HF wave for amplification and capable of interacting with said first beam;
- a second delay line located after the first, considered in the direction of propagation of the beams, and connected to said first line through a matching delay line, said second line being capable of interacting with the second electron beam
- an output coupled to said second line and producing the amplified HF wave either by interaction between the first beam and the first line or by said latter interaction plus interaction between the second beam and the second line.

The invention will be better understood in terms of its characteristics and advantages, from the following detailed description of an embodiment proposed by way of non-limitative example and with reference to the attached drawing:

FIG. 1 illustrates the assembly of a travelling wave tube in accordance with the invention;

FIG. 2 illustrates a detailed view, in longitudinal half-section, of the optical arrangement of the double electron-gun fitted to the tube.

In FIG. 1 there have been schematically illustrated:

- the first electron-gun **1**, with a cathode **11** of circular ring-form, an anode **12** and, between the two, a modulating electrode **13**;
- the second electron-gun **2**, on the same axis as the first, with a cathode **21** of disc-form, an anode **22** and a modulating electrode **23**, there being arranged in front of the cathode **21**, parallel thereto, a blocking grid **24**.

The cathodes **11** and **21**, viewed from the body of the tube, have a concave form which is determined by the geometry of the assembly, and the anodes **12** and **22**, solids of revolution, have profiles which are matched to the curvatures of the generatrices of the electron beams **10** and **20** respectively emitted by the cathodes **11** and **21**, the assembly having been built up by some conventional method or other of the kind employed to define the optical characteristics of the electron-guns in all travelling wave tubes, which methods are known per se and therefore require no explanation here.

The cathodes **11** and **21**, which may in particular be oxide cathodes, are raised to their optimum operating temperature by heater filaments **19** and **29** having shapes matched to said cathodes.

The anode **12** of the electron-gun **1**, which is insulated from the other electrodes, makes it possible to regulate the current carried by the beam from said gun. The modulating electrode **13** of the electron-gun **1** is so designed that its internal profile forms an extension of that of the anode **22** of the electron-gun **2**. The cathode **11**, the modulating electrode **13** of the electron-gun **1**, and the anode **22** of the electron-gun **2**, are electrically interconnected.

Proper focussing of the tubular electron beam on its own, on the one hand, and of this tubular beam and the cylindrical beam together, on the other hand, is ensured, as shown in FIG. **2**, by appropriate positioning in relation to the electron-guns **1** and **2,** of a polepiece **3** and a magnetic screen **4.**

The HF structure comprises the two delay lines **5** and **6** which are associated to a junction **7.** The first delay line **5,** by way of example and as shown in the drawing (although this choice in no way implies any limitation) comprises a helix **51** connected to the input **50** of the tube, and a helix **52** connected to the output **60** of the tube, the two helices being separated by a break **53** designed to limit the risk of oscillation due to reflection. The second delay line **6,** as already stated, has a lower delay factor than the first line **5.** It goes without saying that configurations of all kinds other than those given to the helices shown here can be given to these delay lines, so that for example they can take the form of cavity structures, slotted, fingered, laddered interdigital lines, etc. etc.

The gun assembly **1** and **2** and HF structure **5, 6** and **7,** supplemented by a collector **8** on the same axis, are arranged in an evacuated envelope which, in the manner uniformly adopted in travelling wave tubes, has a diameter, at the portion surrounding the delay lines **5** and **6,** which is less than that of the portion located opposite the electron-guns **1** and **2**: this enables accurate focussing of the assembly of the two beams to be achieved by means of a magnetic field generated by an electromagnet line arranged over the whole length of the aforementioned part of the envelope.

The mode of operation of the travelling wave tube in accordance with the invention is as follows:

In normal operation, there is applied to the cathode **11** of the electron-gun **1** a voltage which is negative in relation to the anode **12** and to the delay line **5,** so that the velocity of the electrons in the tubular beam is equal to the phase velocity of the HF wave propagating along the delay line **5.** The second delay line **6,** which has a lower delay factor, is thus entirely passive; it simply transfers the amplified wave to the output **60** of the tube.

On transition to the second possible mode of operation of the tube, a voltage which is negative in relation to the anode **22** of the electron-gun **2** is likewise applied to the cathode **21** of the electron-gun, the delay line **6** being electrically connected to the anode **22.** In this mode of operation, the voltage applied between the cathode **21** and the anode **22** is regulated in order to impart to the solid beam issuing from the cathode **21** a velocity which is substantially equal to the phase velocity of the HF wave propagating along the delay line **6.**

The first mode of operation described occurs in continuous working, whilst the second occurs in pulsed working, this thanks to the provision of the grid **24** which, by a suitable selection of the voltage applied to it in relation to the cathode **21,** makes it possible to interrupt the emission of electrons from said cathode. In addition, the voltage applied between the cathode **21** and the anode **22** of the solid beam, on the one hand, and the intensity of this beam, on the other, are made substantially greater than those of the annular beam employed in the second mode of operation.

The wave amplified by the delay line **6,** in the second mode of operation, thus has a substantially higher level than the wave amplified by the delay line **5** in the first mode of operation, because of the energy level of the electron beam employed in said latter mode of operation and the cascade amplification resulting from the successive transfer of the beam through the interior of two delay lines **5** and **6.**

It should be noted that under these conditions, the line **6** should have a lower delay factor than the line **5,** the delay factor of the delay line interacting with a beam in a travelling wave tube having, as those skilled in the art will appreciate, to be the lower, other things being equal, the higher is the acceleration voltage of the interacting beam.

By way of example, the data corresponding to two modes of operation might be as follows:

in continuous operation, for a voltage of — 3,000 volts applied to the cathode **11** of the electron-gun and a current of 300 mA in the beam **10** (FIG. **2**) producing an output power of 200 watts, a gain of 25 dB is obtained;

in pulsed operation, for a voltage of 12,000 volts applied to the cathode **21** and a current of 800 mA in the beam **20,** producing an output power of 2 kW, a gain of 35 dB is obtained.

Consequently, there is a variation in gain on transition from one kind of operation to the other, this variation being $35 - 25 = 10$ dB between the two levels corresponding to the modes of operation hereinbefore referred to.

This kind of operation of travelling wave tubes in accordance with the invention, makes such tubes particularly suitable for use in the transmitter sections of multipurpose radars operating on the doppler principle for example and using continuous emission or pulsed emission, as well as in countermeasure devices in which, in association with a continuous noise emission, there is a high-level pulsed emission serving to produce a variable-delay echo. Thus, the continuous component serves to jam the true echos whilst the pulsed component generates false echos which are thus falsely interpreted by the enemy receivers.

What is claimed is:

1. A travelling wave tube for amplifying an HF wave, characterized in that it comprises:

an electron source, comprising two electron guns, each with its cathode and its anode, designed to produce either a first electron beam or simultaneously both said first electron beam and a second electron beam propagating in the same direction as the first one, but separate from said first one and having an accelerating voltage and an energy higher than said first beam:

a first delay line receiving the HF wave for amplification, said first delay line being located after said electron guns, considered in the direction of propagation of the beams, and being designed for matching the phase velocity of said HF wave with the velocity of said first beam;

a second delay line located after the first one, considered in the direction of propagation of the beams, and connected to said first line through a transition line, said second delay line being designed for matching the phase velocity of said HF wave with the velocity of said second beam;

an output coupled to said second delay line, said output being provided for picking up the amplified HF wave, the latter being produced either by interaction between the first beam and the first line or by said interaction followed by an interaction between the second beam and the second line.

2. A travelling wave tube as claimed in claim **1**, characterized in that the two delay lines and said section are cylindrical helices of conductor wire, located upon the same axis, through the inside of which there pass the said two beams, one of them being a solid cylindrical beam and the other a tubular beam coaxial with the former and with said helices.

3. A travelling wave tube as claimed in claim **2**, characterized in that the beam interacting with the second line is the solid beam.

4. A travelling wave tube as claimed in claim **1**, characterized in that the beam interacting with the second line is pulse-modulated.

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