

Sept. 24, 1957

MASAMICHI KENMOKU

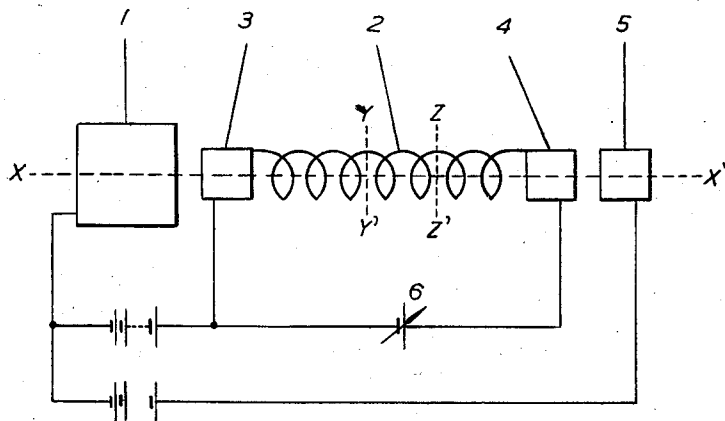
2,807,742

TRAVELING WAVE TUBE

Filed May 27, 1954

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FIG. 1.



Inventor

M. KENMOKU

By Philip M. Bolton

Attorney

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FIG. 2.

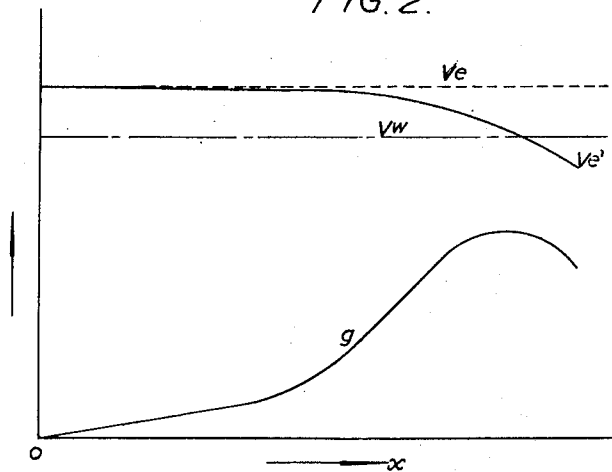
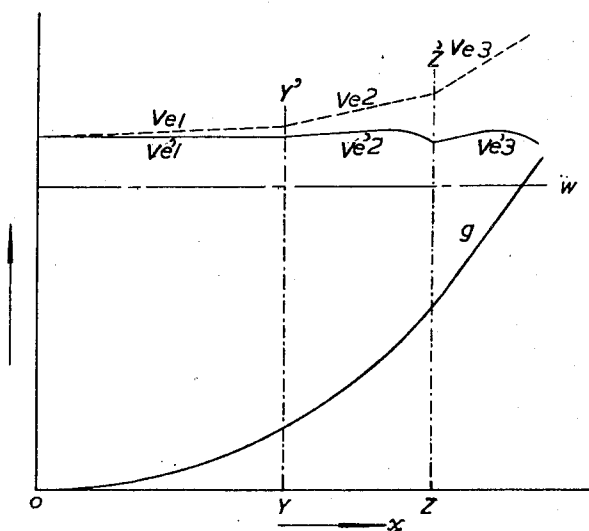


FIG. 3.



Inventor

M. KENMOKU

By *Philip M. Bolton*
Attorney

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TRAVELING WAVE TUBE

Masamichi Kenmoku, Minato-ku, Tokyo, Japan, assignor to International Standard Electric Corporation, New York, N. Y., a corporation of Delaware

Application May 27, 1954, Serial No. 432,763

Claims priority, application Japan June 1, 1953

1 Claim. (Cl. 315—3.5)

This invention relates to traveling wave tubes and particularly to operational systems therefor.

In a traveling wave tube, the helical electrode to be coupled with the electron beam maintains a certain potential as a whole. Consequently, the electron beam having a velocity corresponding to the potential will be decelerated as it gives its kinetic energy to the circuit, with the result that it is difficult for the electron beam velocity always to keep a favorable relationship with the phase velocity of the electromagnetic waves.

An object of the present invention is the provision of a traveling wave tube system or arrangement in which the above-mentioned difficulty is substantially overcome.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood, by reference to the following description of an embodiment of the invention, reference being had to the drawings in which:

Fig. 1 is a schematic diagram of a traveling wave tube arrangement; and

Figs. 2 and 3 are sets of curves illustrating the operation thereof.

According to this invention, as shown in Fig. 1, a D. C. voltage 6 which is to be superposed on the customary helical electrode potential, is applied to the both ends 3 and 4, of the helical electrode. The polarity of said D. C. voltage is effected in such a manner that the end 3 of said electrode 2 on the side of the electron gun 1 is negative with respect to the end 4 on the side of the collector 5, whereby the D. C. voltage in said helical electrode 2 becomes greater the more it approaches towards the collector 5 due to a voltage drop in said helical electrode 2.

By this arrangement, the device tends to increase the velocity of the electron beam as it approaches to the collector. This will adequately compensate for the deceleration in response to the kinetic energy of the electron beam absorbed by the circuit, making it possible for the electron beam velocity to keep a favorable relation with the phase velocity of the wave at all times.

Furthermore, by this invention, since a constant D. C. current flows in the helical electrode, it constitutes an electromagnetic coil generating approximately a uniform magnetic field which, with or without the influence of outside magnetic fields, focuses the electron beam. By either changing the magnitude of the magnetic field, or making its direction the same, or the reverse with respect to the direction of the outside magnetic field, the cross-sectional diameter of the electron beam may be varied, thereby adjusting the degree of coupling between the electron beam and the circuit, simultaneously improving the characteristics of the tube.

Should the axis of the spiral electrode have any deformities, such as eccentricity or bending that are apt to occur during manufacture, the electron beam will be directed along the axis by the current directly flowing in said helical electrode.

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The performance of a traveling wave tube by this invention, compared with that of the customary system is illustrated in Figs. 2 and 3. In Figs. 2 and 3, the distance of the helical electrode from the input end was taken as the abscissa and the velocity of the electron beam as well as the gain or power of the electromagnetic wave as ordinate. In the customary system in which the helical electrode potential is kept constant, the velocity of the beam will remain constant, as indicated by V_e in Fig. 2, provided that the energy of the beam remains as it is. Upon the traveling wave tube being operated, however, the energy of the wave will be increased accompanied by a decrease in the velocity of the beam as shown by v_e' , producing the portion in which values of v_e' are less than that of v_w as illustrated in the same diagram. The gain is expressed by the curve g .

According to the present invention the helical electrode wire is preferably composed of a core made of a material that has a high D. C. resistivity, such as molybdenum or tungsten, the surface of which is covered with a substance that has a low high-frequency loss, such as silver or copper. Considering the operation of the tube, suppose that the total length of the helical electrode is divided into three parts by the line $Y-Y'$ and $Z-Z'$ as illustrated in Fig. 1 and further that either resistances of said parts of the core conductor are made the larger, or the sectional areas are lessened, the closer the part of the electrode approaches to the output end. Then the velocity distribution of the electron beam when the tube is inoperative will be expressed by V_{e1} , V_{e2} , V_{e3} , as shown in Fig. 3. Upon its operation, however, a part of kinetic energy of the beam is transferred to the wave, accompanied by deceleration of its velocity. The corresponding velocity distribution for this case will be expressed by $V_{e'1}$, $V_{e'2}$, each of which show a value larger than the phase velocity v_w of the wave. The gain will be expressed by the curve g in the same figure.

The case has been described in which the helical electrode was divided into three parts by the lines $Y-Y'$ and $Z-Z'$, at the same time different materials or cross-sectional areas were adopted for said three parts. However, a uniform material or the same cross-sectional area may be adopted through the total length of the helical electrode. Said material or the cross-sectional area may also be changed or lessened proportionately along the length. The helical electrode need not necessarily be a wire; any shape may be adopted, for instance, a flat cross section in the direction of the axis. Said cross-section has an advantage of achieving the magnetic effect due to this invention, since it allows a sufficient current to flow therein.

According to this invention, as hereinbefore described, it is possible to increase the velocity of the electron beam, as it approaches to the collector, thereby allowing the electron beam velocity to have a favorable relation with the phase velocity of the wave at all times. Further, a magnetic field developed by a flow of D. C. current in said helical electrode contributes not only to the shaping of the electron beam, but also to easy adjustment of the degree of coupling between the electron beam and the circuit, through change of said D. C. current, thereby improving the characteristics of the traveling wave tube.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claim.

I claim:

In a traveling wave tube having means for producing an electron beam, and an electromagnetic wave transmission path in the form of a helical conductor through

which said beam passes, during which passage the beam gives up energy to the wave traveling on said helix, means for producing a direct current potential gradient along said helix comprising a source of direct current and means for causing the direct current from said source to flow through said helical conductor, said conductor being provided with a core having a relatively high direct current resistivity and a surface having a relatively low high frequency loss.

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