Nov. 24, 1959 R. A. PAANANEN 2,914,700

TRAVELING WAVE TUBES

Filed Feb. 27, 1958

FIG. 1

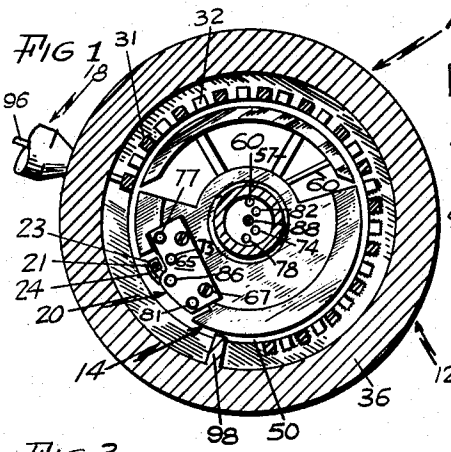


FIG. 2

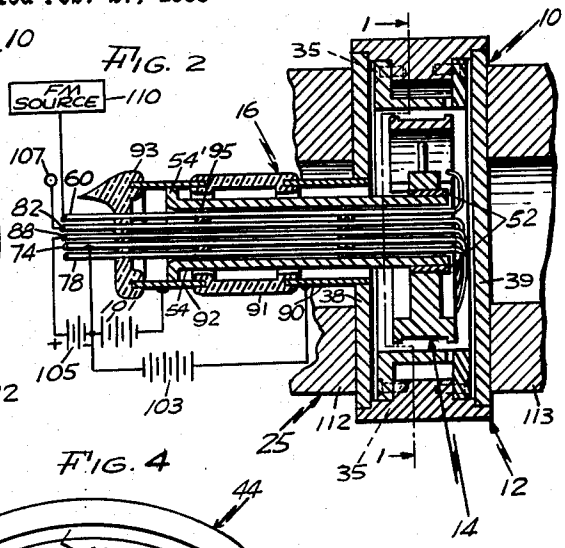


FIG. 3

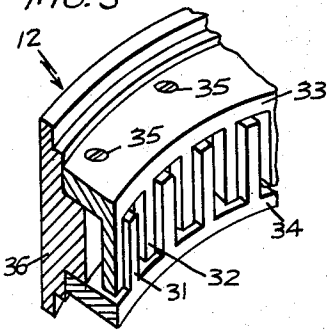


FIG. 4

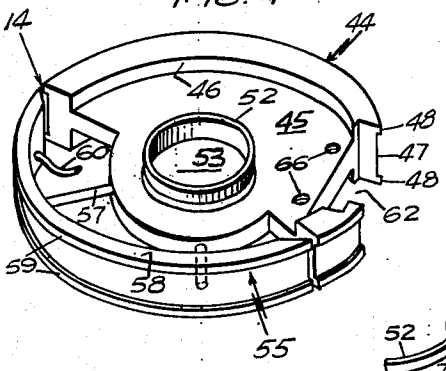


FIG. 5

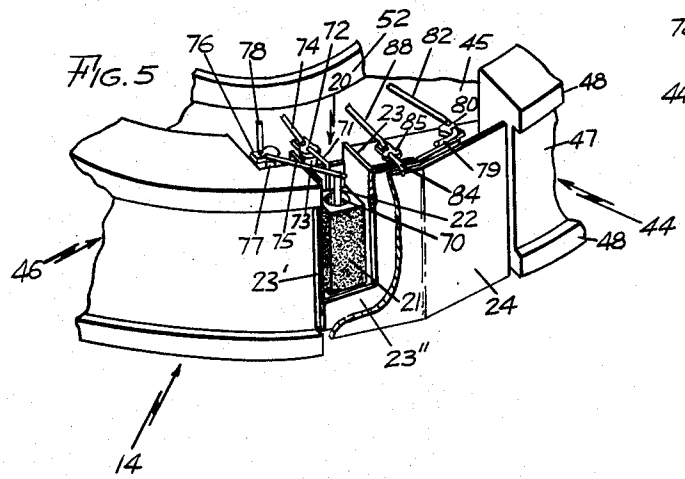
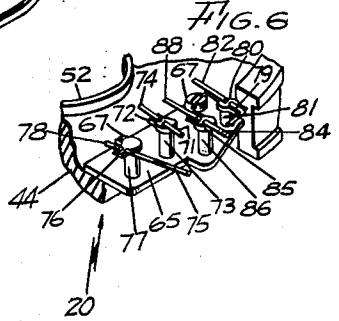


FIG. 6



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TRAVELING WAVE TUBES

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Application February 27, 1958, Serial No. 717,897

18 Claims. (Cl. 315—39.3)

This invention concerns a traveling wave tube, and, more specifically, a modulated traveling wave oscillator having means for minimizing the capacitance between the interaction space-bounding electrodes, thereby reducing the modulator power requirements.

A traveling wave oscillator of the backward wave type is discussed in a copending application for United States Letters Patent of E. C. Dench and A. D. La Rue, Serial No. 562,472, filed January 31, 1956, now U.S. Letters Patent No. 2,888,649, issued May 26, 1959, which includes a nonreentrant slow wave energy propagating structure, a continuous electrode or sole spaced from and disposed substantially parallel to said structure, and an electron gun mounted to said sole adjacent one end of said structure for producing an electron beam which traverses the interaction space bounded by the slow wave structure and the sole.

By virtue of the interaction between the electron beam and the radio-frequency fields of wave energy propagating along said structure, energy is produced by the tube and may be removed therefrom by output coupling means coupled to the delay structure adjacent the end thereof opposite the electron gun.

Electrons may be prevented from traversing the portion of the interaction space between the two ends of the delay structure by means of a collector electrode extending into the interaction space in the region between the electron gun and the output coupling means. Moreover, attenuation may be provided at the end of the slow wave structure opposite the electron gun for reasons already well known to those skilled in the traveling wave tube art. The portion of the tube including the attenuating means and the portion adjacent the electron gun, as well as the portion including the collector electrode, if any, may be referred to as the inactive part of the tube, while the remaining portion of the tube may be referred to as the active part of the tube, viz., the part wherein effective exchange of energy between the electron beam and the R.F. fields of wave energy along the slow wave structure may occur.

The velocity of the backward component of a traveling wave in a periodically loaded microwave slow wave structure, such as a strapped vane structure or an interdigital line, varies with frequency. As the electron beam velocity is varied, substantial synchronism may be obtained with the phase velocity of a backward wave component of the traveling wave, for a given frequency, and oscillations can be generated by the tube. The average velocity of the electron beam is dependent upon the intensity E of the electric field between the slow wave structure and the sole and also upon the strength B of the transverse magnetic field; the average electron beam velocity is equal to the ratio E/B. If the spacing *d* between the anode structure and the sole and the magnetic field strength B are fixed, the average velocity of the electron

beam is dependent only upon the electric field strength E. By varying the strength of the electric field, the beam velocity may be varied, with a resulting variation in frequency of the traveling wave oscillator. If the slow wave structure and sole are supplied by separate sources whose voltages with respect to a common point, such as the cathode, are V_a and V_s, respectively, the electric field E may be given by:

$$E=\frac{\overline{V}_a+\overline{V}_s}{d}$$

The electric field may be altered by varying either the positive delay structure voltage V_a, or the negative electrode (sole) voltage V_s, in order to tune the oscillator. It has been found that a greater tuning range is produced by variation of the voltage V_a than is possible by variation of the sole voltage V_s. Owing to the comparatively heavy current in the anode delay structure relative to that in the sole, however, the power requirements for frequency modulation using anode delay structure voltage tuning are greater than those using sole voltage tuning. If only a small amount of tuning is adequate, tuning may be achieved by varying the potential of the sole or negative electrode. This method of tuning is superior to anode delay structure tuning in that the current may be of a considerably lower order of magnitude. Such tuning, however, is inadequate for applications in which it is desired to modulate the sole potential at high rates, of the order of say 5 to 10 megacycles, since, as will be explained subsequently, the relatively large negative electrode presents considerable capacitance. The sole electrode preferably is made in the form of an arcuate channel having a major surface parallel to the delay structure and vertical walls or flanges at each edge of the sole which approach or slightly overlap the delay structure. The vertical walls serve as a beam-forming end shield to keep the electron beam centered in the system and from diverging in a direction normal to the path of the electrons as a result of mutual repulsion of the electrons in the space charge existing along the length of the tube. The major surface of the sole is spaced relatively close to the delay structure, since the strength of the electric field produced between the delay structure and the sole is inversely proportional to the radial distance therebetween. The spacing between the delay structure and the wall is even smaller in the region of the tips of the vertical walls of the sole. Because of the relatively large size of the sole and its proximity to the anode, the capacitance between the delay line and the sole is quite large. In addition to the capacitance between the juxtaposed peripheries of the sole and the delay structure there is considerable capacitance between the end faces of the sole and the end portions of the delay structure, which may form a part of the tube envelope; this capacitance is comparatively large because of the relatively large exposed surface areas of the sole and the end portions of the delay structure. The large capacitance is of no concern insofar as the unidirectional field-producing means is concerned, but is not permissible for operation at higher frequencies, since the capacitive reactance shunting the modulating voltage source at radio frequencies becomes so low that the power rating of the modulator necessary to produce proper modulation of the electric field over a band of radio frequencies becomes prohibitive.

In accordance with this invention, the capacitance between the delay structure and the sole, across which the modulator is connected, and consequently, the power requirements of the modulator, is substantially reduced by

dividing the sole into two parts, a first of which is substantially coextensive with the inactive section of the delay structure. The second part of the sole, sometimes referred to hereinafter as an auxiliary part, is of greatly reduced volume and total surface area and may, for example, be a thin electrically conductive ring secured to the first part of the sole by electrically insulating supports. The periphery of the second part of the sole forms a continuation of the first part of the sole, so that the arcuate interaction space between the delay structure and the sole is maintained more or less uniform throughout the length of the tube. A uniform interaction space permits of better operation, since there is no discontinuity in the field existing in the interaction space.

The two parts of the sole must be insulated electrically from one another. In order to preserve, as near as possible, a continuous interaction space of uniform width so that the electric field configuration will not be unduly disturbed, and at the same time provide suitable insulation between the two parts, it has been found expedient to taper the ends of the auxiliary part of the sole to a point at the ends, so that the capacitance between the opposed edges of the two parts of the slot is relatively small in spite of a small separation therebetween. The modulating voltage is connected between the auxiliary part of the sole and the anode delay structure.

The depth of the auxiliary part of the sole need not be as great as that of the more massive portion thereof, since the electron beam in most traveling wave tubes is confined to the central transverse region of the tube; it is in this central region particularly that the more effective interaction occurs between the electron beam and the radio-frequency fields existing along the anode delay structure. This is particularly true in traveling wave oscillations using interdigital delay structures, since the radio-frequency distribution is a maximum at the center of the tube and a minimum at the side walls. In other words, for purposes of modulating the electric field between the two electrodes, a large negative electrode is not essential. For the same reason, it may be practical in some instances to build the auxiliary part of the sole without the vertical walls or flanges at the edges previously referred to.

Furthermore, the variation in intensity of the electric field required to frequency-modulate the microwave traveling wave oscillator of a comparatively narrow band is relatively small compared with that essential for the main operating frequency. For example, the oscillator may be varied about a minimum frequency of 1500 megacycles at a ten-megacycle rate. The auxiliary part of the sole, therefore, may consist of a more or less centrally located electrode of relatively small surface area and would still be adequate in obtaining the necessary modulation of the electric field.

By reducing the capacity shunted across the F.M. modulator, modulation at microwave frequencies may be effected with less driving power and, consequently, with a substantial saving of size and weight of modulating apparatus.

Other and further advantages of this invention will be apparent as the description thereof proceeds, reference being had to the accompanying drawings, wherein:

Fig. 1 is a cross-sectional view, partly in elevation, of a traveling wave tube taken along the line 1—1 of Fig. 2, and of a traveling wave oscillator according to the invention;

Fig. 2 is a cross-sectional view of the traveling wave oscillator shown in Fig. 1;

Fig. 3 is a view illustrating details of the slow wave structure of the tube of Figs. 1 and 2;

Fig. 4 is a view showing details of the sole structure; and

Figs. 5 and 6 are detail views illustrating the electron gun assembly of the oscillator of Figs. 1 and 2.

Referring to the drawing, a traveling wave oscillator **10** is shown which comprises a slow wave energy propagating structure or delay line **12**, a cylindrical electrode **14**, sometimes referred to as a sole, concentric with said relay line **12** and preferably maintained negative with respect to the slow wave structure **12**, a lead-in assembly **16**, an output coupling means **18**, an electron gun assembly **20** including at least a cathode **21** and heater **22**, and a magnetic field-producing means **25**, a portion of which is indicated in Fig. 2.

The circular delay line **12** includes several interdigital fingers or elements **31** and **32** which extend from oppositely disposed annular members **33** and **34**, respectively. Members **33** and **34** are secured by screws **35**, shown in Fig. 3, to the shoulder portion of a cylindrical electrically-conductive ring **36**. The remainder of the slow wave structure **12** includes a pair of oppositely located cover plates **38** and **39** hermetically sealed to ring **36**. Although the delay line has been described and illustrated as an interdigital line, the invention is not limited thereto; for example, the delay line may consist of a loop-loaded wave guide, a strapped vane structure, a strapped loop periodic structure, or a disk-loaded coaxial structure.

The sole **14** includes a portion **44** in the form of a cylindrical segment of an electrically-conductive material, such as copper, which includes a web portion **45** bounded by an arcuate section **46** whose periphery consists of a major surface **47** and flanges **48**. The purpose of the flanges **48**, as mentioned previously, is to confine the electron beam within the interaction space **50** between the surface **47** of sole **14** and the interdigital slow wave structure **12**. A tubular metallic insert **52** is brazed into position against the inner periphery of a centrally disposed aperture **53** in the web portion **45** of sole **14**. One end of a hollow supporting member **54** is inserted within the insert **52** and is fixedly secured thereto. Supporting member **54**, in addition to providing support for the sole **14**, forms a portion of lead-in assembly **16** and allows for passage of external circuit-connecting leads, in a manner to be described subsequently. The sole **14** further comprises a portion **55**, such as a curved metallic strip, which may be mounted from the portion **44** of the sole by electrically insulating posts **57** which may be brazed in position. It should be understood, however, that any means of mounting portion **55** of the sole to the tube structure may be used, provided that portion **55** is electrically insulated from the slow wave structure **12** and from the portion **44** of the sole. Portion **55** of sole **14** is made as thin as possible, that is, the dimension of surface **58** is made as small as possible, consistent with mechanical strength and rigidity, in order to minimize the capacitance between portion **55** of the sole and the end members **38** and **39** of slow wave structure **12**, as well as to minimize the capacitance between the portions **55** and **44** of the sole. The periphery of portion **55** of the sole may contain flanges **59**, as in the case of the portion **44** of the sole, for reasons already mentioned; however, the flanges **59** are not always necessary and sometimes may be omitted. A modulating input lead **60** is electrically connected to the portion **55** of the sole, as shown in Fig. 4.

The portion **44** of sole **14** contains a slot **62** to accommodate the electron gun assembly **20**. Electron gun **20** for the tube of Figs. 1 and 2 includes a mounting plate **65** containing threaded apertures **66**. The mounting plate **65** is attached to the web portion **45** of the sole assembly **14** by means of screw **67** inserted into the apertures **66**. Electron gun **20** includes a cathode **21**, heater **22**, a grid electrode **23**, which may be used for control of beam current or for amplitude modulating, and an accelerating electrode **24**. The cathode **21** may be in the form of a rectangular prism provided with a circular bore

70 in which a folded heater wire 22 is inserted. The heater may be connected at one end to the inner wall of the cathode. The cathode body may be made of porous tungsten and the outer surface coated with an emitter, such as a compound of barium. A rigid molybdenum cathode supporting lead 71 is spot welded at one end to one end of the cathode body and affixed at the other end to a metallic terminal 72. Terminal 72 is attached to an insulating mounting post 73, which may be made of ceramic. The mounting post 73 passes through mounting plate 65 and may be brazed thereto. In this manner, the cathode 21 is mechanically supported in the proper position adjacent to and facing the interaction space 50. An external cathode lead-in wire 74 is attached to metallic terminal 72. One end of the heater 22 is connected by a heater supporting lead 75 to a metallic terminal 76 affixed to a second insulating mounting post 77, similar in construction to mounting post 73. An external heater lead-in wire 78 is attached to the metallic terminal 76 on mounting post 77. The grid electrode 23 includes a channel-shaped portion 23' surrounding the cathode and an integral flat elongated portion 23'' brazed thereto for providing increased heat dissipation from the grid. The portion 23'' of the grid contains an opening (not shown), aligned with the cathode 21 to permit emission of the electron beam into the interaction space. Grid 23 is mounted from mounting plate 65 by means of a rigid support wire 79 attached to the portion 23'' of the grid and to a terminal 80 fastened to the ceramic post 81; the latter is brazed to the mounting plate 65 in the same manner as mounting posts 73 and 77. A lead-in wire 82 for the grid is connected to the terminal lug 80. The accelerating electrode 24 is positioned adjacent grid 23 and includes a portion disposed directly over the emitting area of the cathode and an elongated portion substantially parallel to the elongated portion 23'' of the grid. The parallel relationship of the grid and accelerating anode serves to maintain a proper electric field therebetween. The accelerating electrode 24, like grid 23, is made relatively large in order to facilitate heat dissipation therefrom. The accelerating electrode 24 is mounted from mounting plate 65 by means of a rigid support wire 84 attached to a terminal 85 brazed to insulating post 86 in the mounting plate 65. A lead-in wire 88 for the accelerating electrode 23 is connected to terminal lug 85.

The various lead-in wires 74, 78, 82, and 88, together with the modulating input lead-in wire 60, are brought out of the tube envelope through the tubular supporting member 54 of sole 14. Lead-in assembly 16 includes an electrically conductive tube 90 affixed to the inner periphery of cover plate 38, as shown in Fig. 2. A section of cylindrical glass tubing 91 interconnects electrically conductive tube 90 and a second electrically conductive tube 92. The other end of tube 92 is provided with a glass seal 93 for sealing the traveling wave tube 10 after evacuation. Tubes 90 and 92 preferably are constructed of a material having an expansion coefficient closely approximating that of the glass tube 91. The end of sole supporting member 54 contains an outwardly flared portion 54' which is connected to the inner surface of tube 92. The leads 60, 74, 78, 82, and 88 are insulatedly supported from the supporting member 54 by one or more glass beads 95.

The coaxial output coupling means 18 is sealed in an opening of wall 36 of the delay line 12 and is impedance-matched to the delay line. The inner conductor 96 of the output coupling means 18 is connected to a finger of the delay line 12 at or near the end of the delay line adjacent the electron gun 20.

Traveling wave tube 10 may be provided with a collector electrode 98, shown in Fig. 1, for intercepting electrons after one traversal of the arcuate interaction space 50. This collector electrode may take the form of a projection from the back wall 36 of the delay structure 12. In some instances, however, the collector electrode may be omitted and the electron stream made reentrant.

The necessary electric field between the slow wave structure 12 and sole 14 may be obtained by means of a unidirectional voltage applied therebetween. The sole 14 may be biased negative with respect to the cathode 21 by means of a source 101 of voltage connected between cathode lead 74 and sole-supporting member 54 by way of tube 92. The cathode 21 may, in some instances, however, be at the same potential as sole 14, in which case source 101 may be omitted. Similarly, the delay line 12 may be maintained at a potential positive relative to both sole 14 and cathode 21 by means of a source 103 of unidirectional voltage connected between cathode lead 74 and sleeve 90, the latter being connected, in turn, to the delay line 12. The accelerating electrode 24 may be maintained at a positive potential relative to the cathode 21 by means of a source 105 of unidirectional voltage connected between leads 88 and 74. The control grid lead 82 may be connected by way of terminal 107 to an appropriate energy source for controlling the magnitude of the electron beam current in the traveling wave oscillator 10. The modulation lead 60 is connected to a frequency modulation source 110, shown in Fig. 2.

A uniform magnetic field transverse to the direction of propagation of the electron beam is provided by a permanent magnet, or by an electromagnet, having cylindrical pole pieces 112 and 113 radially positioned on or adjacent the anode cover plates 38 and 39, respectively. Pole piece 112 is apertured to receive the lead-in assembly 16, including the sole-supporting member 54, while pole piece 113 is apertured to maintain symmetry of the magnetic field. The flux lines should be concentrated in the interaction space 50 between sole 14 and delay line 12. By proper adjustment of the magnitude and polarity of the magnetic and electric fields, the electron beam may be made to follow a circular path along an interaction space 50 under the combined influence of these transversely disposed fields.

This completes the description of the embodiment of the invention illustrated herein. However, many modifications and advantages thereof will be apparent to persons skilled in the art without departing from the spirit and scope of this invention. Accordingly, it is desired that this invention not be limited to the particular details of the embodiment disclosed herein except as defined by the appended claims.

What is claimed is:

1. A traveling wave oscillating electron discharge device comprising an evacuated envelope within which is disposed an arcuate slow wave energy propagating structure producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, a cylindrical enclosure forming a portion of said envelope, said envelope further including closure members disposed at corresponding ends of said enclosure, an electrode assembly spaced from and substantially juxtaposed with said slow wave structure, and means for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, the surface area of the surface of said second portion facing the adjacent closure member being substantially smaller than the surface area of the surface of the first portion facing said corresponding closure member, the second portion of said electrode assembly being electrically isolated from said first portion, said first and second portions of said electrode assembly presenting a substantially continuous surface to said slow wave structure which is substantially uniformly spaced from said structure.

2. A traveling wave oscillating electron discharge device comprising an evacuated envelope within which is disposed an arcuate slow wave energy propagating struc-

ture which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, a cylindrical enclosure forming a portion of said envelope, said envelope further including closure members disposed at corresponding ends of said enclosure, an electrode assembly spaced from and substantially juxtaposed with said slow wave structure, and means for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, the surface area of the surface of said second portion facing the adjacent closure member being substantially smaller than the surface area of the surface of the first portion facing said corresponding closure member, said first and second portions of said electrode assembly presenting a substantially continuous surface to said slow wave structure which is substantially uniformly spaced from said structure.

3. A traveling wave oscillating electron discharge device comprising an evacuated envelope within which is disposed an arcuate slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, a cylindrical enclosure forming a portion of said envelope, said envelope further including closure members disposed at corresponding ends of said enclosure, an electrode assembly spaced from and substantially juxtaposed with said slow wave structure, and means for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, the radial thickness of said second portion of said electrode assembly being substantially smaller than that of said first portion.

4. A traveling wave electron discharge device comprising a slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, an electrode assembly spaced from and substantially juxtaposed with said slow wave structure, and means for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, the second portion of said electrode assembly being electrically isolated from said first portion, said first and second portions of said electrode assembly presenting a substantially continuous surface to said slow wave structure, the radial thickness of said second portion being substantially smaller than that of said first portion.

5. A traveling wave electron discharge device comprising an evacuated envelope within which is disposed an arcuate slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, a cylindrical enclosure forming a portion of said envelope, said envelope further including closure members disposed at corresponding ends of said enclosure, an electrode assembly spaced from and substantially juxtaposed with said slow wave structure, and means for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, said second portion forming with said corresponding closure member a capacitor whose capacitance is small compared with that of the capacitance between said first portion and said corresponding closure member, the second portion of said electrode assembly further being electrically isolated from said first portion.

6. A traveling wave oscillating electron discharge device comprising an evacuated envelope within which is disposed an arcuate slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, a cylindrical enclosure forming a portion of said envelope, said envelope further including closure members disposed at corresponding ends of said enclosure, an electrode assembly spaced from and substantially juxtaposed with said slow wave structure, means for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, the surface area of the surface of said second portion facing the adjacent closure member being substantially smaller than the surface area of the surface of the first portion facing said corresponding closure member, the second portion of said electrode assembly being electrically isolated from said first portion, and means for supplying a modulating potential between said structure and said second portion only of said electrode assembly for varying the frequency of oscillation of said device.

7. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, an electrode assembly spaced from and substantially coextensive with said slow wave structure, means for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, the second portion of said electrode assembly being electrically isolated from said first portion, said means for directing including means for supplying a unidirectional voltage between said structure and said electrode assembly for establishing an electric field therebetween whose strength is dependent upon the magnitude of said voltage, the frequency of oscillation produced in said device being a function of the strength of said electric field, said first and second portions of said electrode assembly presenting a substantially continuous surface to said slow wave structure, said second portion of said electrode assembly having substantially smaller surface area than said first portion, and means for supplying a modulating potential between said structure and said second portion only of said electrode assembly for modifying the strength of said electric field as a function of said modulating potential to modulate the frequency of said device.

8. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, and means including an electron source positioned adjacent said structure and an electrode assembly spaced from and coextensive with said slow wave structure for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said means for directing including means for producing a unidirectional voltage between said structure and said electrode assembly, said electrode assembly including a first portion and a second portion, the radial thickness of said second portion of said electrode assembly being substantially smaller than that of said first portion, and means for supplying a modulating potential between said structure and said second portion only of said electrode assembly for effecting frequency modulation of said device as a function of said unidirectional voltage.

9. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, and means including an electron source positioned adjacent said structure and an electrode assembly spaced from and coextensive with said slow wave structure for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said means for directing including means for producing a mag-

netic field transverse to said region, said electrode assembly including a first portion and a second portion, the second portion of said electrode assembly being electrically isolated from said first portion, the radial thickness of said second portion of said electrode assembly being substantially smaller than that of said first portion, and means for supplying a modulating potential between said structure and said second portion only of said electrode assembly for effecting frequency modulation of said device.

10. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, means including an electron source positioned adjacent said structure and an electrode assembly spaced from and coextensive with said slow wave structure for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, said electron source being carried by the first portion of said assembly, the second portion of said electrode assembly being electrically isolated from said first portion, said second portion of said electrode assembly having substantially smaller volume and surface area than said first portion, the radial dimension of said second portion being substantially less than that of said portion, and means for supplying a modulating potential between said structure and said second portion only of said electrode assembly for modulating the frequency of oscillation of said device.

11. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, said device including an active section and an inactive section, an electrode assembly including a first portion spaced from and substantially coextensive with said active section of said device and a second portion spaced from and coextensive with said inactive section of said device, and means for directing electrons along paths adjacent said slow wave structure in energy-exchanging relation with said fields of wave energy.

12. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure which is of substantially uniform construction throughout and producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, said device including an active section and an inactive section, an electrode assembly including a first portion spaced from and substantially coextensive with said active section of said device and a second portion spaced from and coextensive with said inactive section of said device, and means for directing electrons along paths adjacent said slow wave structure in energy-exchanging relation with said fields of wave energy, the second portion of said electrode assembly being electrically isolated from said first portion.

13. A traveling wave electron discharge device comprising a slow wave energy propagating structure producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, said device including an active section and an inactive section, an electrode assembly including a first portion spaced from and substantially coextensive with said active section of said device and a second portion spaced from and coextensive with said inactive section of said device, and means for directing electrons along paths adjacent said slow wave structure in energy-exchanging relation with said fields of wave energy, said first and second portions of said electrode assembly presenting a substantially continuous surface to said slow wave structure, the ends of said second portion of said assembly adjacent said first portion being tapered to reduce the capacitance between said first and second portions.

14. A traveling wave electron discharge device comprising a slow wave energy propagating structure producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, said device including an active section and an inactive section, an electrode assembly including a first portion spaced from and substantially coextensive with said active section of said device and a second portion spaced from and coextensive with said inactive section of said device, and means for directing electrons along paths adjacent said slow wave structure in energy-exchanging relation with said fields of wave energy, said second portion of said electrode assembly having substantially smaller surface area than said first portion.

15. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, said device including an active section and an inactive section, an electrode assembly including a first portion spaced from and substantially coextensive with said active section of said device and a second portion spaced from and coextensive with said inactive section of said device, means for directture in energy-exchanging relation with said fields of wave energy, and means for supplying a modulating potential between said structure and said second portion only of said electrode assembly for modulating the frequency of oscillation of said device.

16. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, said device including an active section and an inactive section, an electrode assembly including a first portion spaced from and substantially coextensive with said active section of said device and a second portion spaced from and coextensive with said inactive section of said device, and means for directing electrons along paths adjacent said slow wave structure in energy-exchanging relation with said fields of wave energy, the second portion of said electrode assembly being electrically isolated from said first portion, said second portion of said electrode assembly having substantially smaller surface area and a smaller radial thickness than said first portion.

17. A traveling wave oscillating electron discharge device comprising a slow wave energy propagating structure producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, said device including an active section and an inactive section, an electrode assembly including a first portion spaced from and substantially coextensive with said active section of said device and a second portion spaced from and coextensive with said inactive section of said device, means for directing electrons along paths adjacent said slow wave structure in energy-exchanging relation with said fields of wave energy, the second portion of said electrode assembly being electrically isolated from said first portion, said second portion of said electrode assembly having substantially smaller surface area than said first portion, and means for supplying a modulating potential between said structure and said second portion only of said electrode assembly for modulating the frequency of oscillation of said device.

18. A traveling wave electron discharge device comprising a slow wave energy propagating structure producing in the region adjacent thereto fields of electromagnetic wave energy being propagated, an electrode assembly spaced from and substantially coextensive with said slow wave structure, means for directing electrons along said region in energy-exchanging relation with said fields of wave energy, said electrode assembly including a first portion and a second portion, the second portion of said electrode assembly being electrically isolated from said

first portion, said first and second portions of said electrode assembly presenting a substantially continuous surface to said slow wave structure, said second portion of said electrode assembly having substantially smaller surface area than said first portion, and means for supplying a modulating potential between said structure and said

second portion only of said electrode assembly for modulating the frequency of said device.

References Cited in the file of this patent

UNITED STATES PATENTS

2,794,936 Huber ---------- June 4, 1957

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,914,700 November 24, 1959

Roy A. Paananen

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 5, for "relay" read -- delay --; column 9, line 28, after "said" insert -- first --; column 10, line 25, after "direct-" insert -- ing electrons along paths adjacent said slow wave struc- --.

Signed and sealed this 21st day of June 1960.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents