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ELECTROSTATICALLY FOCUSED TRAVELING WAVE TUBE

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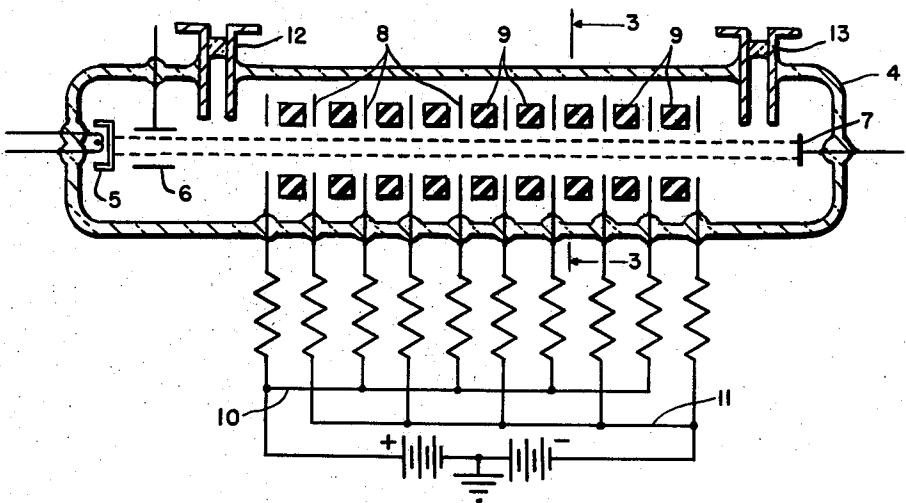


FIG. 1

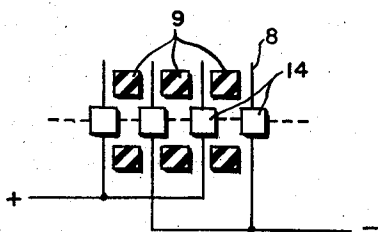


FIG. 2

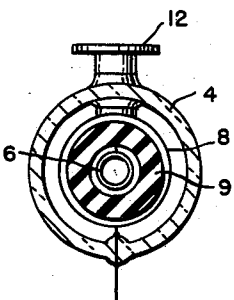


FIG. 3

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1

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ELECTROSTATICALLY FOCUSED TRAVELING WAVE TUBE

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(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to that type of radio frequency amplifier known as a traveling wave tube in which the amplifying ability of the tube results from the transfer of power to the traveling wave from an electron beam and the invention is particularly directed to a manner of forming the electron beam.

In tubes of the type suggested a special problem arises in providing an electron beam which will remain under control for the purpose intended throughout the relatively long path of travel of the electrons. It has been common practice to provide an electromagnetic field to control the beam. Such a field is created by an elongated hollow cylindrical coil of a length to embrace the length of the beam and within which the tube itself is received. This construction is of necessity relatively large and heavy and is very wasteful of power which must be supplied to the coil.

The present invention provides a beam controlling means which is light in weight and is highly efficient in operation. The invention provides a plurality of metallic electrodes arranged in alignment and having aligned apertures through which the electron beam is axially directed and dielectric rings between the metal rings.

In operation direct current potentials are applied to the metallic electrodes in a pattern to suit the particular requirements of a given application. A desirable arrangement would be to divide the metallic members into groups in such a way that successive electrodes have a different potential. Thus a series of electrostatic lenses are formed acting to concentrate the electron beam.

Preferred forms of the invention will be described in detail hereinafter.

It is a primary object of the invention to provide a simplified and more efficient traveling wave tube.

A further object of the invention is to provide a traveling wave tube having an electron beam focusing means characterized by great versatility of control and particularly by its ability to control subdivided portions thereof.

A further object of the invention is to provide in a traveling wave tube an electron beam focusing device which requires only a minimum of power for its operation.

Other objects and features of the invention will more fully appear from the following description taken in connection with the accompanying drawings in which—

Fig. 1 is a diagrammatic illustration of a preferred embodiment of the invention.

Fig. 2 illustrates a modified form of the invention.

Fig. 3 is a cross-sectional view taken on line 3—3 of Fig. 1.

The invention will be described in connection with a traveling wave amplifier tube. The principles of the

2

invention may, however, have application in a wide variety of fields.

The elements of the invention are inclosed within an evacuated envelope 4. The beam of electrons may be supplied in any suitable manner such as by a conventional electron gun having a cathode 5, an accelerator anode 6 and a collector 7. The gun is supplied with suitable power from sources not shown.

To provide efficient operation of the device the electron beam must be kept under the influence of a concentrating or focusing element. The present invention provides such an element which possesses qualities which are novel and which contribute to the overall operating efficiency and versatility of the device.

In place of the usual electromagnetic coil, the focusing device is constructed to function upon the electrostatic principle and is composed of a plurality of electrodes 8 spaced apart and arranged symmetrically with respect to the axis of the electron beam. The discs are held in place by spacing rings 9 of dielectric material situated between the adjacent electrodes 8.

The succession of metallic electrodes 8 arranged as they are provides an ideal means for controlling the dispersion of the beam since it is possible not only to apply any desired potential to each one but it is also possible to provide different potentials to successive individual electrodes or groups of electrodes.

In the drawings a suggested arrangement is to interconnect every other electrode to a common lead wire 10 and the remaining groups of electrodes to a separate common lead wire 11. The voltage applied to each group may be so chosen that in effect the successive groups of electrodes constitute a series of electronic lenses of the required strength to confine the electrons to a path along the tube axis.

Along with the above arrangement of electrostatic lenses other matters must be considered. It will be understood that provision must be made for synchronizing the phase velocity of the radio frequency wave with the velocity of the electron beam which must be correct to sustain the amplifying ability of the tube as in a conventional traveling wave tube.

In all traveling wave tubes there must be some means for slowing the traveling wave such as a helix of conductive material which is widely used in conventional tubes for this purpose. In the present invention, however, the wave slowing means is not determined solely by the electrodes 8 but the degree of retardation is determined by the dielectric constant of the dielectric used for the spacing rings 9 and the dimensions of the electrodes 8 and insulator rings 9. The combination of insulator rings and electrodes together comprise a wave loading or wave slowing structure.

In order to prevent the successive electrodes 8 from being held at a common R.-F. potential by the leads from the battery, resistors are shown inserted between each electrode and the battery so that the electrodes will have high R.-F. impedances to each other through the battery supply. Instead of resistors, other high impedance R.-F. elements may be substituted.

A tube embodying the invention may therefore be designed, by choosing the proper dielectric for the spacer rings 9 and determining the dimensions of the structure which will cause the tube to function within the specifications desired. Then by choosing the correct potential to be applied to the cathode with respect to the groups of electrodes 8 connected respectively to wires 10 and 11, the electron beam will have the correct average velocity to be synchronized with the traveling wave on the wave slowing structure. As above stated, the potentials on the groups of electrodes 8 may also be so chosen that their difference

will be a value which satisfies the condition wherein successive pairs of electrodes 8 act as electrostatic lenses to concentrate the electron beam to the required degree.

It will thus be apparent that all conditions for amplification of the wave are provided and the tube may be efficiently operated without an external cumbersome electromagnetic coil to concentrate the electron beam.

The power to be amplified may be introduced in any suitable manner. A method for accomplishing this is shown in Fig. 1 wherein the input end of the tube is provided with an opening within which is sealed a section of waveguide 12 of standard dimensions which is provided with a flange for connection to a waveguide system conducting power to be amplified. A similar section of waveguide 13 may be provided at the output end of the tube to feed amplified power to a subsequent utilization circuit or device.

The invention may embody other structural forms such as that shown in Fig. 2 wherein the peripheral edge of the aperture in each of the electrodes 8 is made relatively wide to form a short section of tube 14 through which the electron beam passes. By thus modifying the structure a stronger focusing effect on the beam may be realized.

What is claimed is:

1. A traveling wave amplifier tube circuit comprising an exhausted envelope to enclose the elements thereof, combined electrostatic focusing and wave retarding means including a plurality of spaced metallic electrodes arranged in alignment within said envelope, a plurality of dielectric elements alternately arranged with said electrodes, acting to insulate successive electrodes and to act as a radio frequency wave slowing means, means to supply and direct a beam of electrons along said electrodes, a source of direct-current potential separately connected to each of said electrodes to electrostatically converge said electron beam, and means having a high impedance to radio-frequency currents connected between said electrodes and said source of potential, and means to feed power to be amplified to the input of the tube and to conduct the amplified power therefrom.

2. A traveling wave amplifier tube circuit comprising an exhausted envelope, a combined electrostatic focusing and wave retarding means including a plurality of spaced metallic electrodes arranged in alignment within the envelope, a plurality of dielectric elements alternately arranged with said electrodes, means to supply and direct an electron beam along said electrodes and dielectric elements, a source of potential of one polarity separately connected to each of one group of said electrodes and a potential source having an opposite polarity separately connected to each one of another group of said electrodes to provide a series of electrostatic lenses for converging said electron beam, high impedance means connected between said electrodes and said potential source, and means to feed power to the tube and to conduct amplified power therefrom.

3. A traveling wave amplifier tube circuit comprising an exhausted envelope, a combined electrostatic focusing and wave retarding means including a plurality of spaced metallic electrodes within the envelope having aligned apertures, means to supply and direct a beam of electrons along said electrodes, a plurality of annular shaped dielectric elements alternately arranged with said electrodes presenting a radio frequency wave slowing channel for the passage of power therethru, a stepped source of direct-current potential separately connected to each of said electrodes whereby adjacent electrodes may have different potential values to create a series of electrostatic lenses for concentrating the electron beam, radio-frequency isolating means connected between said electrodes and said source of electrical potential, and means to feed radio frequency power to and conduct it from the tube.

4. A traveling wave amplifier tube circuit comprising an exhausted envelope, a plurality of aligned metallic

electrodes spaced apart within said envelope, means to supply and direct a beam of electrons along said electrodes, a stepped direct-current potential source separately connected to each of said electrodes to supply successive electrodes with different potentials whereby a series of electrostatic lenses are formed to concentrate said electron beam, high impedance means connected between electrodes and said potential source, and a channel structure of dielectric attenuating material extending along said electron beam acting as a radio frequency wave slowing and synchronizing means, said channel structure comprising a plurality of dielectric elements alternating with said electrodes.

5. A traveling wave amplifier tube circuit comprising an evacuated envelope, means to supply and direct a beam of electrons along a predetermined path, a plurality of spaced metallic electrodes extending in line along said path, a wave loading structure of dielectric material extending along said path, said structure comprising a plurality of dielectric elements alternating with said electrodes, a stepped direct-current potential source separately connected to each of said electrodes and having an average value calculated to synchronize the electron velocity with the phase velocity of the loaded wave at the operating frequency and wherein different values of potential are applied to successive electrodes to form a series of electrostatic lenses acting to concentrate said electron beam, and radio-frequency isolating means connected between said electrodes and said potential source.

6. A traveling wave amplifier tube circuit comprising an exhausted envelope, a plurality of aligned spaced electrodes in said envelope, means to supply and direct a beam of electrons along said electrodes, a plurality of spaced aligned metallic plate-like electrodes in said envelope, a wave loading dielectric structure having elements alternately arranged with said electrodes acting to support and insulate them in spaced relation, a stepped potential source including wave isolating means connected to each of said electrodes separately and having an average value to synchronize the phase velocity of the loaded wave with the electron velocity at the operating frequency and wherein different values of potential are applied to successive electrodes to form a series of electrostatic lenses acting to concentrate the electron beam.

7. A traveling wave amplifier tube circuit comprising an exhausted envelope, a plurality of spaced electrodes in said envelope, each electrode having short tubular axially aligned portions forming an open channel, means for supplying and directing a beam of electrons through said channel, a wave loading structure of dielectric material also extending along said electron beam, said structure comprising a plurality of dielectric elements alternating with said electrodes a stepped source of potential including wave isolating means connected to each of said electrodes separately and having an average value to synchronize the electron velocity to that of the traveling wave at the operating frequency and to supply successive electrodes with different potentials to form a series of electrostatic lenses, operable to concentrate the electron beam.

8. A traveling wave amplifier comprising means to generate an electron beam, means to propagate radio frequency wave energy along said beam, and a combined wave retarding and beam focusing structure comprising a plurality of substantially noninductive electrostatic focusing elements aligned along the path of said beam and along the path of propagation of said wave energy and operatively associated with said beam to concentrate said beam, said structure including dielectric elements alternately arranged with said focusing elements and having a dielectric constant and dimensions to retard said wave energy sufficiently to produce amplification as a result of interaction between said wave energy and said electron beam.

9. A traveling wave amplifier as set forth in claim 8,

wherein said elements have aligned apertures through which said beam is directed.

10. A traveling wave amplifier comprising means to generate an electron beam, means to propagate radio frequency wave energy along said beam, and a combined wave retarding and beam focusing structure comprising a plurality of electrostatic focusing elements having aligned apertures through which said beam is directed, said structure including dielectric elements alternately arranged with said focusing elements and having a dielectric constant and dimensions to retard said wave energy sufficiently to produce amplification as a result of interaction between said wave energy and said electron beam, means to positively bias alternate focusing elements, and means to negatively bias the remaining focusing elements. 15

11. A traveling wave amplifier as set forth in claim 8, wherein said focusing elements are insulated from each other.

References Cited in the file of this patent

UNITED STATES PATENTS

2,313,018	Krause	Mar. 2, 1943
2,533,790	Grivet	Dec. 12, 1950
2,654,047	Clavier	Sept. 29, 1953
2,660,689	Touraton et al.	Nov. 24, 1953
2,661,441	Mueller	Dec. 1, 1953
2,672,572	Tiley	Mar. 16, 1954
2,725,499	Field	Nov. 29, 1955