

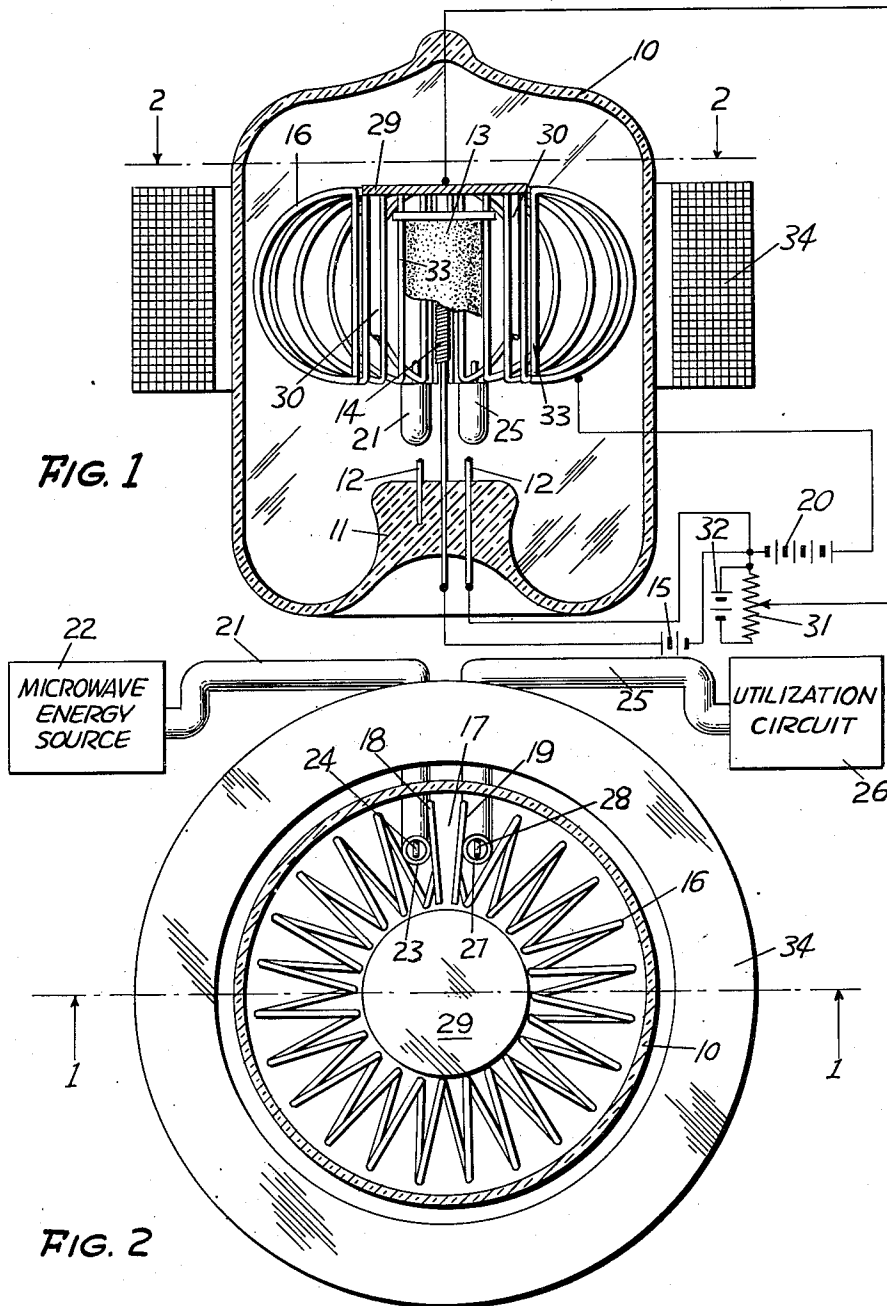
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MICROWAVE AMPLIFIER

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## MICROWAVE AMPLIFIER

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This invention relates to amplifying devices, and more particularly to amplifying devices for electrical energy in the microwave region of the electromagnetic spectrum.

It has heretofore been proposed to produce amplification of such energy by propagating the same down an elongated waveguide, and projecting an electron beam along the axis of said waveguide, extracting amplified energy from the end of the waveguide remote from the input. The waveguide in such an arrangement took the form of a helix in order to reduce the linear phase velocity of the energy to be amplified to a point below the speed of light, this condition obviously being necessary in order to enable the electron beam to be accelerated to velocities in excess of said phase velocity, whereby said electron beam could interact with the microwave energy and transfer its own energy thereto. Such an arrangement further included an anode disposed adjacent the output end of the waveguide to collect the spent electron beam, and a magnetic field along the axis of the waveguide to focus the electron beam.

It has been found that an amplifying device constructed as aforesaid has certain disadvantages. It is complicated and therefore difficult and expensive to manufacture, and its linear construction requires excessively high accelerating potentials.

It is, therefore, an object of the present invention to provide a microwave amplifier which is simple in construction and easy and economical to manufacture.

It is a further object of the present invention to provide an amplifying device which is so designed as to require much lower operating voltages than has heretofore been the case.

These, and other objects of the present invention, which will become more apparent as the detailed description thereof progresses, are attained, broadly, in the following manner.

The present invention contemplates the provision of an evacuated envelope in which is mounted a source of electrons and a helical waveguide, preferably, in the form of a toroid, spaced from and surrounding said source of electrons. A magnetic field is established transverse to the path between said source of electrons and said waveguide, and said waveguide is maintained at a positive potential with respect to said source of electrons. The electrons emitted from said source are, by proper relative adjustment of the above-mentioned magnetic and electric fields, caused to travel in paths similar to the electron

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paths in a conventional multiple cavity magnetron. Microwave energy applied to the helical waveguide is thereby caused to extract energy from these electrons and become amplified.

In the accompanying specification there shall be described, and in the annexed drawing shown, an illustrative embodiment of the amplifying device of the present invention. It is, however, to be clearly understood that the present invention is not to be limited to the exact details of construction herein shown and described for purposes of illustration only, inasmuch as changes therein may be made without the exercise of invention and within the true spirit and scope of the claims hereto appended.

In said drawing:

Fig. 1 is a longitudinal sectional view taken along line 1—1 of Fig. 2, substantially through the center of a microwave amplifier made in accordance with the principles of the present invention; and

Fig. 2 is a transverse sectional view taken along line 2—2 of Fig. 1.

Referring now more in detail to the aforesaid illustrative embodiment of the present invention, with particular reference to the drawing illustrating the same, the numeral 10 designates an envelope made of a dielectric material such as glass. The envelope is provided with a reentrant press 11 in which there is embedded a pair of wire supports 12 which carry at their inner ends a centrally disposed cathode sleeve 13 provided with a conventional electron emissive coating. A cathode heater 14 has one end thereof electrically connected to the sleeve 13 and the other end thereof passed through the press 11 and electrically connected to one terminal of a source 15 of heating current. The other terminal of the source 15 is connected to one of the cathode supports 12.

Spaced from and surrounding the cathode 13 is a waveguide structure 16, this structure, preferably, taking the form of a helical wire, the successive turns of which are uniformly spaced from each other, the entire helix being formed into a toroid having a gap 17 between the adjacent ends thereof. The spaced ends of the toroid are closed by conducting plates 18 and 19 in order to isolate the input end of the waveguide from the output end thereof, thus eliminating unwanted feedback which might otherwise cause oscillation. The waveguide 16 is maintained at a positive potential with respect to the cathode 13 by appropriate connection to a source of voltage 20.

A coaxial transmission line 21, coupled to a

source 22 of microwave energy to be amplified, has its outer conductor 23 electrically connected to the first turn of the helical waveguide 16 adjacent the end plate 18, and its central conductor formed into a coupling loop 24 which extends into said waveguide.

Another coaxial transmission line 25, coupled to any preferred utilization circuit 26, has its outer conductor 27 electrically connected to the last turn of the helical waveguide 16 adjacent the end plate 19, and its central conductor formed into a coupling loop 28 which, like the coupling loop 24, extends into said waveguide.

While not necessary, there may be disposed in the annular space between the cathode 13 and the waveguide 16 a control electrode consisting of a disk 29 from which depends a plurality of spaced pins 30, the control electrode being maintained at a suitable negative potential with respect to the cathode 13 by connecting the same to the adjustable arm of a potentiometer 31, in turn connected across a source of voltage 32. The positive end of the potentiometer 31 is returned to the cathode 13. The magnitude of the bias will control the width of the beams projected from between adjacent pins 30, thereby enabling greater control over the relative phase between the electron beam and the travelling microwave energy to be amplified.

While not necessary, it is preferred that portions 33 of the turns of the helical waveguide 16, facing the cathode 13 and lying in planes parallel to planes including the longitudinal axis of said cathode, be non-arcuate.

The device is completed by providing a coil 34 about the envelope 10 to establish a magnetic field in the space between the cathode 13 and waveguide 16, in a direction transverse to the electron path therebetween.

In operation, the microwave energy to be amplified is applied to the input end of the waveguide 16 by means of the coupling loop 24. The energy is propagated around the waveguide and extracted by the loop 28, the helical form of the waveguide reducing the phase velocity of the energy to a value below the speed of light. The electrons emitted by the cathode 13 are caused, under the influence of the electric field between the cathode and the waveguide, and the magnetic field in the space between said cathode and waveguide, to follow paths similar to those taken in a conventional magnetron. In following such paths, the electrons give up their energy to the microwave energy traveling along the waveguide whereby said microwave energy, when extracted at the output end of the waveguide, is amplified.

This completes the description of the aforesaid illustrative embodiment of the invention. It will be noted from all of the foregoing that the construction herein proposed is such as to simplify manufacturing procedure and assembly and is such as to require considerably lower accelerating potentials than has heretofore been necessary in operating so-called linear amplifiers.

Other objects and advantages of the device of the present invention will readily occur to those skilled in the art to which the present invention relates.

What is claimed is:

1. An amplifier for microwave energy comprising: an evacuated envelope; a helical waveguide, the turns of which are spaced with respect to each other, mounted in said envelope; a source of electrons mounted in said envelope exteriorly of and

in spaced relationship to said waveguide; a control electrode interposed between said electron-source and said waveguide; means for establishing a magnetic field transverse to the path between said electron-source and said waveguide; and microwave input and output means coupled to said waveguide at predetermined points along the length thereof.

2. An amplifier for microwave energy comprising: an evacuated envelope; a helical waveguide, the turns of which are spaced with respect to each other, mounted in said envelope and formed into a toroid; a source of electrons mounted in said envelope coaxially with said toroid; a control electrode interposed between said electron-source and said waveguide; means for establishing a magnetic field transverse to the path between said electron-source and said waveguide; and microwave input and output means coupled to said waveguide at predetermined points along the length thereof.

3. An amplifier for microwave energy comprising: an evacuated envelope; a source of electrons mounted in said envelope; a helical waveguide, the turns of which are spaced with respect to each other, mounted in said envelope, in spaced relationship to said electron-source; the turns of said helical waveguide having non-arcuate portions facing said electron-source and lying in planes parallel to planes including the longitudinal axis of said electron-source; a control electrode interposed between said electron-source and said waveguide; means for establishing a magnetic field transverse to the path between said electron-source and said waveguide; and microwave input and output means coupled to said waveguide at predetermined points along the length thereof.

4. An amplifier for microwave energy comprising: an evacuated envelope; a cylindrical source of electrons mounted in said envelope; a helical waveguide, the turns of which are spaced with respect to each other, mounted in said envelope and formed into a toroid to substantially surround said electron-source, in spaced relationship thereto; the turns of said helical waveguide having non-arcuate portions facing said electron-source and lying in planes parallel to planes including the longitudinal axis of said electron-source; a cylindrical control electrode interposed between said electron-source and said waveguide, means for establishing a magnetic field transverse to the path between said electron-source and said waveguide; and microwave input and output means coupled to said waveguide at predetermined points along the length thereof.

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