

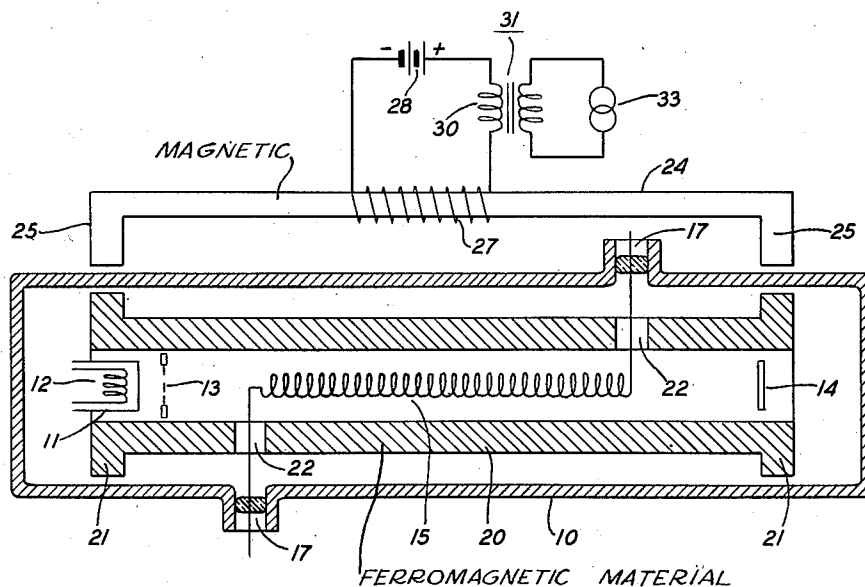
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MODULATED ELECTRON DISCHARGE DEVICE

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MODULATED ELECTRON DISCHARGE DEVICE

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This invention relates to electron discharge devices and more particularly to such devices of the traveling wave tube type.

This application is a division of application Serial No. 280,707, filed April 5, 1952, now Patent 2,691,765, October 12, 1954.

Traveling wave tubes generally comprise a transmission line, which defines an interaction circuit, and a means for projecting an electron stream along that interaction circuit. In one known type of traveling wave tube, the interaction circuit comprises a helix to which the high frequency carrier wave is coupled; in other types of traveling wave tubes, the region of interaction may be defined by a filter-type circuit or by resonators. Amplification in these tubes occurs due to the interaction of the electromagnetic waves associated with both the helix and the electron stream in the vicinity of this interaction region. Priorly, the high frequency carrier wave has had the modulating signal applied thereto, external to the traveling wave tube, so that it is the modulated carrier that is introduced to the traveling wave tube and amplified therein. This, of course, requires that the steps of modulation and amplification be distinct, employing separate apparatus and interconnections therebetween.

In accordance with an aspect of this invention, a high frequency carrier wave, such as may be derived from a crystal controlled oscillator, is directly introduced into a traveling wave tube and the modulating signal applied to the carrier within the tube itself. In a specific embodiment of this invention, this is attained by varying the attenuation of the interaction circuit under the control of the modulating signal.

The amplification or gain of a traveling wave tube depends on the characteristics of the wave associated with the interaction circuit, e. g., with the helix in one known form of tube, and the interaction of that wave with the electromagnetic wave associated with the electron beam. Priorly, loss has been applied to the helix or positioned adjacent thereto to attenuate the electromagnetic wave associated with the helix so that feedback due to the signal being reflected back from the output will not occur. In accordance with a feature of this invention a ferromagnetic member distinct from the helix or interaction circuit encompasses the interaction circuit and provides attenuation in the traveling wave tube. This ferromagnetic member is magnetized and advantageously in accordance with an aspect of the invention is magnetized to be near ferromagnetic resonance.

In one specific illustrative embodiment of this invention a hollow cylinder of a ferromagnetic material, such as ferrite, encompasses the helix of the traveling wave tube and provides attenuation therefor. An initial field strength bias is provided such that the ferromagnetic resonance of the material occurs near the frequency band of the signal being amplified.

In this specific embodiment the ferromagnetic losses in the magnetic material are varied in accordance with a modulating signal by varying the magnetic field through

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the material under the control of the modulating signal. In this manner the attenuation applied to the interaction circuit is varied under control of the modulating signal to decrease the amplification in accordance with the modulating signal, whereby the carrier wave is amplitude modulated.

It is a feature of this invention that attenuation be provided in a traveling wave tube by a magnetized element of a ferromagnetic material encompassing the interaction circuit but distinct therefrom.

It is a further feature of this invention that attenuation in a traveling wave tube be provided by a solid hollow magnetized element of a ferromagnetic material encompassing the path of the electron stream in the traveling wave tube.

It is another feature of this invention that the ferromagnetic element be magnetized to be near its ferromagnetic resonance in the frequency band of the signal to be amplified.

It is still another feature of this invention that the attenuation of the traveling wave tube be varied by an externally applied signal by varying the magnetic field through the magnetized element in accordance with the externally applied signal.

A complete understanding of this invention and of these and other features may be gained from consideration of the following detailed description together with the accompanying drawing, in which the single figure is a sectional representation of a traveling wave tube illustrative of one specific embodiment of this invention.

Referring now to the drawing, the specific embodiment of this invention depicted comprises an envelope 10, which may be of a conducting material and in which are positioned a cathode 11, heater element 12, and accelerating electrode 13, defining an electron gun, an electron receiver 14, and a helix 15. The ends of the helix 15 are brought out through coaxial input and output terminals 17.

A cylindrical member 20 of a sintered ceramic ferromagnetic material, such as manganese zinc ferrite, and having flanges 21 at each end encompasses the cathode 11, control electrode 13, helix 15 and collector electrode 14, leads being brought from the end of the helix 15 through apertures 22 in the cylinder 20 to the coaxial terminals 17. External to the envelope 10, which is of a non-magnetic material, is positioned a long U-shaped core member 24 having its depending portions 25 facing the end flanges 21. The core 24 need only be a segment of a cylinder, or an approximation thereof, and one or several may be employed. A coil 27 is wound around a portion of the core 24, an identical coil being thus positioned for each core utilized. A voltage source 28 and the secondary 30 of the transformer 31 are in series with the coil 27. The core 24 may be of a permanent magnetic material or of a ferromagnetic material, such as ferrite, with a superimposed direct magnetic field in either case. The field strength produced by the permanent magnet and/or the coil 27 in the ferrite cylinder 20 is adjusted so that ferromagnetic resonance occurs near the frequency band of the signal to be amplified, the occurrence of ferromagnetic resonance being dependent on both field strength and frequency. Near the ferromagnetic resonance of the ferrite, the loss in the ferrite will change rapidly with the field strength. For a narrow band of frequencies to be modulated, this variation in the ferromagnetic loss, and thus in the attenuation coupled to the carrier wave, can be controlled by a modulating signal 33 applied to the transformer 31 to vary the magnetic field in the magnetic circuit of the cylinder 20 and the core 24 and thus modulate the carrier.

As the ferrite cylinder 20 entirely encompasses the helix 15 it should also be utilized to provide magnetic

focussing of the electron beam within the helix, as is known in the traveling wave tube art. Therefore, the dimensions and parameters of the cylinder 20 should be chosen so that its ferromagnetic resonance occurs at a value of field strength at least sufficient to focus the electron stream.

Modulating the carrier wave by this specific illustrative embodiment of this invention other than by the other embodiments set forth in the parent application can best be utilized for relatively low modulating frequencies at which the hysteresis effects within the ferromagnetic cylinder 50 will not be a limiting factor.

While this invention has been described with reference to modulation of the carrier wave in accordance with a modulating signal, it is to be understood that the impedance value of the variable impedance element in energy coupled relationship may be varied to vary the attenuation at a given point or along the interaction circuit in accordance with other than modulating signals. Similarly, although the specific embodiment of this invention described above has incorporated a helix as defining the interaction circuit, this invention is equally applicable to other types of traveling wave tubes wherein the electromagnetic wave may be slowed down in other manners and the region of interaction thus defined by other structures, such as by filter-type circuits or resonators. Nor is this invention to be considered limited to the manner of introduction of the carrier wave into the device, as this will depend on a number of considerations, such as carrier frequency. Thus the carrier wave may be coupled to the interaction circuit not only by coaxial terminals, but by wave guides, resonators, grids, electron streams, or in other manners known in the art.

Further, this invention is not limited to the inclusion with the magnetized ferromagnetic attenuating member of elements to vary the attenuation of the ferromagnetic member.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of this invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An electron discharge device comprising means for propagating a traveling electromagnetic wave along an extended path, means for projecting a stream of electrons along said path, means distinct from said propagating means for providing attenuation along said path, said attenuation means including a magnetized element of ferromagnetic material encompassing said path and in energy coupled relationship with the electromagnetic field of said wave, and means for applying a magnetic field to said element such that the magnetic field strength along said path is sufficient to focus said electron stream.

2. An electron discharge device comprising means for propagating a traveling electromagnetic wave along an extended path, means for projecting a stream of electrons along said path, means for providing attenuation along said path, said last-mentioned means including a solid hollow magnetized element of ferromagnetic material encompassing said path, and means applying a magnetic field to said element to focus said electron stream, whereby said hollow element both provides said attenuation and serves as a flux guide for the focusing magnetic field.

3. A traveling wave tube comprising electrical conductor means defining an interaction circuit, means for projecting a stream of electrons along said circuit, means for introducing a carrier wave to said circuit, and means for providing attenuation of said wave along said circuit, said last-mentioned means including a magnetic member encompassing said conductor and means for magnetizing said magnetic member, said magnetizing means including means for providing a sufficient field strength in said member for focusing said electron stream.

4. A traveling wave tube in accordance with claim 3 wherein said magnetic member is of a ferrite material.

5. A traveling wave tube in accordance with claim 3 wherein said means for magnetizing said magnetic member comprises means for providing a magnetic field strength in said member such that said member is near ferromagnetic resonance.

6. An electron discharge device comprising means defining an interaction circuit, means for projecting a stream of electrons along said circuit, means for introducing a carrier wave to said circuit, and means for varying the amplitude of said carrier wave, said last-mentioned means comprising a first magnetic element having a variable ferromagnetic loss characteristic in energy coupled relationship with the electromagnetic field of said carrier, a second magnetic element adjacent said first magnetic element and defining a magnetic circuit therewith, and means for varying the magnetic field strength in said magnetic circuit to vary the ferromagnetic loss in said first magnetic element.

7. An electron discharge device comprising means defining an interaction circuit, means for projecting a stream of electrons along said circuit, means for introducing a carrier wave to said circuit, and means for varying the attenuation along said circuit, said last-mentioned means comprising a ferrite member having a variable ferromagnetic loss characteristic near ferromagnetic resonance, said ferrite member being adjacent said circuit, a magnetic member adjacent said ferromagnetic member and defining a magnetic circuit therewith, means for providing a magnetic field strength in said magnetic circuit such that said ferrite member is near ferromagnetic resonance, and means for varying said field strength.

8. An electron discharge device comprising means defining an interaction circuit, electron gun means for projecting a stream of electrons along said circuit, means for introducing a carrier wave to said circuit, and means for varying the attenuation along said circuit, said last-mentioned means comprising a ferrite cylinder encompassing said electron gun means and said circuit, a magnetic member adjacent said ferrite cylinder and defining a magnetic circuit therewith, means for providing a magnetic field in said magnetic circuit such that said ferrite cylinder is near ferromagnetic resonance and such that the magnetic field within said ferrite cylinder is more than sufficient to focus said electron stream, and means for varying said field strength.

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