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MICROWAVE POWER LIMITER COMPRISING ABUTTING SEMICONDUCTOR
AND FERRITE ELEMENTS
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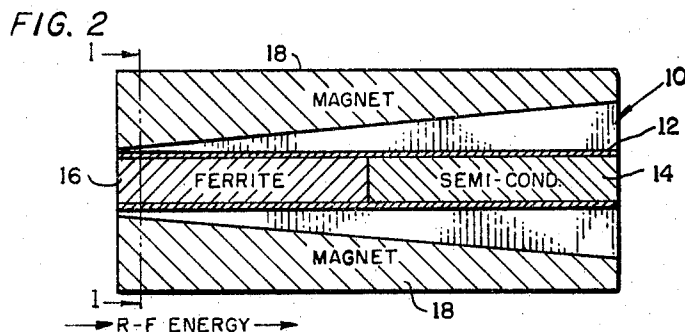
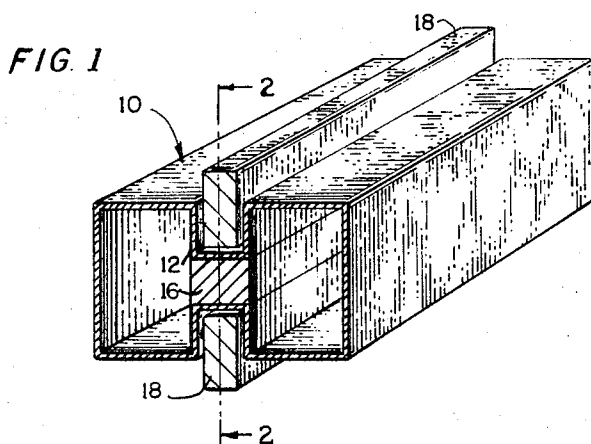
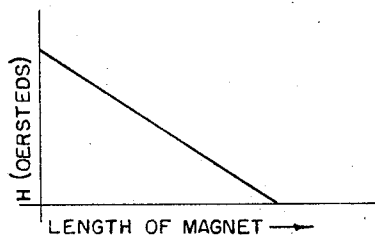


FIG. 3



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MICROWAVE POWER LIMITER COMPRISING ABUTTING SEMICONDUCTOR AND FERRITE ELEMENTS

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4 Claims

ABSTRACT OF THE DISCLOSURE

A microwave power limiter which includes respective blocks of semiconductor and ferrite materials mounted in a ridged waveguide structure through which microwave energy is propagated. A magnetic bias is provided to interact with the ferrite material.

Background of the invention

This invention relates to a microwave transmission system utilizing combined gyromagnetic and semiconductor elements and more particularly to the combined gyromagnetic and semiconductor elements for use in such systems as power limiters.

It is well known that gyromagnetic mediums such as ferrites are characterized by certain unpaired electron spins which respond to a transmitted microwave signal by precessing gyroscopically about the line of an applied magnetic field. When the frequency of the applied signal is equal to the natural precession frequency of the electron spins, a resonant condition exists under which the electron spins are able to absorb large amounts of energy from the signal and thereby greatly attenuate the signal. Assuming a given resonant D.C. magnetic field, it is characteristic of such ferrites that the signal attenuation is very low below a critical power P_c , but beyond this point the attenuation increases linearly due to the resonance effects and, as a result, the power output remains substantially constant for input power levels beyond the critical power level P_c . Power limiting action is thereby achieved. However, with the ferrite biased at subsidiary resonance, the effectiveness of the ferrite as a power limiter is rather limited at relatively high power levels.

Summary of the invention

It is an object of the present invention to provide a control for the level of power flow in a microwave transmission system over a relatively greater dynamic range.

It is a further object of the present invention to provide a power limiter for operation at microwave frequencies which provides a flat response with very little spike leakage over a relatively large dynamic range of power level.

In accordance with the present invention there is provided a waveguide microwave power limiter which includes a ridged waveguide section having longitudinally therein a block of semiconductor material and a block of ferrite material, and further including a D.C. magnetic biasing field which is tapered along the longitudinal dimension of the waveguide.

Brief description of the drawing

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawing in which:

FIGURE 1 is a perspective view, partially in section, of the present invention;

FIGURE 2 is a sectional view taken along the lines 2-2 of FIGURE 1; and

FIGURE 3 is an explanatory curve.

Description of the preferred embodiment

Referring now to FIGURES 1 and 2 of the drawing, at 10 there is shown a ridge waveguide having the narrow or ridge section 12 filled with a block of semiconductor material 14 and a block of ferrite material 16. The semiconductor block 14, preferably composed of intrinsic silicon, and the ferrite block 16 are substantially of equal dimension so that one half the length of ridged section 12 is comprised of the semiconductor block 14 and the other half thereof is comprised of the ferrite block 16. As shown, both the blocks 14 and 16 are in contact with the top and bottom plates of ridged waveguide section 12. Ferrite block 16 may be composed of YIG polycrystalline material or a suitable nickel-zinc ferrite well known in the art.

A tapered D.C. magnetic field is arranged along the longitudinal dimension of the ridged section 12 by means of a permanent magnet 18 or any other suitable means well known in the art, to provide a gradient longitudinally along the semiconductor block 14 and ferrite block 16. It is to be understood of course that the gradations in the magnitude of the biasing field may be supplied by any one of other well known methods including an electrical solenoid or an electrically energized magnet. Also, the D.C. biasing field is approximately half that required for the main resonance, i.e., the ferrite block 16 is biased substantially to subsidiary resonance as is well known in the art. The microwave energy extends through and propagates longitudinally through the ridge waveguide 10 in the conventional manner. A typical variation of the applied D.C. magnetic field with respect to the longitudinal dimension of the waveguide 10 is shown in FIGURE 3. The gradient in the magnitude longitudinally along semiconductor element 14 only affects the ferrite element 16 and allows the power limiter to operate effectively with random variations of the incident power level and frequency. Insofar as the ferrite block 16 is concerned, at each ferromagnet resonance, there is a specific critical incidence power beyond which any further increase in incident power produces little or no increase in output power. As the incident power level increases, for example to a level 30 db above the critical power level P_c , the ferrite block 16 is no longer effective for proper limiting action and at approximately this level the semiconductor block 14 becomes operative to extend the range of the power limiting action. This is due to the fact that under the influence of the high power microwave electric field, there is created a solid state plasma in the semiconductor block 14, due to the phenomenon known as impact ionization wherein the carriers exhibit the well known "avalanche" breakdown characteristic. Thus under the influence of the microwave electric field, the charge carrier is accelerated until it makes a collision with the lattice atom of the silicon semiconductor block 14, and since the mass of the charge carrier is very small in comparison to the lattice atoms, it is reoriented randomly thereby retaining most of the energy gained from the accelerating field. In its motion through the crystal lattice, the charge carriers are subjected to various loss mechanisms by which its energy is dissipated. If the net loss is below the net gain, "avalanche" breakdown is achieved. With the phenomenon taking place, the conductivity of the silicon block 14 is greatly increased so that there is a substantial reduction in impedance in ridge section 12. As a result, the microwave energy now being propagated at higher power levels will be reflected back towards the incident microwave source so that power

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limitation is now extended beyond the range for which the ferrite block 16 is normally effective.

The invention has been described above with particular reference to a semiconductor of intrinsic silicon. However it will be evident to those skilled in the art that the silicon may possess deep lying impurities such as nickel, gold or cobalt.

While the principles of the invention have been described in connection with the above specific apparatus, it will be apparent to those skilled in the art that various modifications may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A device for limiting the power level of microwave energy comprising a waveguide section, a semiconductor element and a ferrite element mounted along the longitudinal dimension of said waveguide section, said elements being in abutment, and means for providing a tapered biasing magnetic field along said longitudinal dimension.

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2. The device in accordance with claim 1 wherein said waveguide section is a ridge waveguide.

3. The device in accordance with claim 2 wherein said elements are mounted end to end along said longitudinal dimension.

4. The device in accordance with claim 1 wherein said semiconductor element is composed of intrinsic silicon and said ferrite element is composed of YIG polycrystalline material.

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333—24.2, 98; 307—309