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PARAMETRIC MICROWAVE NOISE GENERATOR

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FIG. 1.

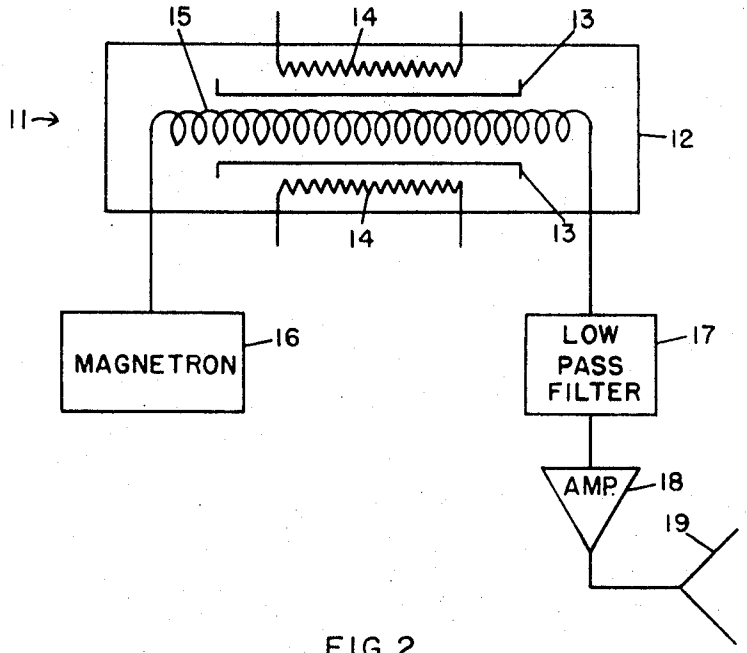
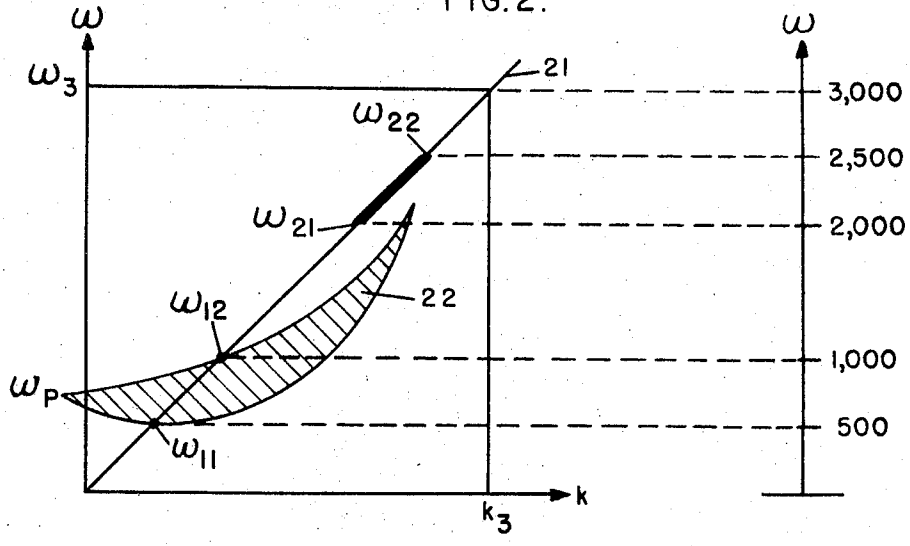


FIG. 2.



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PARAMETRIC MICROWAVE NOISE GENERATOR

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U.S. Cl. 331—78 7 Claims

ABSTRACT OF THE DISCLOSURE

A radio frequency noise generator having a microwave slow-wave structure immersed in a gas discharge plasma is disclosed. A large-signal microwave traveling through the plasma on the slow-wave structure interacts with nonradiative electrostatic plasma oscillations producing idler waves which are parametrically amplified to produce an output noise signal in the microwave frequency range. Adjustment of the pump signal's amplitude and frequency controls the amplitude and bandwidth of the output noise signal.

ORIGIN OF THE INVENTION

The invention described herein was made by an employee of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates generally to a generator for producing radio frequency noise in the microwave frequency range and, more particularly, to such a generator which produces a noise output with a controllable amplitude and frequency spectrum.

Several applications exist wherein one desires a noise signal having given characteristics. For example, during test of electromagnetic wave receivers it is frequently desirable to determine sensitivity of the receiver in the presence of noise. Noise signals also are useful in various types of electronic countermeasure systems.

Previous microwave frequency noise generators have included, for example, systems utilizing electron beam switching tubes, one or more traveling wave tube amplifiers which amplify the noise in the microwave frequency spectrum produced by a gas discharge tube, traveling wave tubes operating without an input signal so as to amplify only their own noise, etc. These previous systems have exhibited either individually or collectively certain certain undesirable characteristics such as nonadjustable output noise signal amplitudes and frequency spectrum, insufficient noise output power densities or extensive signal amplification requirements and failure to provide a completely random thermally generated noise signal.

The object of this invention, therefore, is to provide a relatively simple radio frequency noise generator capable of producing a microwave noise signal of adjustable amplitude and frequency spectrum.

A primary feature of this invention is the provision of a radio frequency noise generator including a slow-wave structure, a gas discharge plasma generator and a large-signal pump wave generator for producing pump waves at a microwave frequency much higher than the resonant frequency of the plasma provided by the plasma generator. Pump waves propagated on the slow-wave structure couple with the electrostatic modes of oscillations in the plasma medium through a nonlinear coupling mechanism. As a result of the nonlinear coupling between the externally applied electromagnetic pump waves

and the spontaneously occurring oscillations in the plasma, idler waves representing difference frequency components are generated parametrically in the microwave frequency range. Furthermore, if the phase velocities of the three waves are properly adjusted, the electrostatic and the idler waves are amplified according to the principal of the traveling-wave parametric amplifier. Thus, the entire spectrum of the normally nonradiative electrostatic plasma oscillations are converted into radiative noise represented by the parametrically amplified idler wave output of the slow-wave structure.

Another feature of this invention is the provision of a radio frequency noise generator of the above featured type wherein the slow-wave structure is a helix and the pump signal generator is a voltage tunable magnetron. The helix slow-wave structure is particularly well suited for this application as is the voltage tunable magnetron which permits selective adjustment of both the amplitude and spectrum center of the noise output represented by the idler waves.

Another feature of this invention is the provision of a radio frequency noise generator of the above featured type including a low pass filter circuit connected to the output of the slow-wave helix. The filter circuit removes the pump signal from the output leaving a random noise output represented only by the idler signal.

These and other features and objects of the invention will become more apparent upon a perusal of the following specification taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a schematic diagram illustrating a preferred radio frequency noise generator embodiment; and,

FIGURE 2 is a graph illustrating the phase velocity relationships and the spectral relationships between the waves generated in the generator of FIGURE 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGURE 1 there is shown the noise generator **11** including the vacuum tight envelope **12** containing cesium atoms at a pressure of, for example, between 10^{-3}–10^{-4} mm. Hg. Disposed within the envelope **12** are the spaced apart gas discharge initiating plates **13** formed of a suitable material such as tungsten or tantalum. Heating of the plates **13** is provided by the adjacent heater elements **14**.

Straddled by the plates **13** within the envelope **12** is the slow-wave helix structure **15**. The input of the slow-wave structure **15** is connected to the voltage tunable magnetron **16** and its output is connected to the series combination of the low pass filter network **17**, the amplifier **18** and the antenna **19**. After energization of the heater elements **14**, cesium atoms contacting the hot plates **13** are ionized generating a quiescent plasma which immerses the slow-wave helix structure **15**.

Operation of the high frequency noise generator **11** will be explained in connection with the graph of FIGURE 2 wherein frequency ω is plotted on the vertical axis and wave number k is plotted on the horizontal axis. The solid line **21** approximates the dispersion characteristics (ω—k relationship) of the slow-wave helix **15** and the shaded area **22** represents the dispersion characteristics of the electrostatic waves in the plasma generated by the plates **13**. The plasma dispersion characteristic **22** is determined by the density and temperature of the plasma electrons and these parameters preferably are adjusted such that the plasma resonant frequency ω_p is at least one order of magnitude lower than the frequency-band in which the noise output is desired. The magnetron **16** is adjusted to provide on the slow-wave structure **15** a large-signal pump wave at a microwave frequency ω_3 much higher than the plasma frequency ω_p. Having phase velocities substantially

equal to that of the signal pump wave, the plasma's electrostatic oscillations within the frequency band from ω_{11} to ω_{12} will interact with the pump signal producing idler waves in the frequency spectrum between ω_{21} and ω_{22}. Because of the substantially straight line dispersion characteristic of the helix structure **15**, these idler waves also have phase velocities substantially equal to that of the pump signal and are parametrically amplified thereby.

Thus, in a particular example indicated in FIGURE 1, the nonradiative electrostatic plasma oscillations in the frequency spectrum between 500 and 1000 megacycles are converted and amplified by a pump signal at a frequency of 3000 megacycles into radiative idler waves in a frequency spectrum between 2000 and 2500 megacycles. Obviously, the center of the idler wave bandwidth is directly dependent upon the frequency of the pump signal. Also, since the idler waves are amplified parametrically, the amplitude of the noise output represented thereby will depend on both the length of the slow-wave structure and the input pump power. Therefore, both amplitude and frequency spectrum of the noise output can be directly controlled by adjustment of the magnetron **16** to produce a pump signal of given input power and frequency. After elimination of the pump signal in the low pass filter **17**, the noise output from the antenna **19** is limited to the desired frequency spectrum represented by the idler wave output.

Although the substantially straight line dispersion characteristics of the slow-wave helix structure is particularly desirable, it will be obvious that other slow-wave structures could be utilized within the scope of the invention provided that the conditions required for parametric amplification are satisfied. The conditions will be satisfied if the relationships $\omega_e+\omega_i=\omega_o$ and $k_e+k_i=k_o$ are both satisfied where ω_e, ω_i and ω_o represent frequencies and k_e, k_i and k_o represent wave numbers, respectively, of the electrostatic waves, the idler waves and the pump waves. In addition, gas discharge plasmas other than a cesium thermal discharge could be utilized as a medium in which the required electrostatic waves are generated.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings.

What is claimed is:

1. A radio frequency noise generator comprising a vacuum sealed envelope, microwave slow-wave structure means disposed within said envelope, plasma generating means disposed within said envelope and adapted to generate a gas discharge plasma therein, and signal generator means for producing on said slow-wave structure electromagnetic pump waves which extract random electrostatic energy from the gas discharge plasma.

2. A radio frequency noise generator according to claim **1** wherein said random electrostatic energy is extracted as parametrically amplified idler waves produced by interaction between the pump waves and the electrostatic plasma oscillations.

3. A radio frequency noise generator according to claim **2** wherein said signal generator produces a pump wave frequency substantially higher than the resonant oscillation frequency of the gas discharge plasma so as to provide an idler wave output spectrum in the microwave frequency range.

4. A radio frequency noise generator according to claim **3** wherein said signal generator provides a selectively variable pump signal frequency so as to permit control of the idler wave output spectrum.

5. A radio frequency noise generator according to claim **4** wherein said signal generator comprises a voltage tunable magnetron.

6. A radio frequency noise generator according to claim **5** wherein said slow-wave structure means comprises a helix.

7. A radio frequency noise generator according to claim **6** including a low pass filter circuit connected to the output of said slow-wave structure and adapted to eliminate the pump signal component from the slow-wave structure output.

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