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VARIABLE FREQUENCY OSCILLATOR

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FIG. 1

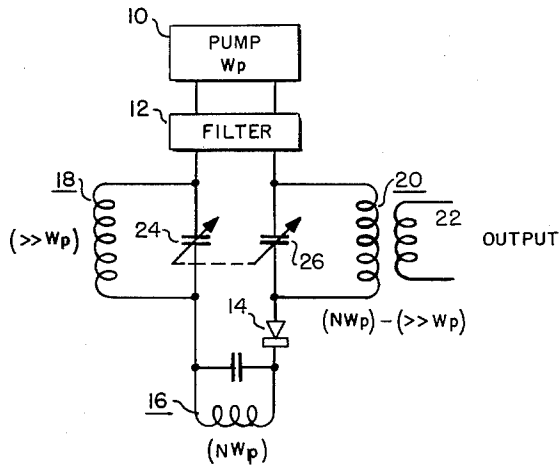
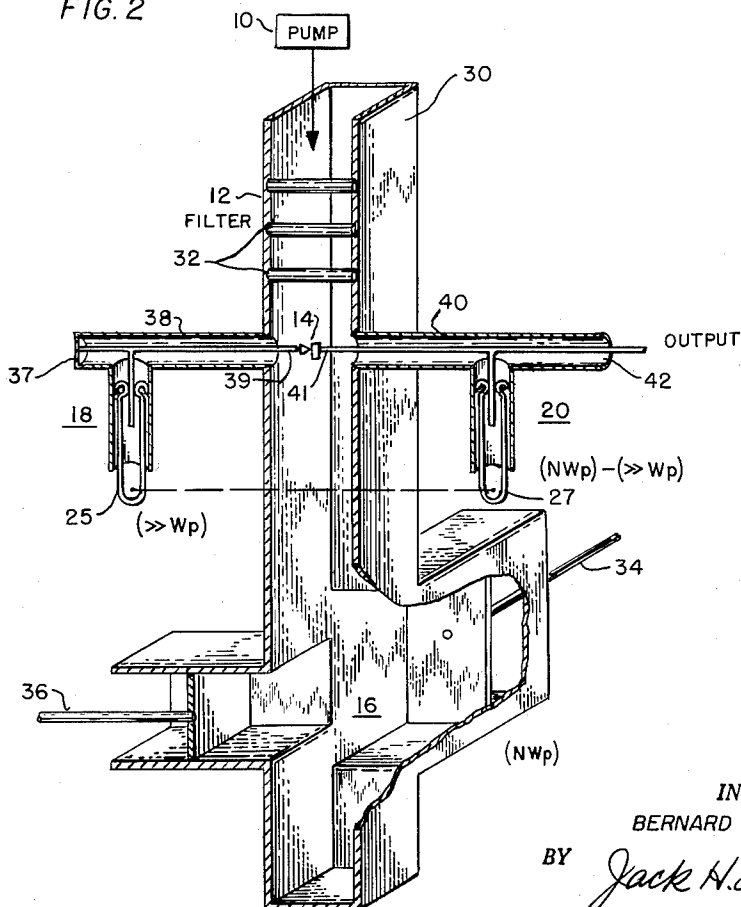


FIG. 2



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VARIABLE FREQUENCY OSCILLATOR

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2 Claims. (Cl. 321-69)

(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 frequency generators and particularly to frequency generators operating over extreme ranges. More particularly, this invention relates to frequency generators whose output is produced by the combination of two alternating current signals; one fixed and one variable.

Most frequency generators utilize some form of conventional oscillator, operated in one of its harmonic modes, and variable over a given band of frequencies. Some of the frequency generators derive their output from the combination of two separate frequencies, and these utilize two separate oscillators, individually powered, and with no interaction prior to the mixing stage.

These frequency generators are limited in efficiency by the requirements of the two separate oscillators and auxiliary harmonic generating circuitry, and limited in frequency range by the given band coverage of the variable frequency oscillator and by the harmonic content of the conventional oscillators employed.

It is therefore an object of this invention to provide an improved frequency generator.

It is a further object of this invention to provide an improved frequency generator of the mixer type.

It is a further object of this invention to provide an improved frequency generator utilizing harmonics of a parametric amplifier pump and variable frequency oscillations generated through the action of a non-linear reactance.

These and other objects are accomplished by connecting a high frequency, parametric-amplifier pump, through a non-linear reactance, to a tank resonant at one of the harmonics of the pump, and connecting a first, variable-frequency tank into the same circuit. The tank is made to oscillate through the negative resistance action of the non-linear reactance, with power supplied by the energy available from the pump source.

The first variable-frequency tank oscillations combine with the harmonic of the pump frequency signals in the non-linear reactance to produce a product frequency that energizes a second, variable-frequency tank tuned to resonate at that product frequency. An output circuit coupled to the second, variable-frequency tank circuit provides a product frequency signal as the output of the signal generator.

This invention will be better understood and other and further objects of this invention will become apparent from the following specification and the drawings of which;

FIGURE 1 shows a combination block and circuit diagram of the essential elements of this invention; and

FIGURE 2 shows a cross section of the physical layout of the elements in a typical embodiment of this invention.

Referring now more particularly to FIGURE 1, the circuit includes a source of pump energy 10 connected through a filter 12 and a non-linear reactance 14 to a resonant tank 16. The tuned, variable-frequency tanks 18 and 20 are also connected into this circuit. The control elements of these two variable frequency tanks are ganged together.

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The FIGURE 2 shows a cross section of physical embodiments of the circuit elements of FIGURE 1, oriented and interconnected to function according to the teachings of this invention.

The elements in FIGURES 1 and 2 are similarly positioned, and similarly numbered, in order that they can be more easily identified.

The elements of FIGURE 2 include the pump 10 which connects through the waveguide filter section 12 and the varactor diode 14 to the tuned wave-guide section 16. The tuned, variable-frequency, tanks are provided by the tuned coaxial stubs 18 and 20.

In operation, the pump 10 supplies power to the whole circuit at a relatively high frequency and at a power level substantially higher than that of the desired power output. The power is supplied to the circuit through the filter 12, a band pass filter, tuned to the frequency of the pump, to keep the many assorted harmonic and product frequencies, that are being generated within the circuit, from being fed back to the pump.

Since the resonant tank 16 is tuned to a harmonic of the pump frequency, it is obvious that it will be energized by the harmonic components of the pump frequency and will build up an alternating current signal at the harmonic frequency. The harmonic components of the pump frequency will be produced by the effect of the non-linear diode 14.

The non-linear diode also sets up a negative resistance condition that causes the tuned circuit 18 to be unstable and, drawing power from the pump source of energy, to oscillate at the resonant frequency of this tank. This is a well known phenomenon that may appear in conventional parametric amplifiers. However, in parametric amplifiers, the circuit that is tuned to the incoming frequency must be held in a non-oscillating condition in order to receive and amplify the incoming signals.

The non-linear diode also has a well known mixing action that, in this circuit, will combine the signals, built up in the fixed frequency and in the variable frequency tuned circuits, to produce the usual sum and difference frequency products. The difference product of the two signals energizes the third tuned circuit 20, which is also variable and is tuned to be resonant at the difference frequency.

The output of the signal generator, which is at the difference frequency, is taken from this third tuned circuit as shown by the inductively coupled coil 22 of FIGURE 1. In practice this output may be taken from any coupling, such as the extension 42 of the coaxial cable that couples the variable tuned circuit to the diode and the waveguide section.

The harmonic of the pump frequency is a constant and the circuit 16 tuned to this frequency is also constant. No variation is possible, other than the choice of different harmonics of the pump frequency or the variation of the pump frequency itself. The tuned circuit 18, that is made to oscillate through the action of the negative resistance of the non-linear diode, and the excessive power available from the pump, is variable and variations of this frequency cause variations in the difference or intermediate frequency which appears in the tuned circuit 20, which is also variable.

The frequencies of the self resonant tuned circuit 18 and of the intermediate frequency tuned circuit 20 have, of course, a constant relationship and their variable tuning elements are ganged together for coupling to a common control device. The variation in the frequencies of the two tuned circuits for a change in the mechanical control of the tuning elements must be such that they will maintain a constant relationship with respect to each other and to the fixed frequency of the remaining tuned circuit.

In other words, these tuning elements must track each other in the well known manner of the radio frequency and the oscillator tuning elements of a superheterodyne circuit.

The variable elements of the circuit of FIGURE 1 are shown as the variable condensers 24 and 26. The mechanical coupling is shown by the dashed line between the two. In practice, at the frequencies covered by this signal generator, the variable elements would be shorting bars such as 25 and 27 of the tuned coaxial stubs 18 and 20 seen in FIGURE 2. Any mechanical coupling that will provide motion in the correct direction and at a suitable rate will be applicable here. The coupling is indicated by the dashed lines between 25 and 27.

The energy from the pump 10 is coupled to the circuit through the waveguide 30 of FIGURE 2 in a well known manner. The filter 12 consists of the bars 32 through the waveguide. The tuned circuit 16 consists of the E-H tuning stubs 34 and 36 at the closed end of the waveguide 30.

The variable frequency tank circuits 18 and 20 are coupled to the waveguide 30 through the coaxial lines 38 and 40 respectively. The coaxial lines are positioned opposite to each other and permit a convenient mechanical and electrical coupling to the waveguide, to the non-linear diode, and to each other. The non-linear, or varactor diode 14 has its opposing electrodes connected between the opposing projections 39 and 41 of the center conductors of the coaxial lines 38 and 40.

The unused end 37 of the coaxial line 38 is terminated by shorting the conductors together. The output is taken from the other end 42 of the opposing coaxial line 40. This line can be extended as far as may be necessary to be coupled to any suitable electrical device so that the signals generated in the circuit may be utilized in a well known manner.

In this typical embodiment of this invention, the waveguide and coaxial lines, and the means for coupling them together and to the source of pump energy and utilization circuits are well known. The means for tuning them to provide resonant circuits, or for filtering the signals passing through them, are also well known. Other well known methods for performing the same functions may be suitable for use here and will be obvious to those skilled in the art.

In this typical embodiment of this invention, the klystron is a 2K41 of the Sperry Gyroscope Corp., and is operated at a frequency of 2,700 mc. The variable capacity diode is an MA4298 manufactured by the Microwave Associates Inc. The resonant circuit 16 is tuned to a frequency of 10,800 mc. and the variable frequency circuits 18 and 20 are tuned to frequencies that add up to this sum at all times. The frequency of the variable tuned circuit 18 is normally substantially less than the frequency of the pump.

What is claimed is:

1. A signal generator comprising a klystron tuned to a first frequency; a rectangular waveguide section including a band-pass filter at said first frequency coupled to said klystron; E-H tuning stubs, tuned to a second frequency, coupled to said wave guide section; a first coaxial cable, tuned to a third frequency, having a center conductor projecting within one side of said waveguide section; a second coaxial cable, tuned to a fourth frequency, having a center conductor projecting within the opposing side of said waveguide section; a varactor diode connected between the center conductors of said first and second coaxial cables; and an output circuit coupled to said second coaxial cable; said second frequency being the fourth harmonic of said first frequency, said third frequency being less than said first frequency, and said fourth frequency being the difference between said second and said third frequencies.

2. A signal generator as in claim 1, wherein said first and second coaxial cables have mechanical tuning means, and said mechanical tuning means are mechanically ganged together to maintain said fourth frequency at the difference between said second and said third frequencies throughout the tuning ranges of said coaxial cables.

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