July 11, 1939. E. GERHARD 2,165,847

METHOD OF MODULATING ULTRA SHORT WAVES

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Fig. 1

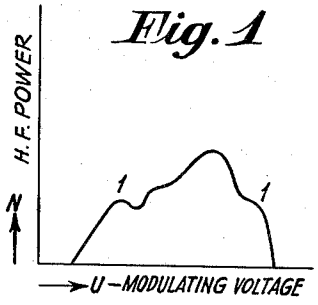


Fig. 2

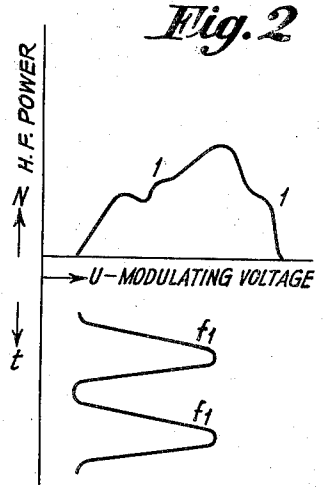


Fig. 3

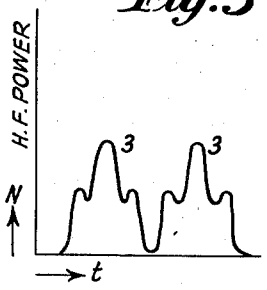


Fig. 4

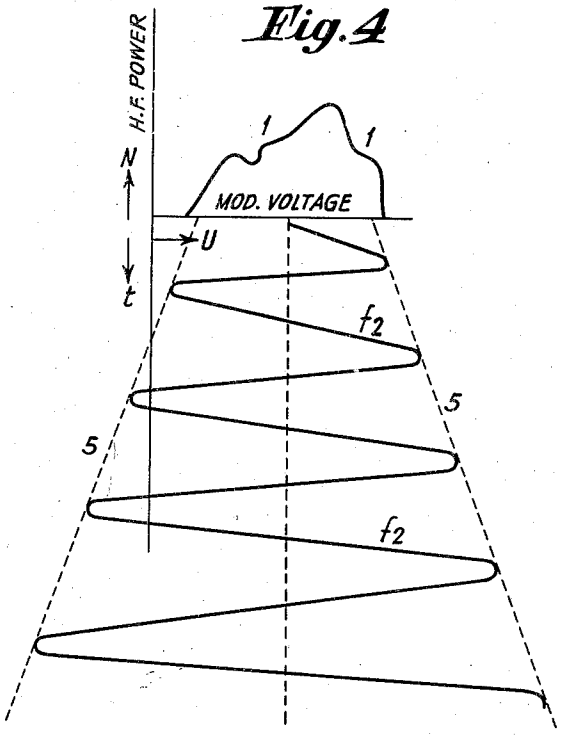
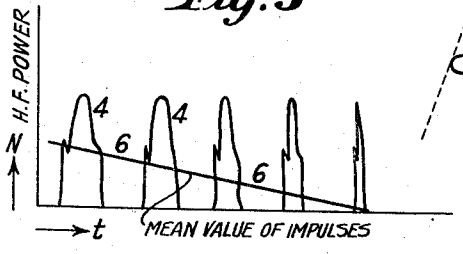


Fig. 5



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Fig. 4a

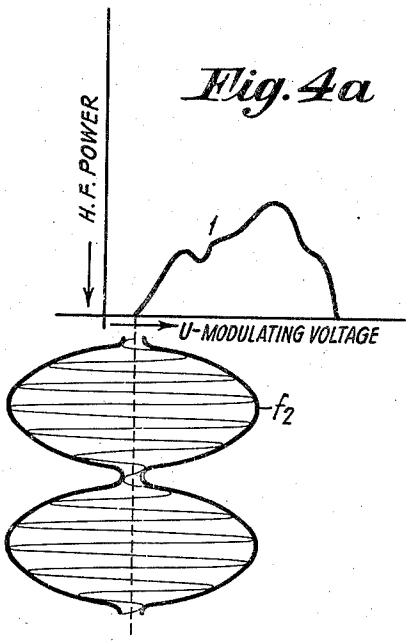


Fig. 5a

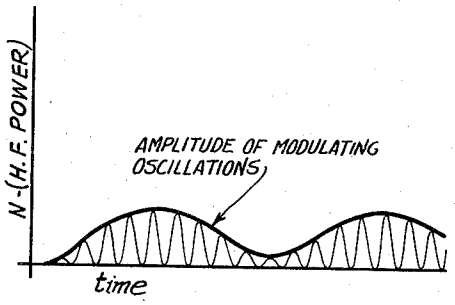
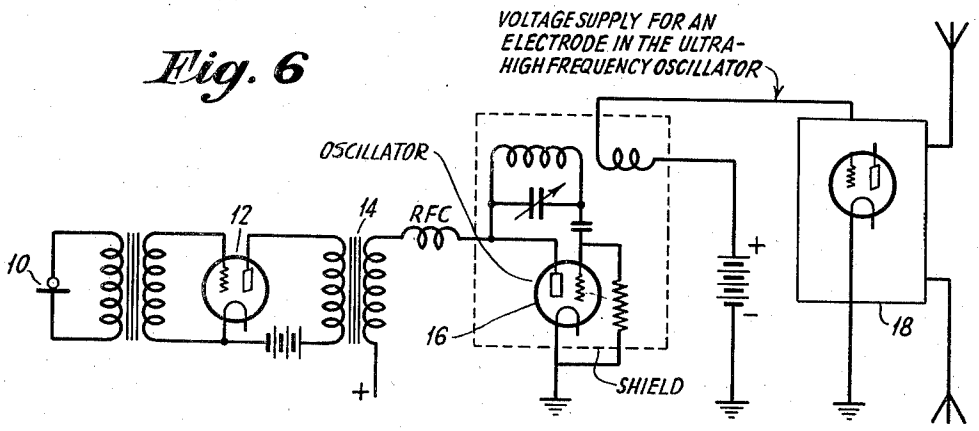


Fig. 6



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METHOD OF MODULATING ULTRA SHORT WAVES

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2 Claims. (Cl. 179—171)

The present invention is concerned with a modulation method for use with ultra-short waves such as might be produced with a Barkhausen oscillator or one with similar high frequency characteristics.

Various modulation methods have been disclosed in the prior art for ultra-short waves. For instance, it has been suggested to modulate ultra-short waves by radio-frequency energy which, in turn, is modulated by low frequency energy. In order to avoid distortions it is necessary in all modulation methods known in the prior art to work upon a rectilinear portion of the modulation characteristic. However, the straight part of the characteristics happens to be very reduced in the case of ultra-short wave generators in consequence of which only small modulation percentages are obtainable without distortion.

In describing my new method, reference will be made to the drawings in which curves or graphs referred to as Figures 1, 2, 3, 4, 4*a*, 5, and 5*a* illustrate the modulator characteristics and wave characteristics of the energies used in my novel method and to Figure 6 which illustrates one circuit arrangement including the main or principal elements for carrying out the method of my invention.

Figure 1 shows, for instance, the modulation characteristic of an ultra-short wave generator. N stands for the ultra-high frequency power and U for the anode or other electrode potential of the generator tube. In Figure 2 is shown the identical modulation characteristic I. The transmitter radio frequency power in Figure 2 is to be modulated by the sinuous oscillation f_1 of lesser frequency. The resulting modulation of the ultra-high frequency power is shown in Figure 3. Curve 3 in comparison to the curve f_1, of the modulating voltage, shown below in Figure 2, is entirely distorted. Such distortion could be avoided if the amplitude of the modulating frequency f_1 were reduced to one-fourth, for in that case it would no longer go beyond the hump on the left-hand side of the modulation characteristic I of Figure 2.

According to an embodiment of this invention the ultra-short waves which I will refer to as f_3 are acted upon by longer high frequency waves referred to as f_2, which are, in turn, modulated by low frequency waves or signal potentials f_1, in such a way that during each half-period or alternation of the high frequency wave f_2 one or two or a plurality of energy impulses of the ultra-high frequency f_3 are produced whose duration is a function of the amplitude of the radio frequency oscillations f_2, the maximum amplitude of the ultra-short waves f_3 being, however, in this scheme independent of the amplitude of the high frequency f_2.

Figures 4 and 5 illustrate the operation of the modulation method here disclosed. The high frequency oscillation f_2 in Figure 4 covers the entire modulation characteristic I of the ultra short wave generator producing frequency f_3. In Figure 5 are shown the ensuing ultra-short wave impulses 4 whose energy content is an inverse function of the amplitude of the high frequency f_2. If the high frequency f_2 is in addition modulated by audio frequency potentials f_1 as indicated, for instance, by line 5, in Figure 4, then also the median value of the ultra-short wave energy pulses represented by curves 4 is subject to low frequency modulation. Thus, there results the median line 6 in Figure 5. Inasmuch as in this arrangement the ultra-short wave energy f_3 becomes less as amplitude of the high frequency energy f_2 increases, the low frequency or signal modulation of the radio frequency wave f_2 must be controlled in a negative sense by the modulating potentials f_2, in other words, the amplitudes of the high frequency f_2 must be so much lower, the greater the audio frequency potential. This is indicated by lines 5 of Figure 4 which indicate modulation of a small number of cycles of f_2. Nevertheless the lowest amplitudes of f_2 modulate f_3 throughout its entire range. This desired relation between the amplitude of the audio frequency potentials and the amplitude of f_2 may be obtained by properly connecting the circuit leads such as those to the modulation transformer or reversing said leads if they are not connected in the proper sense, or by other similar expedients. When the connections are proper the audio frequency envelope of the modulated carrier f_2 is reversed, and when the signal is positive more energy will be radiated than on the negative half, as shown by Figure 5. Thus both positive and negative halves of the signal are useful in controlling the carrier energy. On the negative half of the signal f_2 is larger in amplitude and hence the energy content of f_3 is correspondingly smaller. The audio frequency modulation of the ultra-short waves f_3 is entirely independent of the shape of the modulation characteristic I of the ultra-short wave generator. If f_2 were of small amplitude relative to the full modulation range then f_3 would vary in amplitude between a fixed upper limit and some lower value. If f_2 has an

amplitude that is equal to or greater than the modulation range through which f_3 can be modulated, and it has, as indicated in Figure 4, the power output f_3 is zero (tube cut off) except for a small portion of the cycle (f_2) which lies within the modulation range of voltages. This portion of the cycle of f_2 at which f_3 is cut off becomes larger as f_2 increases and vice versa. This is shown in Figure 5 where the amplitudes of the envelopes of f_3 are constant and the narrowest f_3 power graphs designate the higher f_2 amplitudes where the periods of time f_3 is cut off by f_2 are longest. In other words, the basic idea of this invention will be useful wherever a modulation characteristic comprises such a reduced linear portion that the percentage modulation would be very low in the conventional working methods if distortion is to be avoided. In other words, the chief fields of use are with Habann tubes, magnetrons, and the like.

By reducing the normal direct current potential on which the modulated high frequency modulating wave f_2 is superposed the f_3 output may be made linear in amplitude and power with respect to the audio frequency input. This method of operation is illustrated in the curves of Figures 4*a* and 5*a*. Here negative modulation of f_2 is not necessary.

In Figure 6 which illustrates a circuit arrangement for carrying out the invention, modulating potentials from 10 act through modulation amplifier 12 and transformer 14 to modulate oscillator 16. 16 may produce oscillations of a frequency f_2. The output of 16 modulates the ultra-high frequency oscillator 18 by controlling the potential supplied to an electrode of a tube generator therein. This electrode may be the grid in the case of Barkhausen oscillators, or the anode. As pointed out hereinbefore, other types of oscillators such as a magnetron oscillator, or dynatron, or any oscillator having as a characteristic feature an oscillatory power output which ceases when the supply voltage exceeds a certain value may be used at 18. 18 may generate a frequency f_3 which when modulated is supplied to any utilization circuit. To operate the circuit of Figure 6 in accordance with the method illustrated graphically in Figures 4 and 5 the normal potential on 18 establishes a normal ultra high frequency carrier f_3. Now when f_2 is impressed from 16 on 18 the output of 18 is reduced for each half period of the wave. If f_2 is of very small amplitude relative to the range of potentials that are to be applied to the modulator stage 18 without reducing the output of the same to zero, f_3 will merely vary in amplitude between a fixed upper limit and some lower value as shown in Figure 3. However, if f_2 has a much larger amplitude as shown in Figure 4, the output of 18 (f_3) is modulated to zero except for a portion of the cycle of f_2 which lies within the range of voltages insufficient to modulate 18 to zero output. The duration of f_2 voltages insufficient to modulate 18 (f_3) to zero is greatest for the lower values of f_2. See Figures 4 and 5. And decreases as the amplitudes of f_2 increase so that for smaller values of f_2 we get larger output (energy content of f_3) from 18 and for larger values of f_2 smaller output from 18. This has been shown graphically in Figure 5 wherein the narrowest power graphs indicate the higher amplitudes of f_2.

However, the idea underlying the invention is not exhausted by the exemplified embodiments here shown.

I claim:

1. The method of signalling by means of ultra high frequency oscillations, oscillations of lower frequency and of amplitude which is great relative to the amplitude of said ultra high frequency oscillations and voltages which vary at signal frequency which includes the steps of, modulating said oscillations of lower frequency in a negative sense in accordance with said voltages of signal frequency, and impressing said modulated oscillations of lower frequency on said ultra high frequency oscillations to interrupt the flow thereof during a portion of each cycle of the modulated oscillations of lower frequency which is a function of the amplitude of the modulated oscillations of lower frequency.

2. The method of signaling by means of ultra-high frequency waves which consists in, producing a relatively low frequency oscillatory voltage, modulating the amplitude of said voltage in accordance with signal potentials, superimposing said modulated relatively low frequency oscillatory voltage on a direct current voltage and generating, by means of said superimposed voltages, ultra-high frequency oscillations to produce an ultra-high frequency power output which increases from zero to a maximum and back again to zero as the superimposed voltages increase from a first value to a second value, the unmodulated amplitude of said relatively low frequency oscillatory voltage being greater than half the difference between said first and second values at all phases of the cycle of modulation of said relatively low frequency oscillatory voltage by said signal potential.

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