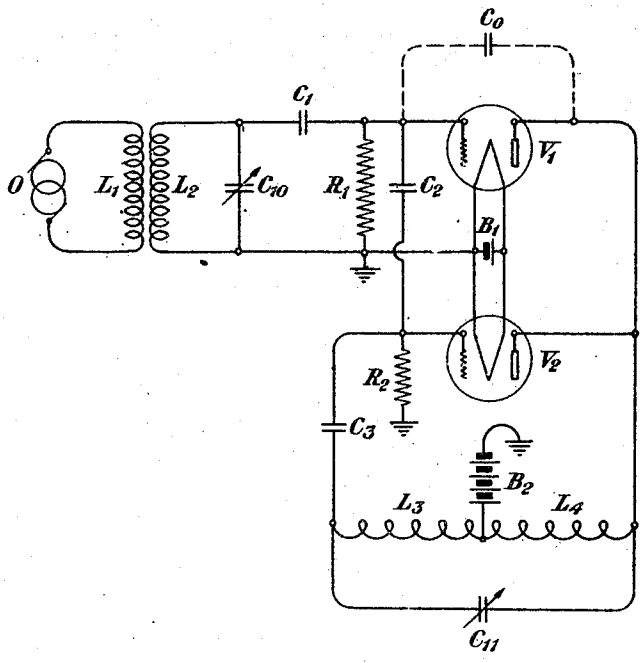
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HARMONIC PRODUCER

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HARMONIC PRODUCER

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This invention relates to alternating current generators, and more particularly to arrangements for efficiently generating high frequency energy at high energy levels.

High frequency energy may be generated by any well known oscillator which may be, for example, of vacuum tube type. High frequency energy so generated often is of rather low energy level and of somewhat variable frequency. Yet such high frequency energy may be maintained constant in frequency only with considerable difficulty with the aid of additional apparatus. Moreover, the energy level may be raised by adding several stages of amplifiaction to the oscillator. Nevertheless, a system including such an oscillator and several stages of amplification is known to be very inefficient

Accordingly, it is one of the objects of this invention to produce high frequency energy at high energy levels with higher efficiency than has heretofore been possible.

It is another object of this invention to so relate a source of high frequency energy of definite frequency and of low level to a source of high frequency energy of substantially equal frequency and of high level that the energy of definite frequency will synchronize the energy of substantially equal frequency and, moreover, become integrated with it.

And it is a further object of this invention to relate a low frequency oscillator to a vacuum tube system acting as a distortion device to produce a harmonic of the low frequency energy, so that the energy of the harmonic of the low frequency may be employed to synchronize, and to become integrated with, a wave of high frequency and of high energy level.

While this invention will be pointed out with particularity in the appended claims, the invention itself, both as to its further objects and features, will be better understood from the detailed description hereinafter following, when read in connection with the accompanying drawing, showing one embodiment of the invention merely for the purpose of illustration.

Referring to the drawing, an alternating current oscillator or generator is designated by the reference character O, which oscillator or generator supplies current of fundamental frequency to the system. It will be understood that while this generator has been shown as a simple alternating current generator merely for the purpose of illustration, any other oscillator well known in the art may equally well be employed instead thereof, within the scope of this invention. The oscillator O is connected to an inductance L_1, which inductance is coupled to another inductance L_2. The inductance L_2 is employed to transmit the fundamental frequency of the oscillator O to a vacuum tube circuit which includes a vacuum tube V_1 working on the thermionic principle, including an anode, a cathode and a grid or control electrode. More specifically, the inductance L_2 transmits the fundamental frequency of the oscillator O to the grid and cathode of the vacuum tube V_1 through a condenser C_1 and a resistance R_1, the condenser C_1 and the resistance R_1 having such a time constant as to render the grid highly negative with respect to the cathode so that the vacuum tube operates on the lower portion of its characteristic plate current-grid voltage curve. By so operating the vacuum tube, harmonics of the fundamental frequency are produced, one of which will be utilized to synchronize current of substantially equal frequency, as will be shown more fully hereafter. A variable condenser C_{10} is in parallel relationship with the inductance L_2 and serves the two-fold purpose of tuning the circuit to the frequency of the oscillator O, and of providing a suitable impedance relationship between the oscillator O and the grid and cathode of the vacuum tube V_1. A condenser C_0 represents the inherent capacity between the anode and grid electrode of the vacuum tube V_1, including the capacity of the leads connected thereto.

Another vacuum tube circuit is employed herein to produce high frequency energy at a comparatively high energy level, the frequency of which may be somewhat different

from the frequency of one of the harmonics of the fundamental frequency produced by the vacuum tube circuit described hereinabove. This circuit comprises another vacuum tube V_2, also working on the thermionic principle, including also an anode, a cathode, and a grid or control electrode. The cathodes of the vacuum tubes V_1 and V_2 are both heated to an electron-emitting temperature by current from a battery B_1. Two mutually reactive inductances L_3 and L_4 may be considered connected, respectively, between the grid and cathode and the anode and cathode of the vacuum tube V_2. These inductances are shunted by a variable condenser C_{11} so that a tuned circuit is provided, having substantially no reactance at a frequency which may be substantially equal to, though somewhat different from, the frequency of a desired harmonic of the oscillator O. A battery B_2 supplies space potential to the anodes of the vacuum tubes V_1 and V_2 through inductance L_4. A resistance R_2 is connected between the grid electrode of the vacuum tube V_2 and ground so as to provide the proper bias for the grid electrode, to thereby substantially prevent the production of harmonics of the frequency sustained by the latter vacuum tube circuit. A condenser C_2 is connected between the grid of the vacuum tube V_1 and the grid of the vacuum tube V_2, and acts to neutralize the inherent capacity between the anode and grid electrode of the vacuum tube V_1 represented by the condenser C_0. Consequently the current flowing through the condenser C_2 is substantially equal in magnitude and opposite in phase to the current flowing within the vacuum tube V_1 by virtue of the inherent capacity between the anode and the grid electrode of said vacuum tube. Another condenser C_3 is connected between the left-hand terminal of the inductance L_3 and the grid electrode, and prevents the potential of the battery B_2 from being applied to the grid electrode.

The arrangement of this invention operates as follows: Current of a fundamental frequency is generated by the oscillator O. This current is transmitted to the input circuit of the vacuum tube V_1 in which the grid electrode is maintained highly negative with respect to the cathode so that the vacuum tube may act as a distortion device to produce a harmonic, or harmonics, of the fundamental frequency of the oscillator O. This harmonic, or harmonics, flows between the anode and cathode of the vacuum tube V_1. The vacuum tube circuit, including the vacuum tube V_2, acts as an oscillator to sustain oscillations of a high frequency and of high energy level, the frequency of which may be substantially equal to, though somewhat different from, the frequency of the harmonic produced by the vacuum tube V_1 acting as a distortion device. Moreover, the vacuum tube oscillator V_2 is rendered substantially free from the production of harmonics of its characteristic frequency by the provision of the resistance R_2 which maintains the grid electrode of the vacuum tube V_2 suitably biased with reference to its cathode. However, the output circuits, which include the anodes of the vacuum tubes V_1 and V_2, are tied together so that these vacuum tubes are effectively in parallel relationship with each other. Consequently, current generated by the vacuum tube oscillator V_2 will be synchronized by the harmonic of the fundamental frequency produced by the vacuum tube V_1, assuming of course that the output circuit of the vacuum tube V_1 is tuned to a frequency which is approximately equal to the frequency of the current generated by the vacuum tube oscillator V_2. If, for example, the frequency of the generator O is substantially equal to half of the frequency of the current generated by the vacuum tube oscillator V_2, then at every second cycle current in the output circuit of the vacuum tube V_1 will be transmitted to the output circuit of the vacuum tube V_2. Thus, it can readily be understood that the current of a harmonic of a fundamental frequency will be utilized to synchronize, and to become integrated with, current of an oscillator having a frequency substantially equal to that of the harmonic.

While this invention has been shown in one particular embodiment merely for the purpose of illustration, it is to be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. The combination of two vacuum tubes the output circuits of which are in parallel relationship with each other, one tube having a fundamental frequency impressed thereon, means whereby the other tube may generate a frequency which is a harmonic of the fundamental frequency, and means associated with the first tube for producing the same harmonic of the fundamental frequency, the effects of said tubes being effectively synchronized.

2. The combination of a vacuum tube circuit including a cathode, an anode and a control electrode, an oscillator of fundamental frequency, a resistance connected between the control electrode and the cathode of said vacuum tube circuit of such magniture that the control electrode becomes highly negative with respect to the cathode when energy of the fundamental frequency is impressed thereon, means for impressing the

fundamental frequency on said vacuum tube circuit, said vacuum tube circuit acting to produce a harmonic of the fundamental frequency, a second vacuum tube circuit also including a cathode, an anode and a control electrode, two mutually reactive inductances one interconnecting the control electrode and the cathode and the other interconnecting the anode and the cathode of the second vacuum tube circuit, a capacitative reactance of suitable magnitude so related to said inductances as to bring them into resonance at a frequency substantially equal to the harmonic of the fundamental frequency, and means interconnecting the anodes of said vacuum tube circuits so that the currents flowing between said anodes and the corresponding cathodes are brought into synchronism.

3. The combination of a generator of a fundamental frequency, a vacuum tube generator of a harmonic of the fundamental frequency, and means including a vacuum tube for converting the fundamental frequency into a harmonic of the fundamental frequency equal to the harmonic generated by the vacuum tube generator, the output circuits of the vacuum tube of said converting means and of the vacuum tube generator being interconnected in parallel relation whereby stabilization of the harmonic of the fundamental frequency will take place.

4. The combination of a first vacuum tube oscillator capable of generating current of a high frequency, a second oscillator capable of generating current of a frequency which is fundamental to the frequency of the first oscillator a vacuum tube circuit acting as a distortion device to produce a harmonic of the fundamental frequency substantially equal in frequency to the high frequency generated by the first oscillator, and means interconnecting the plate and filament electrodes of the vacuum tube of the first oscillator in parallel relation with the plate and filament electrodes of the vacuum tube circuit acting as a distortion device so that the frequency of the first oscillator will be in synchronism with the harmonic produced by said vacuum tube circuit.

5. The combination of a three-element vacuum tube system generating a wave of definite frequency of low energy level, another three-element vacuum tube system generating oscillations of high energy level of any frequency within definite frequency limits, the frequency of said wave of low energy level lying within said definite frequency limits, and means coupling the output circuits of said vacuum tube systems in parallel relation for bringing the oscillations of high energy level into synchronism with the oscillations of definite frequency of low energy level.

6. The combination of a source of current of low frequency, means including a three-element vacuum tube for producing a harmonic of the current of said low frequency having a definite position in the frequency spectrum, means including another three-element vacuum tube for producing a wave substantially equal in frequency to the frequency of the harmonic of the low frequency wave, and means interconnecting the output circuits of said vacuum tubes in parallel relation for synchronizing and integrating the respective effects of said harmonic of definite frequency and the wave of substantially equal frequency.

In testimony whereof, I have signed my name to this specification this 21st day of September, 1926.

RUSSELL S. OHL.