Jan. 6, 1942. W. R. HEWLETT 2,268,872

VARIABLE FREQUENCY OSCILLATION GENERATOR

Filed July 11, 1939

FIG. 1.

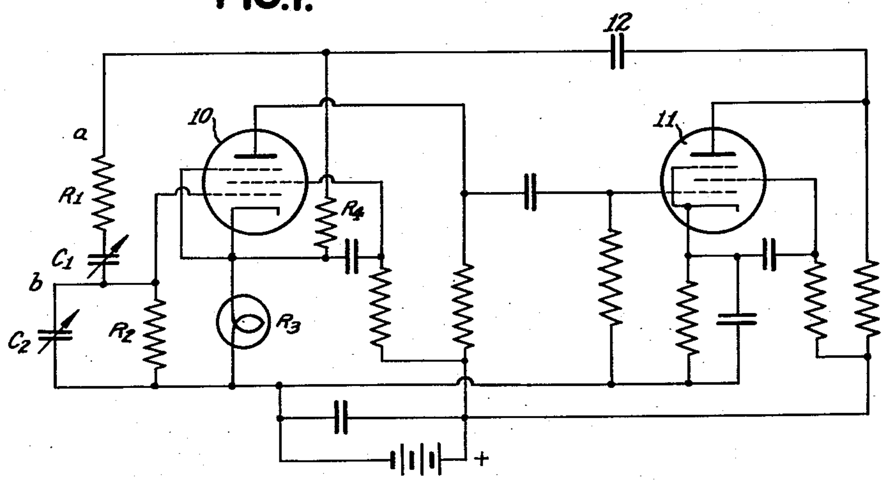
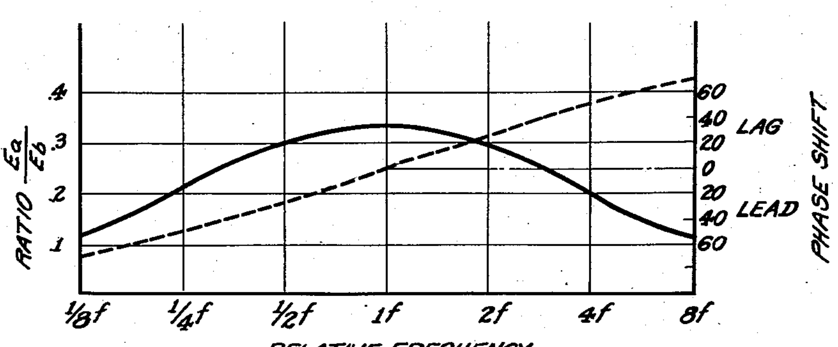


FIG. 2.



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VARIABLE FREQUENCY OSCILLATION GENERATOR

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6 Claims. (Cl. 250—36)

My invention relates to variable frequency oscillation generators and more particularly to oscillation generators wherein the frequency is determined by means of resistance capacity networks.

Oscillation generators capable of tuning over a wide range of frequencies are useful for many purposes, for example, as test oscillation generators in place of beat frequency generators. In general such oscillation generators have been provided with a variably tuned resonant circuit to maintain the oscillations at a frequency to which the tuned circuit is adjusted.

According to my invention, I provide an oscillation generator with a variable resistance capacity network forming a positive feedback path for the purpose of determining the frequency of oscillation.

According to another feature of my invention an oscillation generator with resistance capacity frequency determining arrangements and with a negative feedback circuit for reducing distortion caused in the amplifier circuit, is provided.

According to a further feature of my invention I provide an automatic amplitude control arrangement in a negative feedback path of an oscillation generator to maintain the amplitude of the generated oscillations constant despite changes in the supply voltages for the tubes.

Other advantages and features of my invention will be apparent from the particular description thereof made in connection with the accompanying drawing, in which

Fig. 1 shows a diagrammatic circuit of the preferred form of an oscillation generator in accordance with my invention, and

Fig. 2 shows curves for the purpose of illustrating the operation of the circuit.

In Fig. 1 is shown an oscillation generator comprising two amplifying tubes 10 and 11, coupled together by resistance capacity means in a known manner. The voltage supply sources and the cathode heating supply are omitted for simplifying the circuit. The anode of tube 10 is coupled to the input grid of tube 11 and the anode of tube 11 is then connected to a circuit which provides a feedback path through a coupling condenser 12 and series connected resistance R_1 and variable capacity C_1, and a second circuit comprising R_2 and variable condenser C_2, to the input of tube 10. The circuit including R_1, C_1, R_2, C_2, provides a regenerative or positive coupling between the output and input circuits of the amplifiers 10 and 11, so that feedback occurs sufficient to maintain oscillations in the circuit. By properly proportioning the value of the resistance capacity networks R_1, C_1, R_2, C_2, the desired frequency may be obtained. If R_1, and C_1, respectively, equal R_2, and C_2, the ratio of the voltage E_b at point *b* to the voltage E_a at point *a* varies with frequency in a manner similar to a resonance curve. In Fig. 2 this curve is shown in solid lines with voltage ratios of E_a and E_b plotted as ordinates against the relative frequency. At the maximum of this curve, the frequency

$$f_0=\frac{1}{2\pi\sqrt{R_1,R_2,C_1,C_2}}$$

and the voltages at points *a* and *b* have the same phase. Accordingly, oscillations tend to occur at the frequency f_0 for this circuit.

In Fig. 2 the broken line curve indicates the phase shifts as ordinates with the change in relative frequency. It can be seen that at zero phase shift, the maximum of the E_a, E_b ratio occurs. If the various condensers and resistances are not made equal as they were for plotting this curve, the maximum would occur at some other point and a symmetrical curve would not be obtained. However, the principles of my invention apply to the circuit regardless of equality of these elements. In practical construction, however, it is generally desirable to make the separate elements equal.

As shown in Fig. 1, frequency shift in the oscillation generator is accomplished by adjusting variable capacities C_1 and C_2. It is clear, however, that since the resistances as well as the capacities serve to control the frequency of the oscillator, either the resistances alone or both the resistances and capacities may be adjustable for varying the tuning.

For the type of oscillators illustrated in Fig. 1, it is necessary in order to obtain satisfactory operation that the amplifiers comprising tubes 10 and 11 have phase shift independent of changes in supply, etc., and furthermore, there should be provided some means for controlling the amplitude of the oscillations so that they do not exceed the range over which tubes 10 and 11 will operate as class A amplifiers. A constant amplifier phase shift is necessary to insure a constant frequency, because the phase angle of the transfer impedance of the resistance capacity network from point *a* to point *b* varies only slowly with frequency. Accordingly, a small change in amplifier phase shift such as might be produced by a variation in voltage supply requires a comparatively large change in the frequency of operation to produce a compensating phase shift in the resistance capacity coupling system.

In the circuit of Fig. 1, I provide a negative feedback arrangement for stabilizing the amplifier. This feedback is made from the output of amplifier 11 over coupling condenser 12 and the resistance R_3, R_4 to the cathode of tube 10. The potential drop across the resistance produces a negative feedback to the input of amplifier 10. This negative feedback operates in a manner known per se to reduce the amplification of the system and at the same time to stabilize the amplifier gain in magnitude and phase with respect to variations occurring within the amplifier, such as tube changes, temperature variations and changes caused by fluctuation in the voltage supplies to the electrodes of the amplifier system.

Amplitude control to prevent the oscillations from building up to such a large value that distortion occurs, is obtained according to my invention by non-linear action in the amplifier circuit. In order to produce this non-linear variation, I provide for resistance R_3 a small incandescent lamp, or similar device in which the resistance increases rapidly with increased current flow, the lamp being heated by the plate current of the tubes 10 and 11 or by an auxiliary means, so such a temperature that its resistance will vary rapidly with a small change in current. Thus, when the oscillation amplitudes tend to increase, the temperature of the lamp R_3 increases with a resulting increase in resistance thereby causing a greater negative feedback, thus reducing the amplification. Similarly, as the oscillations decrease in amplitude, the current through the lamp is reduced permitting the lamp to cool with an accompanying decrease in resistance and reduction of the negative feedback, thus increasing the amplitude of the generated oscillations. As a result the system operates at substantially a constant amplitude which is preselected to be below the value at which grid current flows. As a result no distortion of the wave form takes place.

While I have described the amplitude control system in connection with my particular resistance capacity tuned oscillation generator, it is clear that this feature of my invention is similarly applicable to various types of oscillation generators, wherein frequency stabilization is obtained by means of negative feedback. Since the lamp itself responds relatively slowly to current changes it tends to average out the voltage peaks and does not cut off the peaks of the generated waves, maintaining the amplitude constant without producing distortions in wave form.

In the construction of oscillation generators in accordance with my invention, it is generally convenient to make the resistance R_1 equal to R_2, and capacity C_1 equal to C_2. Under these conditions the frequency of oscillation is

$$f_1=\frac{1}{2\pi R_1, C_1}$$

It will be noted that this frequency is inversely proportional to the capacity instead of being inversely proportional to the square root of the capacity, as in the case of the tuned circuit arrangement. Accordingly, the frequency may be varied over a much wider range, utilizing the same type of condensers than in the case of oscillation generators utilizing a tuned circuit feedback. A frequency range of 10 to 1 can be easily obtained on a single dial in accordance with this system. If other ranges are desired, decimal multiplying factors can be obtained by changing resistances R_1, R_2, in decimal values.

An experimental arrangement employing a four gang broadcast condenser with the sections connected in parallel in pairs, so that one pair corresponds to C_1, and the other pair corresponds to C_2, has been found capable of covering the frequency range of 20–20,000 cycles in three subdivisions, namely, 20–200, 200–2000 and 2000–20,000 cycles, by employing three sets of resistances. The output voltage on this circuit was found to be constant within approximately 10% over the entire frequency range, while it was found that the output waves had a distortion in the order of .25% only. The frequency stability was such that only a negligible frequency shift in the order of less than .1% with quite a large variation in voltage supply occurred. It can, therefore, be seen that an oscillation generator in accordance with my invention is capable of covering an extremely wide frequency range and maintaining substantially pure sine wave output throughout the entire range.

While I have illustrated my invention merely by showing a preferred embodiment thereof, it is clear that many variations thereof may be made by those skilled in the art within the teachings of this disclosure. The particular connections of the amplifier circuit may be varied considerably and as above stated, the capacities and/or resistances may be varied in order to change the tuning. Although I have shown an ordinary filament lamp as the volume control resistor, any known arrangement may be utilized for this purpose, for example, these lamps used for such purpose are generally termed ballast lamps.

What I consider to be my invention is defined in the accompanying claims.

What I claim is:

1. In an oscillation generator for producing sustained electrical oscillations of a desired substantially constant frequency and amplitude, vacuum tube means having control, anode and cathode elements, and a frequency determining electrical network connected to the vacuum tube means for generation of electrical oscillations, said network including a substantially non-inductive positive feed back path and also a degenerative circuit including a path for oscillatory current of said generator, oscillatory current flow through the last named path serving to reduce the amplitude of oscillations generated, said path in said degenerative circuit having an impedance variable in response to variations in the amplitude of the oscillatory current of the generator to tend to maintain the amplitude of oscillations constant.

2. In an oscillation generator for producing sustained electrical oscillations of a desired substantially constant frequency and amplitude, vacuum tube means having control, anode and cathode elements, and a frequency determining electrical network connected to the vacuum tube means for generation of electrical oscillations, said network including a substantially non-inductive positive feed back path and also a negative feed back path for oscillatory currents, oscillatory current flow through the last named path serving to reduce the amplitude of oscillations generated, said negative feed back path including a resistance element which increases its resistance with an increase in oscillatory current flow through the same, thereby serving to auto-

matically stabilize the amplitude of oscillations generated and to maintain the amplitude of oscillations constant.

3. In an oscillation generator for producing sustained electrical oscillations of a desired substantially constant frequency and amplitude, vacuum tube means having control, anode and cathode elements, and an electrical network connected to the vacuum tube means for generation of electrical oscillations, said network having a non-inductive frequency determining positive feed back path including resistive and capacitative elements variable for varying the frequency of operations, and also having a separate non-inductive negative feed back path having an impedance variable in response to variations in the output current of the generator, thereby serving to automatically stabilize the amplitude of oscillations generated and to tend to maintain the amplitude of oscillations constant.

4. In an oscillation generator for producing sustained electrical oscillations of a desired substantially constant frequency and amplitude, vacuum tube means having control, anode and cathode elements, and an electrical network connected to the vacuum tube means for generation of electrical oscillations, said network having a non-inductive frequency determining positive feed back path including resistive and capacitative elements variable for varying the frequency of operations, and also having a separate non-inductive negative feed back path including a resistive element connected to pass anode current through the same and said element being adapted to increase its resistance with an increase in oscillatory current flow through the same, thereby serving to stabilize the amplitude of oscillations generated and to maintain the frequency of the same constant.

5. In an oscillation generator for producing sustained electrical oscillations of a desired substantially constant frequency and amplitude, at least two vacuum tubes each having control, anode and cathode elements, and a frequency determining electrical network connecting the tubes in cascade, said network including adjustable substantially non-inductive reactive means forming a path for positive feed back of oscillatory energy from said second tube to said first tube whereby oscillations are generated at a selected frequency, and means forming a path for negative feed back of oscillatory energy from said second tube to said first tube whereby energy transferred by said path tends to reduce the amplitude of oscillations generated, said last means including an impedance connected to pass anode current for the first tube and adapted to increase its resistance with an increase in flow of oscillatory current through the same.

6. In an oscillation generator for producing sustained electrical oscillations of a desired substantially constant frequency and amplitude, at least two vacuum tubes each having control, anode and cathode elements, a non-inductive frequency determining electrical network connecting the tubes in cascade, said network including means forming a path for positive feed back of oscillatory energy from said second tube to said first tube whereby oscillations are generated, and means forming a path for negative feed back of oscillatory energy from said second tube to said first tube whereby energy transferred by said path tends to reduce the amplitude of oscillations generated, said last means including a resistance element connected to pass oscillatory anode current for the first tube and oscillatory anode current from said second tube and which increases its resistance with an increase in oscillatory current flow through the same thereby serving to stabilize the amplitude of oscillations generated.

WILLIAM R. HEWLETT.