

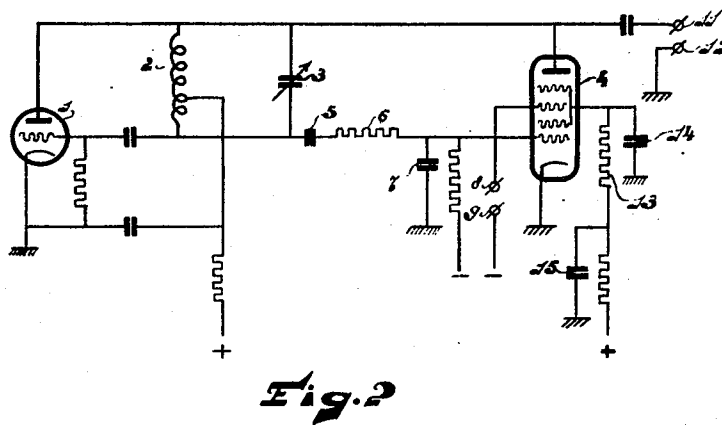
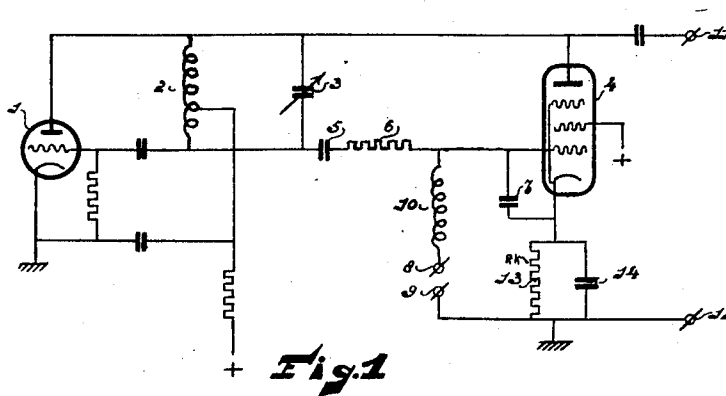
Jan. 15, 1952

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2,582,673

CIRCUIT ARRANGEMENT FOR WAVE LENGTH MODULATION

Filed July 15, 1946



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UNITED STATES PATENT OFFICE

2,582,673

CIRCUIT ARRANGEMENT FOR WAVE
LENGTH MODULATION

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Application July 15, 1946, Serial No. 683,696
In the Netherlands February 25, 1943

Section 1, Public Law 690, August 8, 1946
Patent expires February 25, 1963

6 Claims. (Cl. 332-18)

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The invention relates to a circuit-arrangement for modulating the frequency or the phase of electrical oscillations by means of a reactance tube controlled by the modulating oscillations.

By a reactance tube is meant hereinafter a discharge tube which is connected in such manner that for the oscillations to be modulated there occurs between two electrodes a reactance which depends upon the slope of one of the tube characteristics. For this purpose it is common practice to utilize in the tube in question for the oscillations to be modulated a so-called wattless feedback, i. e. a feedback with which there occurs in the feedback circuit a phase displacement of approximately 90°.

In a circuit-arrangement known for this purpose there is provided between the anode and the control grid of a discharge tube, for example a triode or a pentode, such a phase-rotating network that the control grid alternating voltage of the frequency of the oscillations to be modulated is out of phase by approximately 90° with respect to the anode alternating voltage. The anode alternating current exhibits in this case likewise a phase displacement of approximately 90° with respect to the anode alternating voltage, so that between the anode and the cathode there occurs a virtual reactance whose value is inversely proportional to the slope of the discharge tube. The phase-rotating network consists as a rule of an ohmic resistance and a reactance, of which elements the one is located between the anode and the control grid and the other between the control grid and the cathode whilst the impedance of the element provided between the anode and the control grid is large relatively to that of the other element.

In another known circuit-arrangement with wattless feed-back use is made of a similar phase-rotating network of which the one element is connected between the anode and the control grid of a discharge tube and the other, which has a considerably smaller impedance, is connected between the anode and the cathode of this tube whilst between the control grid and the cathode there exists a virtual reactance which is inversely proportional to the slope of the tube.

The modulating oscillations are supplied to a control electrode of the reactance tube for example to the previously mentioned control grid or to a second control grid, so that the slope of the reactance tube varies in the rhythm of the modulating oscillations. Between two electrodes of the reactance tube (in the above-mentioned known circuit-arrangements between the anode

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and the cathode and between the control grid and the cathode respectively) there occurs in this case a virtual reactance whose value varies in the rhythm of the modulating oscillations. By coupling this virtual reactance to the frequency-determining oscillatory circuit of an oscillator which generates the oscillations to be modulated, we obtain modulation of the frequency of these oscillations whilst phase modulation may be realized by including the said virtual reactance in a phase-rotating network to which the oscillations to be modulated are supplied.

In order to render possible reproduction without distortion in the reception of oscillations modulated either in frequency or in phase, it is desirable that the instantaneous value of the frequency- or phase-displacement brought about by the modulation should always be proportional to the instantaneous value of the modulating oscillations. With those values of the maximum frequency- or phase-displacement and of the frequency of the oscillations to be modulated which occur in practice, this condition is always fulfilled with sufficient exactitude when for the oscillations to be modulated the slope of the reactance tube is a linear function of the instantaneous value of the modulating oscillations. The latter condition implies that the characteristic which represents the anode current of the reactance tube as a function of the voltage of the control grid to which the modulating oscillations are supplied, should be an exactly square function if the oscillations to be modulated are supplied to the same control grid, and an exactly linear function if the oscillations to be modulated are supplied to a second control grid.

Discharge tubes with an exactly square or linear characteristic are generally not available in practice, so that in the case of modulation there occurs nearly always a certain distortion. It is known to eliminate this distortion by means of a negative feedback; for this purpose the modulated oscillations are detected and the oscillations thus obtained are combined in anti-phase with the modulating oscillations. This method has the drawback that the desired modulation without distortion is only obtained if the detection of the modulated oscillations takes place without any distortion. The latter requirement leads in practice to very complicated circuit-arrangements.

The invention has for its object to remove the said drawbacks and to provide means which permit to obtain in a simple manner frequency- or phase-modulation without distortion with the aid of a discharge tube of any type.

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According to the invention a feedback for the modulating oscillations is utilized in the reactance tube in such a sense and with such an intensity that the instantaneous value of the frequency- or phase-displacement brought about by the modulation is always proportional or at least approximately proportional to the instantaneous value of the modulating oscillations.

The invention will be explained more fully with reference to the accompanying drawing forming a part of the specification and in which:

Fig. 1 is a schematic diagram of a circuit arrangement for wave length modulation according to the invention, and

Fig. 2 is a schematic diagram of an alternate embodiment of the invention.

Fig. 1 represents a circuit-arrangement for frequency modulation wherein the oscillations to be modulated are generated by an oscillator tube 1 which is connected for this purpose in three-point connection to an oscillatory circuit, which consists of an inductance coil 2 and a condenser 3. That portion of the oscillatory circuit 2, 3 which is located between the anode and the cathode of the tube 1 has connected in parallel with it a reactance tube 4 constructed as a pentode whilst in parallel with the remainder of the said oscillatory circuit is connected the series-connection of a separating condenser 5, an ohmic resistance 6 and a condenser 7. The condenser 5 forms a short-circuit for the oscillations to be modulated whilst the resistance 6 is large relatively to the impedance of the condenser 7 and forms, jointly with the latter, a phase-rotating network by which a phase-displacement of approximately 90° is brought about. The voltage set up across the condenser 7, which voltage is out of phase by approximately 90° with respect to the voltage across the circuit 2, 3, is supplied to the control grid of the tube 4 so that for the oscillations to be modulated this tube behaves as a reactance.

The value of the reactance formed by the tube 4 is controlled in the rhythm of the modulating oscillations by supplying these oscillations via terminals 8 and 9 and a high-frequency reactance coil 10 to the control grid. The oscillations modulated in frequency are taken via terminals 11 and 12 from that portion of the circuit 2, 3 which is located between the anode and the cathode of the tube 1.

With the aid of the circuit-arrangement described so far it would only be possible to obtain frequency-modulation without distortion if the anode current-control grid voltage characteristic of the tube 4 were an exactly square function. According to the invention, with a characteristic of arbitrary shape frequency modulation without distortion is rendered possible by utilizing feedback for the modulating oscillations. This feedback is so chosen that for the modulating oscillations the resulting dynamic characteristic of the reactance tube is a square function or approximately a square function. With the major part of the pentodes the static characteristic may be represented by a function of the shape

$$i_a = (a + bV_g)^n$$

wherein the exponent n is more than 2. In order to obtain a square dynamic characteristic, use must be made in this case of negative feedback. If, on the contrary, the static characteristic can be represented by a similar power function with an exponent less than 2, use should be made of positive feedback.

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With the circuit-arrangement represented in Fig. 1, negative feedback for the modulating oscillations is obtained by means of a resistance 13 which is included in the cathode lead of the reactance tube 4 and which, for the frequency of the oscillations to be modulated, is preferably shunted by a condenser 14.

It may be observed that it is known to linearize the characteristic of an amplifying tube by utilizing a resistance R_k in the cathode lead. In this case the desired linear dynamic characteristic is the better approximated the higher R_k is chosen. For this purpose use is generally made of a value of R_k with which $SR_k \geq 4$ wherein S represents the slope. Apart from the fact that, instead of relating to an amplifying circuit-arrangement, the invention has reference to a circuit-arrangement for frequency- or phase-modulation, the circuit arrangement according to the invention also differs from the known circuit-arrangements with negative feedback in that in the case under consideration it is possible to ascertain an exactly determined value of R_k with which the characteristic approximates the desired square shape with the greatest exactitude whereas such is not the case with larger or lower values of R_k . The value of R_k which is utilized in accordance with the invention, is generally considerably smaller than in the known amplifying circuit-arrangements with negative feedback, and this to such an extent that $SR_k \leq 0.5$. The desired negative feedback may also be obtained by incorporating an ohmic resistance in the screen grid circuit or, when a triode is utilized as the reactance tube, in the anode circuit. In those cases in which positive feedback is required, this may be obtained in the known manner by coupling the circuit of one of the current-carrying electrodes by means of a transformer to the control grid circuit.

Fig. 2 represents a circuit-arrangement according to the invention wherein the reactance tube 4 is constructed as an hexode. The oscillations to be modulated are supplied to the inner control grid whereas the modulating oscillations are supplied to the outer control grid. According to the invention, use is made in this case of such a negative feedback for the modulating oscillations that the dynamic characteristic, which represents the anode current as a function of the voltage of the outer control grid, has a linear or at least an approximately linear course. Since the cathode current does not comprise a component with the frequency of the modulating oscillations, the incorporation of a resistance in the cathode lead would not lead to the purpose in view. For this reason the feedback resistance 13 is connected into the screen grid lead whilst that end which is remote from the screen grid is earthed through the intermediary of a condenser 15. If desired, it would also be possible to obtain the effect aimed at by means of a resistance included in the anode circuit. Here again, just as in the circuit arrangement according to Fig. 1, it is possible to ascertain a value of the resistance 13 with which the purpose in view is attained with the greatest approximation whereas such is not the case either with higher or with lower values of this resistance.

What I claim is:

1. A circuit arrangement for wave length modulating an electric wave, comprising means to generate said electric wave, a reactance tube circuit coupled to said generating means and comprising an electron discharge tube having a plu-

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rality of electrodes, means to apply modulating potentials to said reactance tube to wave length modulate said wave, means comprising an impedance element coupled to one of the electrodes of said discharge tube to derive a voltage proportional to the amplitude of said modulating potentials, and means to combine said voltage and said modulating potentials, said impedance element having a negligible impedance value at the frequency of said electric wave and a given impedance value at the frequency of said modulating potentials thereby to produce wave length modulation of said electric wave proportional to the instantaneous amplitude of said modulating potentials.

2. A circuit arrangement for wave length modulating an electric wave, comprising means to generate said electric wave, a reactance tube circuit coupled to said generating means and comprising an electron discharge tube having a cathode, a grid and an anode, means to apply modulating potentials to the grid of said reactance tube to wave length modulate said wave, means comprising an impedance element coupled to the cathode of said discharge tube to derive a voltage proportional to the amplitude of said modulating potentials, and means to apply said voltage to the grid of said reactance tube, said impedance element having a negligible impedance value at the frequency of said electric wave and a given impedance value at the frequency of said modulating potentials whereby the resultant value of anode current of said reactance tube is proportional to the square of the value of voltage applied to the grid thereby to produce wave length modulation of said electric wave proportional to the instantaneous amplitude of said modulating potentials.

3. A circuit arrangement for wave length modulating an electric wave, comprising means to generate said electric wave, a reactance tube circuit coupled to said generating means and comprising an electron discharge tube having a cathode, a grid and an anode, the static characteristic of said electron discharge tube being represented by a power function having an exponent greater than 2, and means to apply modulating potentials to the grid of said reactance tube to wave length modulate said wave, means to derive a voltage proportional to the amplitude of said modulating potentials, means to apply said voltage to the grid of said reactance tube, and a resistor interposed in the anode-cathode circuit of said tube and having a resistance value at most equal to the value one-half divided by the transconductance of said tube thereby to produce wave length modulation of said electric wave proportional to the instantaneous amplitude of said modulating potentials.

4. A circuit arrangement for wave length modulating an electric wave, comprising means to generate said electric wave, a reactance tube circuit comprising an electron discharge tube having a cathode, a first grid, a second grid, a screen grid and an anode, means to couple said generating means to one of the grids of said reactance tube, means to apply modulating potentials to the other of the grids of said reactance tube to wave length modulate said wave, and means including a resistance element coupled to said screen grid to derive a negative feedback voltage proportional to the amplitude of said modulating

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ing potentials, said resistance element having a resistance value at which the resultant wave length modulation of said electric wave is proportional to the instantaneous amplitude of said modulating potentials.

5. A circuit arrangement for wave length modulating an electric wave, comprising means to generate said electric wave, a reactance tube circuit comprising an electron discharge tube having a cathode, a first grid, a screen grid, a second grid and an anode, the static characteristic of said electron discharge tube being represented by a power function having an exponent greater than 1, means to couple said generating means to the first grid of said reactance tube, means to apply modulating potentials to the second grid of said reactance tube to wave length modulate said wave, means to derive a voltage proportional to the amplitude of said modulating potentials, means to apply said voltage to the screen grid of said reactance tube, and a resistor interposed in the screen grid-cathode circuit of said tube and having a resistance value at which the resultant value of anode current of said reactance tube is linearly proportional to the voltage applied to the said second grid thereby to produce wave length modulation of said electric wave proportional to the instantaneous amplitude of said modulating potentials.

6. A circuit arrangement for wave length modulating an electric wave, comprising means to generate said electric wave, a reactance tube circuit comprising an electron discharge tube having a cathode, a first grid, a screen grid, a second grid and an anode, the static characteristic of said electron discharge tube being represented by a power function having an exponent greater than 1, means to couple said generating means to the first grid of said reactance tube, means to apply modulating potentials to the second grid of said reactance tube to wave length modulate said wave, means to derive a voltage proportional to the amplitude of said modulating potentials, means to apply said voltage to the screen grid of said reactance tube, a resistor interposed in the screen grid-cathode circuit of said tube, and a capacitive element coupled in parallel with said resistor and having a reactance value substantially equal to zero at the frequency of said modulating potentials, said resistor having a resistance value at which the resultant value of anode current of said reactance tube is linearly proportional to the voltage applied to the said second grid thereby to produce wave length modulation of said electric wave proportional to the instantaneous amplitude of said modulating potentials.

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