

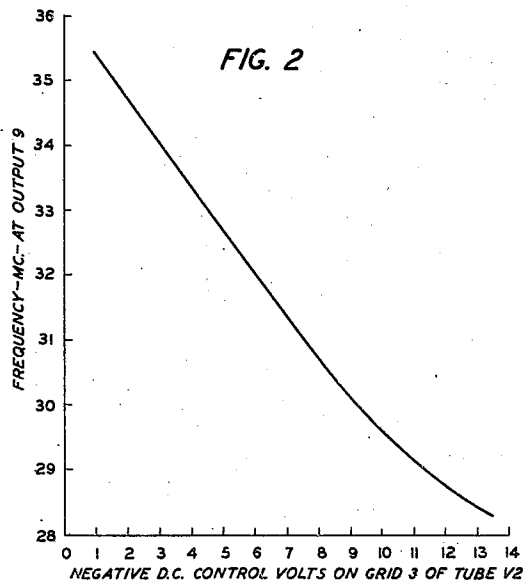
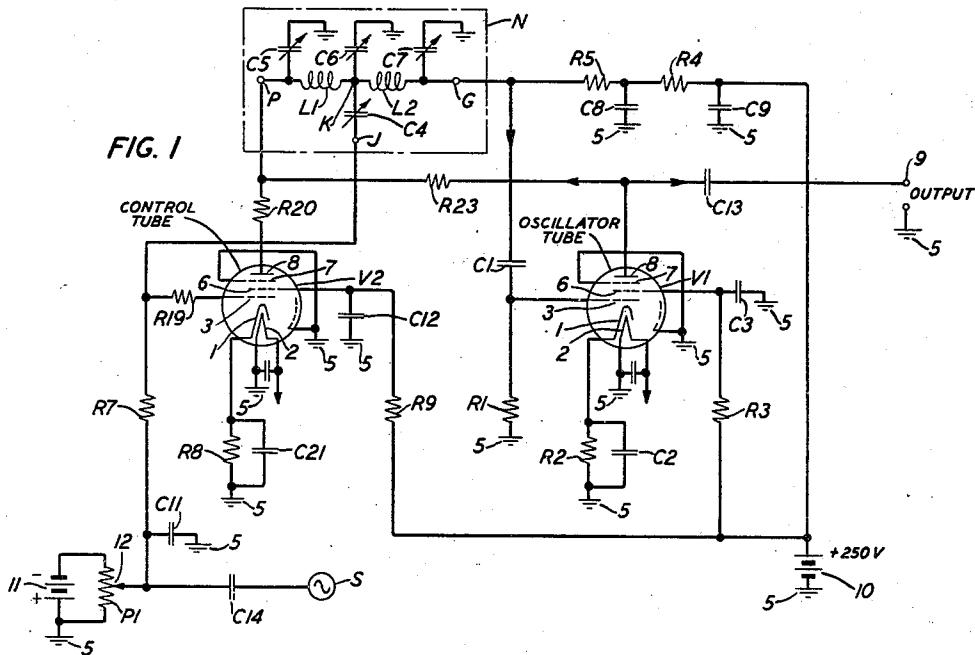
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F. R. DENNIS

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VARIABLE FREQUENCY OSCILLATOR

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INVENTOR
F. R. DENNIS

BY
W. J. O'Neill

ATTORNEY

UNITED STATES PATENT OFFICE

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VARIABLE FREQUENCY OSCILLATOR

Fred R. Dennis, Lyndhurst, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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This invention relates to oscillation generators and particularly to means for modulating or varying the oscillation frequency thereof.

One of the objects of this invention is to provide frequency control of or frequency modulating in an oscillating system.

Another object of this invention is to provide a relatively wide range of frequency deviation in a frequency modulated oscillator with small amplitude modulation.

Another object of this invention is to obtain a relatively wide range linear sweep in a frequency modulated oscillator.

Oscillators having a frequency which can be continuously varied over a specified band of frequencies by either mechanical or electronic means are useful in many applications in the radio art. Such an oscillator may form a part of a visual gain set for example, wherein the required scanning range may be a relatively wide band of frequencies such as, for example, a range of 40 to 4,000 kilocycles per second. In order to scan up to such a frequency of 4 or more megacycles per second, the scanning oscillator may be operated at a much higher frequency and then modulated down with an associated fixed frequency oscillator fed into a common mixer type modulator tube, for example. In accordance with this invention, an oscillator of the reactance tube modulator type is provided in a simplified form which gives an improvement not only with respect to the percentage of frequency change obtainable but also with respect to the linearity of frequency variation. For example, a frequency variation of over 20 per cent may be obtained at 30 megacycles per second with a linear scanning range of about 5 megacycles per second or more. For this purpose, the oscillator circuit may comprise as an element thereof an artificial half wavelength section of transmission line used in combination with a reactance tube modulator for obtaining the wide range linear sweep.

One of the most practical ways of obtaining frequency modulation is through the use of a reactance tube modulator. In this arrangement, the plate-cathode circuit of the modulator control tube may be connected across a portion of the oscillator frequency-determining circuit and made to appear either as a capacitive or inductive reactance by exciting the modulator grid with a voltage which either leads or lags the oscillator voltage by 90 degrees. The leading or lagging grid voltage causes a corresponding leading or lagging plate current, and the plate-cathode circuit may appear as a capacitive or

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inductive reactance across the oscillator frequency-determining circuit. When the transconductance of the modulator control tube is varied, as by varying one of the element voltages thereof, the magnitude of the reactance across the oscillator tuning circuit may be varied. By applying an audio or other modulating voltage to one of the control tube electrodes, the transconductance and hence the frequency of the oscillations generated may be varied at an audio or other rate. When properly designed and operated, the reactance tube modulator is capable of producing large amounts of frequency deviation, and of giving linear frequency modulation. The type of phase-shifting circuit which is used to give a grid voltage which is in phase quadrature with the radio frequency oscillator voltage at the plate of the modulator tube, is a feature of special interest in accordance with this invention, in that it comprises the phase-shift networks of the oscillator itself, instead of a separate discriminator or phase-shifting means.

The oscillator circuit per se may comprise a so-called phase-shift type oscillator which may utilize a plurality of ladder type phase-shift networks in the feedback circuit of the oscillator tube, and an auxiliary control path may be provided in the form of a reactance tube which is used to modulate or vary the frequency of the phase-shift type oscillation generator, the phase-shifted input for the reactance tube being obtained from the frequency sensitive networks in the oscillator feedback circuit, rather than from a separate discriminator. A reactance type control tube modulator rather than a resistance type control tube modulator is employed for frequency control purposes, and the 90-degree, or integral multiple thereof, phase-shifted input for the reactance control tube modulator is obtained directly from the oscillator feedback network, rather than from a separate 90-degree phase-shifting discriminator usually associated with the reactance tube as in prior art arrangements. Accordingly, the phase-shifted input to the reactance tube is, in accordance with this invention, obtained from a part of the oscillating circuit in order to obtain a simple form of wide range frequency modulated oscillator which may be used as a scanning oscillator, for example, for obtaining a wide range linear sweep frequency variation. The previously known form of separate 90-degree phase-shift discriminator arrangement is illustrated by such patents as Chireix et al. United States Patent 2,076,264 dated April 6, 1937, Crosby United States Patent 2,383,848

dated August 28, 1945, British Patent 564,504 of September 29, 1944, and British Patent 570,392 of July 5, 1945. Another form of prior art frequency modulator utilizes an impedance control tube functioning by resistance variation rather than by reactance variation and is illustrated by such patents as Poch United States Patent 2,300,632 dated November 3, 1942, Artzt United States Patent 2,321,269, June 8, 1943 and British Patent 571,840 of September 11, 1945.

For a clearer understanding of the nature of this invention and the additional advantages, features and objects thereof, reference is made to the following description taken in connection with the accompanying drawing, in which like reference characters represent like or similar parts and in which:

Fig. 1 is a diagram illustrating a variable frequency oscillation generator circuit, in accordance with this invention;

Fig. 2 is a graph illustrating an example of the variable frequency characteristics of an oscillator circuit of the type illustrated in Fig. 1.

Referring to the drawing, Fig. 1 is a diagram illustrating a frequency modulated oscillator circuit which may comprise an oscillator tube V1 provided with a main feedback circuit network system N which regeneratively couples the output and input circuits of the oscillator tube V1. Also, there is provided an auxiliary control path comprising a frequency control tube in the form of a reactance control tube V2 which is connected with the half wave transmission line network system N. As illustrated in Fig. 1, the oscillation generator part of the circuit of Fig. 1 is comprised mainly of the oscillator or power tube V1 constituting the gain circuit, and the feedback circuit network system N comprising a terminated plurality of tandem-connected networks coupling the output or plate electrode circuit of the oscillator tube V1 with the input or control grid electrode circuit thereof. The control means comprises an auxiliary path including the tube V2 which is adapted to modulate or vary the frequency of the oscillations generated in accordance with the amplitude of the voltage which may be applied to the control grid 3 of the reactance tube V2 from any suitable source, such as the negative direct current bias voltage supplied from the potentiometer P1 and the alternating current signal voltage supplied from the audio signal source S. The output oscillations from the plate circuit of the oscillator tube V1 may be taken off at the output terminals 9 and 5, labeled output in Fig. 1, and may be supplied to any desired utilization or load circuit through any suitable limiter or buffer tube, or through a mixer modulator tube for heterodyne purposes for example.

As illustrated in Fig. 1, the oscillator tube V1 may comprise a conventional pentode V1 having a cathode electrode 1 which may be heated by a cathode heater filament 2, a control grid electrode 3 which may be connected to ground 5 through a grid resistor R1 and which may be connected to the grid terminal G of the network system N through a condenser C1, a screen grid electrode 6 which may be connected to ground 5 through a condenser C3 and which may be connected through a resistor R3 to the positive (+) terminal of a suitable power supply source 10, a suppressor grid electrode 7 which may be connected in a conventional manner to the shell of the oscillator tube V1 and to ground 5, and an anode or plate electrode 8 which may

be connected through a condenser C13 to the output terminal 9 and which may be connected through a resistor R23 to the plate terminal P of the network system N. For obtaining plate supply voltage for the plate electrode 8 of the oscillator tube V1, the connection may extend through the series connected windings L1 and L2 of the network system N and through terminating resistor R5 and isolating resistor R4 to the positive (+) terminal of the power supply source 10. Condensers C8 and C9 may be provided between the ground 5 and the positive terminal line of the power supply source 10. The cathode electrode 1 of the oscillator tube V1 may be connected to ground 5 through a cathode resistor R2 which may be shunted by a by-pass condenser C2. The cathode heater filament 2 may be energized by any suitable supply source (not shown). While the oscillator tube V1 has been illustrated in Fig. 1 as comprising a single pentode V1, it will be understood that any suitable oscillator tube system may be utilized to provide the μ or gain source for the oscillations generated in the circuit.

The network system N, as illustrated in Fig. 1, is disposed in the main feedback circuit of the oscillator tube V1 and regeneratively couples the output and input circuits thereof, the output or plate electrode 8 of the oscillator tube V1 being connected with the input terminal P of the multi-stage network N, and the output terminal G of the network N being connected with the input or control grid electrode 3 of the oscillator tube V1 through the condenser C1. The arrangement of the network system N is such that it provides a total phase shift of substantially 180 degrees, or an integral multiple thereof, in the feedback or β circuit of the oscillator tube V1 and operates as a frequency-determining means for controlling the frequency of the oscillations generated in the oscillator circuit comprising the tube V1 and the network system N, the frequency of oscillations being determined mainly by the values of the component elements of the network system N which may comprise inductance and capacitance elements as particularly illustrated in Fig. 1, or other suitable phase-shifting elements that yield a total phase shift of nominally 180 degrees, or an integer multiple thereof, in the feedback network system N.

As particularly illustrated in Fig. 1, the network system N comprises a two-stage ladder type phase-shifting network system consisting of the series inductance elements L1 and L2 and the shunt capacitance elements C5, C6 and C7, thus providing in effect a pair of tandem-connected networks at the sides of the junction point K between the inductance elements L1 and L2; each section of the pair of networks yielding a phase shift of nominally 90 degrees. A condenser C4 may be provided between the terminal J of the network system N and the junction point K referred to, that is between the inductance windings L1 and L2. The substantially 90-degree or quadrature phase shift that is provided between the terminal J and either the input terminal P or the output terminal G of the oscillator feedback network system N may be utilized, in cooperation with the auxiliary control path including the reactance control tube V2, for obtaining a relatively wide range linear frequency variation or modulation of the frequency of the oscillations generated by the oscillator circuit comprising the oscillator tube V1 and the feedback network system N.

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As illustrated in Fig. 1, an auxiliary control path including the control tube V2 may be provided for modulating or varying the frequency of the oscillations generated by the oscillator tube V1. The control tube V2 may be, as illustrated in Fig. 1, a pentode having a cathode electrode 1 which may be connected to ground 5 through a cathode resistor R8 shunted, if desired, by a condenser C21, a cathode heater 2 which may be energized by any suitable power supply source (not shown), a control grid electrode 3 which may be connected through a grid resistor R19 to the junction terminal J of the oscillator network system N, a screen grid electrode 6 which may be connected through a condenser C12 to ground 5 and which may be connected through a resistor R9 to the positive (+) terminal of the power supply source 10, a suppressor grid electrode 7 which may be connected in a conventional manner to ground 5, and an anode or plate electrode 8, which may be connected through a resistor R20 to the input or plate terminal P of the oscillator network system N. The control grid electrode 3 of the reactance tube V2 may also be connected through the resistor R19 and a resistor R7 to the resistance potentiometer P1, and also to the modulating signal source S through a condenser C14, and to ground 5 through a condenser C11.

The resistance potentiometer P1 may be energized by a suitable direct current power supply source 11 having its positive (+) terminal connected to ground 5 and to one end of the potentiometer resistance P1, and having its negative (-) terminal connected to the other end of the potentiometer resistance P1. The potentiometer P1 may be utilized to provide a negative direct current bias input voltage to the control grid electrode 3 of the reactance tube V2, the magnitude of the voltage being made adjustable by variation of an adjustable tap 12 on the potentiometer resistance P1 in order to vary the frequency of the oscillation generator or to provide for a center frequency adjustment thereof. The signal source S may be any suitable modulating source such as, for example, a 60-cycle sine wave or triangular wave source adapted to vary the frequency of the oscillation generator V1 in accordance with the amplitude of the voltage applied by the signal source S to the control grid electrode 3 of the reactance control tube V2. The control tube V2 reflects a reactance into the oscillating circuit which is a function of the control voltage applied to the control grid electrode 3 of the reactance tube V2 through the resistor R7, provided such control voltage has a 90-degree phase shift with respect to the voltage of the plate circuit electrode 8 of the oscillator tube V1. Such a grid quadrature voltage may be obtained, in accordance with this invention, at the mid-branch of the line windings L1 and L2, as illustrated in Fig. 1, and may be taken off at the junction terminal J of the network system N.

As illustrated in Fig. 1, the reactance elements L1, L2, C5, C6 and C7 of the two-section network system N are connected at one end terminal P thereof to the output or plate circuit electrode 8 of the oscillator tube V1 and comprise the equivalent of a half wavelength or 180-degree phase-shift section of transmission line. Since a total phase shift of substantially 180 degrees occurs in the line section N at the operating frequency of the oscillator V1, the oscillatory loop circuit may be completed by connecting the

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other end terminal G of the network system N to the control grid electrode 3 of the oscillator tube V1. If R0 designates the line impedance at the operating frequency f , the following relations obtain:

$$fc = \frac{f}{.707}, \text{ where } fc \text{ represents cut-off frequency.}$$

$$C5 = C7 = \frac{1}{2\pi fc R_0}$$

$$C6 = 2C5$$

$$L1 = L2 = \frac{R_0}{\pi fc}$$

$$R_0 = \frac{1}{2\pi fc C_5}$$

For design purposes, reasonable values for capacitance may be assumed for the end condensers C5 and C7, and then the values for the remaining constants of the network system N may be computed. As an illustrative example, if 30 microfarads is chosen as the value of the condensers C5 and C7, for a frequency f of about 30 megacycles per second, the inductance value of L1 or L2 comes out about 0.94 microhenry, which gives about 125 ohms for R0 which is the optimum value for terminating resistor R5.

While the use of the resistor R8 in the circuit of the cathode electrode 1 of the reactance tube V2 somewhat decreases the total frequency variation obtainable, the linearity of the frequency variation is improved thereby. Where the supply voltage applied to the screen grid electrode 6 of the reactance tube V2 from the supply source 10 is maintained of constant value by means of a suitable voltage regulator tube such as by a VR-105-30 tube (not shown), there results a slightly greater total frequency variation with less control voltage variation applied to the control grid electrode 3, but the series screen grid type of supply voltage feed, as illustrated in Fig. 1, may be utilized to give increased linearity.

The oscillator loop circuit gain represented by the tube V1 may be made of a value not greatly exceeding that required to maintain stable oscillation over the entire control range for maximum frequency deviation, as provided by the control tube V2, by adjustment of cathode resistor R2. The condensers C5, C6 and C7 of the network system N may be adjusted to the proper capacitance values in order to give an approximately constant amplitude of output voltage at the output terminals 5 and 9 over the sweep frequency range. Also, the output amplitude may be made to either increase or decrease its magnitude with frequency by proper adjustment of the condensers C5, C6 and C7, but with some reaction on the extent of the sweep range and its linearity. The output amplitude and the sweep range can be controlled to some extent by variation of terminating resistor R5. The circuit of Fig. 1 may be provided with some negative feedback for the modulating frequency through the cathode resistor R8 by making the capacitance of the condenser C21 only enough to by-pass the high frequency of oscillation.

As an illustrative example for an oscillator circuit constructed substantially in accordance with the circuit of Fig. 1 and having an output linear sweep frequency range of approximately 25 to 30 or more megacycles per second, the component elements thereof may be made to have the following values: the power supply source 10 may

supply a voltage of about +250 volts, or other suitable value. The negative bias supply source 11 for the potentiometer P1 may supply a bias voltage of about -15 volts direct current, or other suitable value. The modulating sweep signal source S may be, for example, a 60-cycle triangular wave having a suitable amplitude of voltage to modulate the control tube V2. The oscillator tube V1 and the reactance tube V2 may be conventional 6AG7 vacuum tubes, or other suitable electron discharge devices. The inductance windings L1 and L2 may be equal inductance retardation coils having about 9 microhenries of inductance value for each, or other suitable inductance value to suit the phase shift and impedance requirements. The condenser C4 may have a capacitance value of about 500 micromicrofarads, and the condensers C5, C6 and C7 about 5 to 20 micromicrofarads each, and the remaining condensers may have capacitance values expressed in micromicrofarads about as follows: condenser C1=500, C2=5,000, C3=500, C8 and C9=5,000, C11=500, C12=500, C13=25, C14=4 microfarads. The resistors may have resistance values expressed in ohms about as follows: R1=10,000, R2=150, R3=33,000, R4 if used=1,000, R5=135, R7=10,000, R8=47, R9=33,000, R19=33, R20=100, R23=33, P1=10,000. It will be understood that the resistance and capacitance and inductance values given are illustrative, and that other values may be used in accordance with the requirements of the particular operating conditions.

Fig. 2 is a graph illustrating a typical plot of the variation in output frequency as expressed in megacycles per second at the output terminals 9 and 5 of the circuit illustrated in Fig. 1, as a function of change in the value of the direct current control voltage supplied to the control grid electrode 3 of the control tube V2 by the potentiometer P1 associated with the negative bias voltage supply source 11 of Fig. 1. As illustrated in Fig. 2, a substantially linear frequency characteristic may be attained over a relatively wide range of frequencies as produced by the variable frequency oscillator circuit illustrated in Fig. 1. As shown in Fig. 2, the frequency decreases with increasing control voltage values, but should it be desired to have the frequency increase with increasing control voltage value, the plate electrode 8 of the control tube V2 may be connected to the output terminal G of the network system N, instead of to the input terminal P thereof, as now shown in Fig. 1. As illustrated in Fig. 2, a linear scanning range of well over 4 megacycles per second may be provided by the 30-megacycle circuit of Fig. 1, with relatively low amplitude modulation and an output amplitude variation of not over $\pm \frac{1}{2}$ decibel over the scanning range.

While the sweep oscillator circuit as illustrated in Fig. 1 has been particularly described for operation at a frequency in the vicinity of 30 megacycles per second with a frequency modulation range of about 7 megacycles per second of which over 4 megacycles per second is linear with respect to variation in the control voltage applied to the control grid electrode 3 of the reactance control tube V2, the circuit may be made to operate at other frequencies with stable and reliable operation and with results in general closely duplicating those obtained by the 30-megacycle per second oscillator referred to which had a network line N of about 100 ohms impedance. As an illustrative example, the oscillator frequency of the circuit of Fig. 1 may be made to be in the

vicinity of one megacycle per second for example with a network line N of relatively high impedance of the order of 3,000 ohms for example, or with a network line N of relatively low impedance of the order of 150 ohms for example. The circuits employed may be substantially the same as that illustrated in Fig. 1, with suitable changes provided in the values of the constants of the network line N, and in the couplings thereto to insure the application of the correct operating voltages to the grids of the oscillator and control tubes V1 and V2. A somewhat greater frequency spread and better linearity may be more readily obtainable with a low capacitance network line N than with a high capacitance line N. It will be understood that increased frequency variation may be obtained when the circuit of Fig. 1 is operated without a strict linearity relation between the oscillation frequency and the value of control voltage variation applied to the control grid electrode 3 of the reactance control tube V2. The degree of linearity of the oscillation frequency, the frequency spread and the constancy of oscillator output voltage are rather critical functions of the amount of quadrature voltage fed from the network N to the control grid 3 of the control tube V2, and of the variations of the capacitances C5, C6 and C7, particularly the terminating capacitance C7. Variations up to about ± 20 per cent in the resistance of the line terminating resistor R5 may not greatly affect the result.

It will be understood that oscillators of the type illustrated in Fig. 1 may be made to operate in practically any frequency band. For the low frequency bands, the phase shift elements of the network system N may comprise resistance and capacitance elements arranged in suitable networks N. For the higher frequency bands conductor core coils or coaxial circuit elements for example may be used.

Although this invention has been described and illustrated in relation to specific arrangements, it is to be understood that it is capable of application in other organizations and is therefore not to be limited to the particular embodiments disclosed.

What is claimed is:

1. A generator of electrical oscillations comprising an electron discharge device having input and output circuits, means for regeneratively coupling said output circuit with said input circuit comprising a plurality of phase-shifting networks connected in tandem and constituting means for yielding a total phase shift therein corresponding to one of the values of substantially 180 degrees and an integral multiple thereof at the operating frequency of said oscillations, and frequency controlling means including an auxiliary variable reactance controlled transmission path for introducing variable reactance into said phase-shifting networks and thereby changing said frequency of said oscillations, said variable reactance path being operatively connected between two connection points on said phase-shifting networks the phase shift between which corresponds to one of the values of substantially 90 degrees and an integral multiple thereof at said operating frequency.

2. A generator of electrical oscillations comprising an electron discharge device having input and output circuits, means for regeneratively coupling said output circuit with said input circuit comprising a plurality of phase-shifting networks connected in tandem and constituting means for

yielding a total phase shift therein corresponding to one of the values of substantially 180 degrees and a multiple thereof at the operating frequency of said oscillations, and frequency controlling means including an auxiliary variable reactance controlled transmission path for introducing variable reactance into said phase-shifting networks and thereby changing said frequency of said oscillations, said variable reactance path being operatively connected between two connection points on said phase-shifting networks the phase shift between which corresponds to one of the values of substantially 90 degrees and a multiple thereof at said operating frequency, said path including an electronic reactance control device having its input and output electrodes individually connected with said two connection points on said phase-shifting networks, and means for supplying a variable potential to one of said electrodes of said control device for changing said frequency of said oscillations in accordance with the magnitude of said variable potential.

3. A generator of electrical oscillations comprising an electron discharge device having input and output circuits, means for regeneratively coupling said output circuit with said input circuit comprising a plurality of phase-shifting networks constituting means for yielding a total phase shift therein corresponding to one of the values of substantially 180 degrees and a multiple thereof at the operating frequency of said oscillations, and means including an auxiliary transmission path for changing said frequency of said oscillations, said path being operatively connected between two connection points on said phase-shifting networks the phase shift between which corresponds to one of the values of substantially 90 degrees and a multiple thereof at said operating frequency, said path including an electronic reactance tube having a grid electrode and a plate electrode, said grid and plate electrodes being individually connected with said two connection points on said phase-shifting networks, and means supplying a variable potential to said grid electrode of said electron tube for changing said frequency of said oscillations in accordance with the magnitude of said variable potential.

4. A generator of electrical oscillations comprising an electron discharge device having input and output circuits, means for regeneratively coupling said output circuit with said input circuit comprising a plurality of phase-shifting networks connected in tandem and constituting means for yielding a total phase shift therein corresponding to one of the values of substantially 180 degrees and a multiple thereof at the operating frequency of said oscillations, and means including an auxiliary transmission path for changing said frequency of said oscillations, said path being operatively connected between two connection points on said phase-shifting networks the phase shift between which corresponds to one of the values of substantially 90 degrees and a multiple thereof at said operating frequency, said path including an electronic reactance tube having a grid electrode and a plate electrode, said grid and plate electrodes being individually connected with said two connection points on said phase-shifting networks, and means supplying a variable potential to said grid electrode of said electron tube for changing said frequency of said oscillations in accordance with the magnitude of said variable potential, said last-mentioned means comprising a source of

alternating current signal potential connected with said grid electrode for modulating said frequency of said oscillations in accordance with the amplitude of said variable signal potential, and a source of negative direct current bias potential connected with said grid electrode for adjusting for the center frequency position of said frequency of said oscillations.

5. A generator of electrical oscillations comprising an electronic source of gain having input and output circuits, feedback circuit means for regeneratively coupling said output circuit of said electronic source with said input circuit thereof and comprising a pair of phase-shifting networks connected in tandem and constituting means for yielding a phase shift of substantially 90 degrees in each of said pair of networks at the operating frequency of said oscillations, means including a reactance control tube having its input and output electrodes connected across only one of said 90-degree phase-shift networks for changing said frequency of said oscillations in accordance with the magnitude of a control potential supplied to said input electrode of said control tube.

6. A generator of electrical oscillations comprising an electronic source of gain having input and output circuits, feedback circuit means for regeneratively coupling said output circuit of said electronic source with said input circuit thereof and comprising a pair of phase-shifting networks constituting means for yielding a phase shift of substantially 90 degrees in each of said pair of networks at the operating frequency of said oscillations, means including a reactance control tube having its input and output electrodes connected across only one of said 90-degree phase-shift networks for changing said frequency of said oscillations in accordance with the magnitude of a control potential supplied to said input electrode of said control tube, said input electrode of said control tube being connected to the junction connection between said pair of 90-degree phase-shift networks, and said output electrode of said control tube being connected to the other or opposite end of one of said pair of 90-degree phase-shift networks.

7. A generator of electrical oscillations comprising an electronic source of gain having input and output circuits, feedback circuit means for regeneratively coupling said output circuit of said electronic source with said input circuit thereof and comprising a pair of phase-shifting networks connected in tandem and constituting means for yielding a phase shift of substantially 90 degrees in each of said pair of networks at the operating frequency of said oscillations, means including a reactance control tube having its input and output electrodes connected across only one of said 90-degree phase-shift networks for changing said frequency of said oscillations in accordance with the magnitude of a control potential supplied to said input electrode of said control tube, said input electrode of said control tube being connected to the junction connection between said pair of 90-degree phase-shift networks, and said output electrode of said control tube being connected to the other or opposite end of one of said pair of 90-degree phase-shift networks, said other or opposite end of said one of said pair of networks being the end connected with said output circuit of said source of gain.

8. An oscillation generator in accordance with claim 7 wherein said pair of networks comprises

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ladder type networks having inductive series arms and capacitive shunt arms.

9. A generator of variable frequency oscillations comprising an electronic source of gain, a feedback circuit coupling the output with the input of said source of gain, said feedback circuit comprising a frequency sensitive phase-shift network system having a plurality of phase-shift sections, and means including a reactance control tube having its input and output electrodes connected with said network system in said feedback circuit for changing said frequency of said oscillations in accordance with the magnitude of control potential applied to said input electrode of said control tube, said input electrode of said control tube being connected to a connection point in said feedback network system having a substantially 90-degree phase shift with respect to the connection point where said output electrode of said control tube is connected to said network system.

10. A generator of variable frequency oscillations comprising an electronic source of gain, a feedback circuit coupling the output with the input of said source of gain, said feedback circuit comprising a frequency sensitive phase-shift network system having a plurality of phase-shift

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sections, and means including a reactance control tube having its input and output electrodes connected with said network system in said feedback circuit for changing said frequency of said oscillations in accordance with the magnitude of control potential applied to said input electrode of said control tube, said input electrode of said control tube being connected to a connection point in said feedback network system having a substantially 90-degree phase shift with respect to the connection point where said output electrode of said control tube is connected to said network system, said network system comprising a pair of ladder type sections having inductive series arms and capacitive shunt arms.

FRED R. DENNIS.

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