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AUTOMATIC-FREQUENCY-CONTROL SYSTEM FOR AN OSCILLATOR

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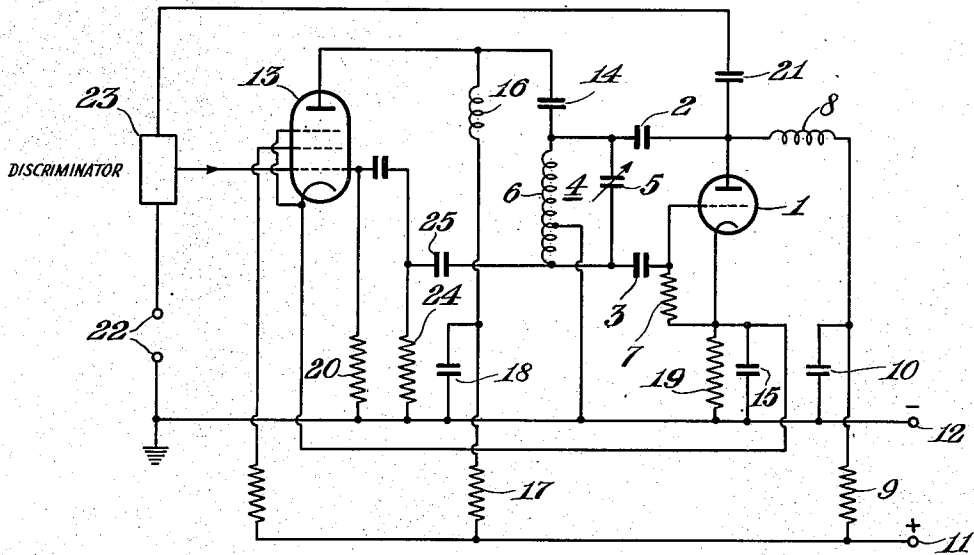


Fig. 1.

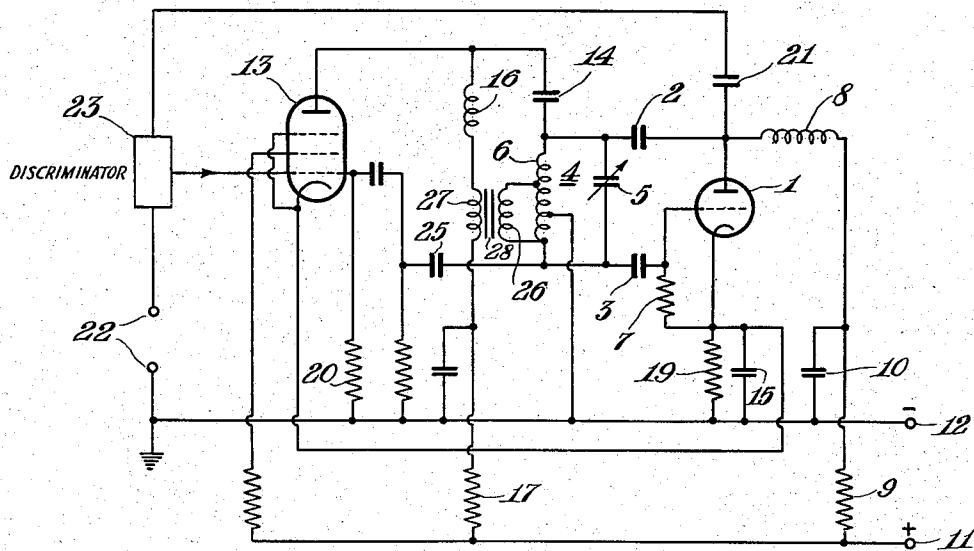


Fig. 2.

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AUTOMATIC-FREQUENCY-CONTROL
SYSTEM FOR AN OSCILLATOR

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1

This invention relates to a circuit-arrangement comprising an oscillator of which the frequency-determining oscillatory circuit is coupled to a grid-controlled amplifying tube which is connected as a variable reactance and used for automatic frequency correction (AFC) on a control oscillation, the control grid of the amplifying tube being supplied with the AFC control voltage and also with a negative grid-bias, which serves to fix the working point of the reactance tube.

In control circuits comprising a reactance tube it is known to obtain the negative grid-bias required for this tube by including a resistance shunted by a condenser in the cathode lead of the reactance tube.

This method of obtaining negative grid-bias is in certain cases inconvenient in connection with the resultant negative back-coupling of the reactance tube.

Furthermore it is known to derive the negative grid-bias required for a reactance tube from a voltage divider which is connected parallel to the anode voltage supply and a tap of which is connected to the cathode of the reactance tube.

The object of the invention is to provide a more advantageous method of obtaining the negative grid-bias required for a reactance tube.

Applicant has surprisingly found that, according to the invention, in AFC circuit-arrangements of the type described, the negative grid-bias for the reactance tube may be derived from a cathode resistance included in the cathode lead of the oscillator tube.

Despite the consequent direct-current coupling of the oscillator and reactance tubes and the frequency of the oscillations produced being dependent upon the direct-current position of the two tubes, it is found that any disturbing oscillatory phenomena do not occur. Evidently, the influence of the stabilising control oscillation predominates in such a circuit.

It is possible to utilise the voltage loss at the cathode resistance of the oscillator tube also as a negative grid-bias for the oscillator tube. Under certain conditions, however, the negative grid-bias of the oscillator tube may, as a result of the anode current of the reactance tube, have a value such that the oscillator circuit does not start to oscillate upon switching-in the arrangement.

In order to avoid this, it is advantageous for the extremity of the grid leak which is remote from the control grid to be connected to the extremity of the cathode resistance which is adjacent the cathode of the oscillator tube.

2

A particular advantage when using the invention resides in the fact that variation in the working point of the reactance tube which is produced in known circuits upon anode-voltage variations may be counteracted and this by choosing the potential of the phase shift between the grid and anode voltages of the reactance tube to be such that the transit-time variations in the oscillator tube which are provoked by anode voltage variations bring about a variation in the oscillator frequency which produces a shift of the working point of the reactance tube which is inverse to the shift of the working point of the reactance tube as a result of the variation in anode current produced upon anode voltage variations and the variation in the negative grid-bias of the reactance tube which is derived therefrom.

In this connection it may be observed that it is common practice in amplifying circuits, for example in radio-receivers, to derive the negative grid-bias of several amplifying tubes connected in cascade from a cathode resistance which is common to the tubes. In such circuit-arrangements the consequent direct-current coupling of the tubes does not involve undesirable oscillatory phenomena owing to the absence of direct-current coupling between the amplifying tubes connected in cascade.

The invention is also applicable with advantage to a circuit-arrangement of the indicated type in which to the frequency-determining oscillatory circuit of the oscillator is coupled a further adjustable reactance the value of which is controlled by the direct output current of an output electrode of the reactance tube. However, in this case the potential of the phase shift required between the grid and anode voltages of the reactance tube must be chosen to be such that the reactance tube and the further adjustable reactance assist one another in their operation, so that the potential of the phase shift can no longer be chosen freely in order to prevent variation in the working point of the reactance tube upon anode voltage variations.

The invention will now be explained more fully by reference to the accompanying drawing, in which Figures 1 and 2 represent circuit-arrangements according thereto without and with additional frequency correction.

Identical elements are indicated in the figures by the same reference numerals.

In Fig. 1, reference numeral 1 indicates a triode which is used as an oscillator and of which the anode and the control grid are connected by way of coupling condensers 2 and 3 to different

extremities of a frequency-determining oscillatory circuit 4. This oscillatory circuit comprises a tuning condenser 5 and a circuit coil 6, a tapping of which is connected to earth. A grid leak 7 of the oscillator tube is connected to the cathode.

The anode of the oscillator tube is connected via a choke coil 8 and a resistance-condenser circuit 9, 10, which serves to smooth the anode voltage, to the positive terminal 11 of the anode voltage supply, of which the negative terminal 12 is earthed.

Parallel to the frequency-determining oscillatory circuit 4 of the oscillator circuit is connected a pentode 13, which is connected as a reactance tube, for the purpose of automatic frequency correction on a control frequency.

The anode of the reactance tube 13 is connected by way of a blocking condenser 14 to that extremity of the circuit coil 6 which is coupled to the oscillator anode, while this circuit coil has derived from it, in a manner which will be described later, the alternating control-grid voltage of the reactance tube which is shifted in phase by 90° with respect to the anode voltage. The cathode of the reactance tube is earthed via a condenser 15, so that the anode-cathode space of the reactance tube for the operating frequency is connected parallel to that part of the circuit coil 6 which is located between the extremity of the oscillator and the earthed tapping.

The anode of the reactance tube is connected via a decoupling choke 16 and a resistance-condenser circuit 17, 18, which serves for decoupling, to the positive terminal 11 of the anode voltage supply.

According to the invention, the cathode of the reactance tube is connected to earth by way of a cathode resistance 19, which is included in the cathode lead of the oscillator tube and shunted by the condenser 15. The latter has a capacity value which is common for shunting cathode resistances, for example from 1 to 2 microfarads. Since the control grid of the reactance tube is connected to earth via a leak resistance 20, the negative grid-bias required for fixing the operating point of the reactance tube is thus derived from the oscillator tube circuit. If desired, the grid bias may be derived from a part of the cathode resistance by connecting the cathode of the resistance tube to a tap on the cathode resistance 19.

In order to obtain the control voltage required for the tube 13, connected as a variable reactance, for automatic frequency correction of the oscillations generated by the oscillator on a control oscillation, the oscillations generated by the oscillator are supplied via a blocking condenser 21 and a control oscillation supplied to the terminals 22 directly to a discriminator 23. The latter is so constructed as to supply a control voltage to the control grid of the reactance tube, the value and potential of which vary with the value and potential of the required frequency correction.

Transit-time variations in the oscillator tube provoked by anode voltage variations bring about variation in the frequency of the oscillations generated by the oscillator. This results, with unvaried control frequency, in a variation in the control voltage supplied to the reactance tube such that the oscillator frequency again corresponds to the control frequency.

These anode voltage variations will, in addition,

produce a variation in the anode current of the oscillator tube and hence of the voltage set up at the cathode resistance 19 of the tube, which results in variation in the negative grid-bias of the reactance tube and hence of the working point of this tube.

In order to prevent the control range of the reactance tube from being greatly reduced in one sense or another upon anode voltage variations, the attended variations in the control voltage of the reactance tube and the shift of the operating point may be made opposite to one another.

To this end, according to the further invention, the potential of the phase shift between the grid and anode voltages of the reactance tube is suitably chosen, for which purpose in the example shown, for example the alternating control-grid voltage of the reactance tube may be derived across a phase-shifting network constituted by a resistance-condenser circuit 24, 25 from the grid side of the circuit coil 6 instead of from the anode side thereof, as is usually the case.

The example shown in Fig. 2 is a circuit which is essentially identical with that shown in Fig. 1, only use being made of an additional frequency correction. Coupled to the frequency-determining circuit 4 of the oscillator 1 is an adjusting coil 26 which is connected parallel to a part of the circuit coil 6. The regulating coil 26 is provided, jointly with a pre-magnetizing winding 27, which is included in series with the decoupling choke 16 in the anode circuit of the reactance tube 13, on a common core 28. The variation in direct anode current provoked by variation in the control voltage supplied to the control grid of the reactance tube controls the pre-magnetization of the core 28 and hence the inductance of the adjusting coil 26, which brings about variation in the tuning of the frequency-determining circuit 4.

The polarity of the inductance variation of the adjusting coil 26 is fixed with frequency correction by variation in the pre-magnetization of the core 28. Since for obtaining additional frequency correction it is required that the frequency correction produced by this adjusting coil and the frequency correction produced in itself by the reactance tube should assist one another, it is not possible, as in the example shown in Fig. 1, to choose freely the polarity of the phase-shift between the grid and anode voltages of the reactance tube in order to prevent variations in the operating point of the reactance tube upon anode voltage variations.

It is possible to utilize the voltage set up at the cathode resistance 19 or a part thereof also as a negative grid-bias for the oscillator tube. In order to avoid, however, that upon switching-in the circuit the oscillator would not start to oscillate on account of undue negative grid-bias as a consequence of the anode current of the reactance tube, the grid leak 7 of the oscillator is preferably connected to the cathode of this tube.

What I claim is:

1. An electrical circuit arrangement comprising wave generating means comprising a first discharge tube system having cathode, control grid and anode electrodes, and a resonant circuit coupled to said electrodes in regenerative feedback relationship to produce a wave having a given frequency, means to apply an energizing potential to said anode electrode, said wave generating means undergoing variations in frequency

in a given direction proportional to the value of said energizing potential, reactance variation means comprising a second discharge tube system having cathode, control grid and anode electrodes, a resistor element connected in common to the cathode electrodes of said first and second discharge tube systems to thereby apply a biasing voltage to the control grid electrode of said second discharge tube system proportional to the amplitude of current flow through said first discharge tube system, means to couple the cathode and anode electrodes of said second discharge tube system to said resonant circuit, phase shifting means coupled to said resonant circuit for producing a quadrature voltage, and means to apply said quadrature voltage to said control grid of said second discharge tube system in such a phase that frequency changes due to variation in value of the said energizing potential are compensated by reactance changes due to changes in said biasing potential.

2. An electrical circuit arrangement comprising wave generating means comprising a first discharge tube system having cathode, control grid and anode electrodes and a resonant circuit coupled to said electrodes in regenerative feedback relationship to produce a wave having a given frequency, means to apply an energizing potential to said anode electrode, said wave generating means undergoing variations in frequency in a given direction proportional to the value of said energizing potential, reactance variation means comprising a second discharge tube system having cathode, control grid and anode electrodes, a first resistor element connected in common to the cathode electrodes of said first and second discharge tube systems to thereby apply a biasing voltage to the control grid electrode of said second discharge tube system proportional to the amplitude of current flow through said first discharge tube system, a second resistor element intercoupling the control grid and cathode electrodes of said first discharge tube, means to couple the cathode and anode electrodes of said second discharge tube system to said resonant circuit, phase shifting means coupled to said resonant circuit for producing a quadrature voltage, and means to apply said quadrature voltage to said control grid of said second discharge tube system in such a phase that frequency changes due to variation in value of the said energizing potential are compensated by reactance changes due to changes in said biasing potential.

3. An electrical circuit arrangement comprising wave generating means comprising a first discharge tube system having cathode, control grid and anode electrodes and a resonant circuit coupled to said electrodes in regenerative feedback relationship to produce a wave having a given frequency, means to apply an energizing potential to said anode electrode, said wave generating means undergoing variations in frequency in a given direction proportional to the value of said energizing potential, reactance variation means comprising a second discharge tube system having cathode, control grid and anode electrodes, a resistor element connected in common to the cathode electrodes of said first and second discharge tube systems to thereby apply a biasing voltage to the control grid electrode of said second discharge tube system proportional to the amplitude of current flow through said first discharge tube system thereby to vary the reactance of said reactance variation means in a given sense, means to couple the cathode and anode electrodes of said

second discharge tube system to said resonant circuit, phase shifting means coupled to said resonant circuit for producing a quadrature voltage, and means to apply said quadrature voltage to said control grid of said second discharge tube system in such a phase that the reactance of said reactance variations means is varied in a sense opposite to said given sense thereby to compensate for frequency changes due to variations in value of the said energizing potential.

4. An electrical circuit arrangement comprising wave generating means comprising a first discharge tube system having cathode, control grid and anode electrodes and a resonant circuit coupled to said electrodes in regenerative feedback relationship to produce a wave having a given frequency, means to apply an energizing potential to said anode electrode, said wave generating means undergoing variations in frequency in a given direction proportional to the value of said energizing potential, reactance variation means comprising a second discharge tube system having cathode, control grid and anode electrodes, a resistor element connected in common to the cathode electrodes of said first and second discharge tube systems to thereby apply a biasing voltage to the control grid electrode of said second discharge tube system proportional to the amplitude of current flow through said first discharge tube system, means to couple the cathode and anode electrodes of said second discharge tube system to said resonant circuit, phase shifting means coupled to said resonant circuit for producing a quadrature voltage, means to apply said quadrature voltage to said control grid of said second discharge tube system in such a phase that frequency changes due to variation in value of the said energizing potential are compensated by reactance changes due to changes in said biasing potential, frequency detector means coupled to said resonant circuit to produce a control potential having a polarity and amplitude proportional to variations in frequency from said given frequency, and means to apply said control potential to the control grid of said second discharge tube to vary the reactance of said reactance variation means thereby to maintain the frequency of said wave substantially constant.

5. An electrical circuit arrangement comprising wave generating means comprising a first discharge tube system having cathode, control grid and anode electrodes and a resonant circuit coupled to said electrodes in regenerative feedback relationship to produce a wave having a given frequency, means to apply an energizing potential to said anode electrode, said wave generating means undergoing variations in frequency in a given direction proportional to the value of said energizing potential, reactance variation means comprising a second discharge tube system having cathode, control grid and anode electrodes, a resistor element connected in common to the cathode electrodes of said first and second discharge tube systems to thereby apply a biasing voltage to the control grid electrode of said second discharge tube system proportional to the amplitude of current flow through said first discharge tube system, a reactive element having a reactance value proportional to the anode current of said second discharge tube system and being coupled to said resonant circuit to vary the resonant frequency of said resonant circuit proportional to the voltage applied to the control grid of said second discharge tube, means to couple the cathode and anode electrodes of said second discharge

7

tube system to said resonant circuit, phase shifting means coupled to said resonant circuit for producing a quadrature voltage, and means to apply said quadrature voltage to said control grid of said second discharge tube system in such a phase that frequency changes due to variation in value of the said energizing potential are compensated by reactance changes due to changes in said biasing potential.

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8

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