

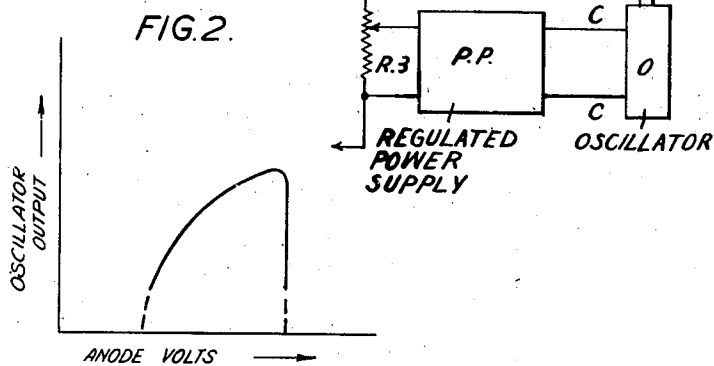
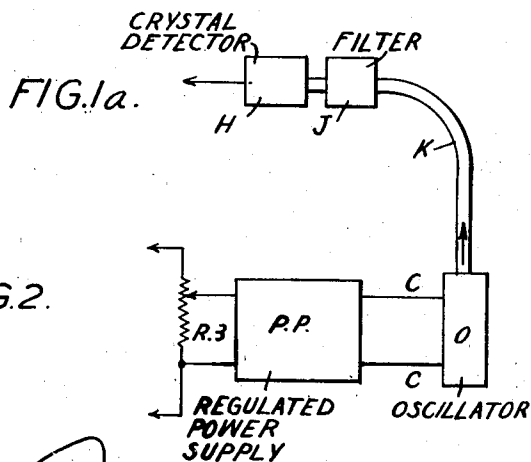
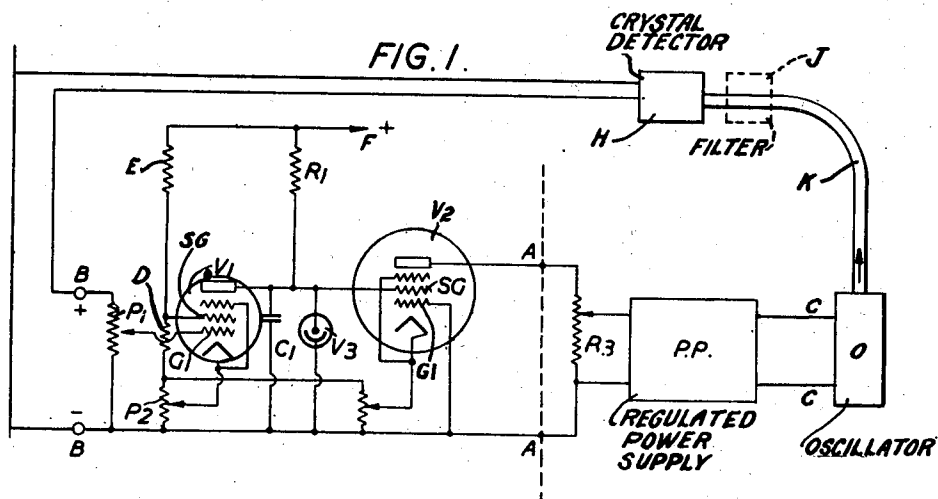
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VOLTAGE CONTROL ARRANGEMENT

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VOLTAGE CONTROL ARRANGEMENT

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1

The present invention relates to electrical oscillation generator systems in which a characteristic of the output is dependent upon two or more variable factors of the system. By a factor is meant an applied voltage, filament temperature, tuning adjustment of a resonant circuit, or other variable which affects the output characteristic of the system. The invention is particularly though not solely applicable to ultra-high frequency oscillation generators of the velocity modulation type for automatically adjusting the applied voltage which determines the transit time of the electrons as the tuning of the resonant circuit or chamber is varied, or vice versa.

Oscillators of the velocity-modulated type require applied voltages of a definite value—within certain margins—corresponding to the frequency to which the electrical circuit elements are tuned to respond. For example, in the coaxial line oscillator as described in Patent No. 2,320,860, granted June 1, 1943, to J. H. Fremlin, as the coaxial line physical length is varied from, say 5 to 10 cms. the frequency of oscillation may (due partly to capacity loading of the line) change from 3750 mc./s. (8 cm.) to 2500 mc./s. (12 cm.). Oscillations, however, will only be sustained provided the applied anode voltage is adjusted in sympathy with the electrical length of the coaxial line so as to adjust the electron transit times or angles and thus provide the requisite conditions for oscillation. In practice the voltage would vary from about 550–250 volts over the frequency range mentioned.

In order to construct an oscillator of this type to cover a frequency range it is therefore necessary to provide two controls, one to adjust mechanically the electrical dimensions of the circuit and the other to adjust the applied voltage or voltages which govern the transit angles. The two controls may be ganged together mechanically in known manner, but such systems are not satisfactory in mass-production due to variations which inevitably occur in valve characteristics and make necessary a readjustment of the coupling relationship between the two controls or a re-tracking of the ganging arrangements whenever a valve is replaced.

When only small variations of frequency have to be catered for, the tuning of the circuits may be accomplished electrically—for example by application of the Miller effect or any of the means known to those skilled in the art of automatic frequency control, and then this electrical control of frequency may be derived from the applied voltages and arranged to maintain the resonant

2

circuits in sympathy with the applied voltage. This method too, would require tracking and readjustment of tracking for each valve employed.

It is the object of this invention to provide control arrangements in which common control, such as ganging, between two or more variable factors which determine a characteristic of the output of the system is eliminated. Only a single factor need be adjusted and will cause the automatic adjustment of one or more factors. A more specific object of the invention is to provide control arrangements in an ultra-high frequency oscillation generator of the velocity modulation type in which the applied voltage which determines the transit time or angles of the electrons is automatically adjusted in sympathy with the variations in tuning of the resonant circuit or chamber of the oscillator or vice versa, the voltage and the tuning of the resonant chamber being factors which determine the frequency of the oscillations generated.

According to the present invention an electrical oscillation generator system in which a characteristic of the output is dependent upon two or more variable factors of the system is characterised by the provision of means for controlling automatically one or more of said factors in response to variations in other of said factors so as to maintain said characteristic at optimum or predetermined value.

According to a more specific aspect the invention comprises an electric oscillation generator system provided with means for stabilising an applied voltage at or near its optimum value for a predetermined characteristic.

The output characteristic may be, for example, the frequency of power level of the oscillator output, and the invention will be described in its application to maintaining the output level substantially constant, and in an embodiment to be described this condition also ensures that the variable factors are adjusted for maximum output.

In a specific embodiment of the invention an ultra-high frequency oscillation generator of the velocity modulation type is provided with means for automatically controlling, in response to the output power level of the generated oscillations, the applied voltage which determines the transit time or angles of the electrons. In such a system, it will be understood that the generation of oscillations can only take place when the applied voltage is suitably adjusted to correspond to the tuning of the output resonant chamber or circuit, and the output power level is a maximum when the applied voltage is optimum for the fre-

quency to which the resonant chamber is tuned.

In one way of carrying out the invention in practice, means is provided for searching for the correct value of the controlled factor, for example the applied voltage to give a desired output characteristic when the other factor or factors on which the characteristic depends has or have been adjusted to predetermined values. In the particular case of the ultra-high frequency oscillation generator, the desired frequency, which is the characteristic of the output, is predetermined by the setting of the resonant chamber and the applied voltage is varied cyclically, for example, over a range of voltages, means being provided to arrest the variation when the correct frequency indicated by the maximum output level is attained.

Means are provided for detecting the oscillation output, if necessary amplifying the output before or after detection, and employing the detected output to control one or more variable factors in sympathy with a varied factor. For example, in the ultra-high-frequency oscillation generator of the velocity modulation type the derived voltage is used to control the applied D. C. voltage in sympathy with the manually varied resonator tuning or to control electrical arrangements which vary the circuit adjustments in sympathy with variations in the applied voltage to maintain oscillation for which that voltage is suitable.

In the embodiment of the invention comprising an ultra-high frequency oscillator of the velocity modulation type, as the applied voltage passes through the correct value, the oscillator bursts into oscillation and the output immediately excites the control circuit which, in its turn, is employed to stabilise the applied voltage at the value at this moment. In some cases it is possible to dispense with the periodical fluctuation and allow the voltage to rise or fall through the required excursion once each time the apparatus is switched on or readjusted. Alternatively it may be economic to set the voltage by hand in the first instance and thereafter let it follow the variation of its own accord.

It is a requirement that any embodiment of the invention should be inherently stable, and it is also desirable that the voltage should not "hunt" about the exact final value. In the case of the oscillator, for example, the former condition can be obtained by ensuring that increase in output amplitude from the oscillator causes the applied voltage to change in the direction which reduces the output amplitude and vice-versa; the latter condition may be obtained by suitable choice of time-constants and sensitiveness of control.

In other embodiments of the invention it may be desirable to control the applied voltage dependent upon the rate of change of the output amplitude with respect to change in applied voltage, rather than directly upon the output amplitude, using the rate of change of output amplitude to cause corresponding changes in the applied voltage.

Many forms of oscillator have more than one mode of oscillation; i. e. they will oscillate at various wave-lengths for one setting of the circuit dimensions at different discreet voltages and vice-versa. It will often be necessary to include in the system means for preventing the excitation of unwanted modes.

The invention will be better understood from the following description taken in conjunction with the accompanying drawing, of arrange-

ments embodying the invention for regulating an ultra-high frequency oscillator, for example of the velocity modulation type and having a coaxial tunable resonant chamber, as described in Patent No. 2,320,860.

In the drawings

Figure 1 shows the circuit arrangements, Fig. 1a a modification, and

Figure 2 is a graph which will be referred to in the description.

The circuit described was designed to search for, and fix, the correct voltage necessary for oscillation in an ultra-high frequency generator of the type described in Patent No. 2,320,860, for any given frequency, as determined by the electrical length of the associated coaxial resonator.

Referring to Figure 1, the terminals AA are connected to a conventional control circuit PP of a regulated power pack normally used and arranged to supply H. T. volts via CC to the electron collecting electrode or anode of the oscillator O. To the left of AA is the regulator circuit of the invention, the operation of which is as follows:

Under conditions when no oscillations can occur in the ultra high frequency oscillator O, the valve V₁ is biased to cut off by means of a variable tapping on resistance P₂ in a chain of resistances including besides P₂, the resistances D and E connected across the source of supply from B- to F+. A resistance R₁ is connected between the positive source F+ and the plate of the valve V₁, and a condenser C₁ and a neon discharge lamp V₃ are connected in parallel between this plate and the negative potential B-. The plate of the valve V₁ is also connected to the screen grid SG of a pentode valve V₂. The circuit formed by the resistance R₁, the condenser C₁ and the neon discharge lamp V₃, produces a saw tooth voltage which is applied to the screen grid SG of the pentode V₂ and amplified thereby. This amplified voltage of saw-tooth wave-form is applied across a resistance R₃ and the voltage obtained from a variable voltage tap on resistance R₃ is applied to the control circuit of the regulated power pack PP and causes the H. T. voltage applied to the ultra-high-frequency oscillator to sweep over the range of voltages which is likely to cause oscillation. The phase of this voltage sweep will be the same as the voltage on the condenser C₁.

If conditions are such that oscillations can occur in the ultra-high frequency oscillator, then as the voltage sweeps through the correct value, a high-frequency output will be produced. This output is rectified by a crystal detector H and the rectified D. C. output is applied to the input of the regulator circuit at BB through resistance P₁ to provide a voltage to overcome the bias applied to the first grid G₁ of valve V₁, this grid being connected to a variable contact on the resistance P₁. This derived voltage tapped off from P₁ causes anode current to flow through the valve V₁ in proportion to the value of the voltage. The additional flow of current through R₁ causes a drop in the potential applied to condenser C₁ and thus arrests the charging of the condenser C₁ and prevents the voltage thereacross from reaching its maximum. The voltage sweep is thus arrested and the control voltage applied to the power pack PP will remain constant, so long as the amplitude of the output of the ultra-high frequency valve O remains constant, and this output is a maximum for any particular setting of the ultra-

high frequency oscillator at the resonance frequency of the resonant circuit, and thus the output voltage of the power pack will thereafter be entirely dependent on the amplitude of the generated oscillations. The maximum amplitude of the output oscillations over a range of frequencies will be substantially constant.

The general shape of the output-anode voltage curve of an ultra-high frequency velocity modulation type oscillator with resonant chamber is shown in Fig. 2. The regulator circuit is such that any increase in oscillation amplitude causes a corresponding decrease in applied anode voltage, so that the circuit is inherently stable provided that the applied voltage is lower than that giving maximum output. By adjusting the potentiometer P₁ or the biasing control potentiometer P₂ so that a smaller fraction of the oscillator output is applied to the regulator, the power-pack voltage can be increased until the oscillator is giving an output only very slightly less than the maximum possible output.

In operation the circuit functions well, provided precautions are taken to ensure (1) that the correct relationship exists between the variation of the voltage applied to BB and the corresponding variation in the voltage applied to the anode, so that the voltage applied to the anode should vary with frequency generated in a predetermined way to ensure optimum operation over the frequency range, (2) that unwanted modes of oscillation do not cause voltages to appear at BB. These two difficulties may be overcome in the following way. Firstly the crystal detector circuit must at any wave length be so arranged as to derive the correct voltage, which when applied to BB causes the power-pack PP to deliver the optimum voltage to the oscillator for that wave-length. A crystal of the silicon-tungsten type may be employed as the detector H of the high-frequency energy output from the oscillator, and the crystal is coupled to the oscillator through a length of attenuating cable K (about 10 db. total attenuation). This attenuation prevents standing-wave patterns from being set up in the cable and thus avoids mismatch of the detector at some wavelengths which would cause a dissipation of power variable with frequency with the consequent anomalous variation of the voltage applied to BB.

Secondly three different methods of preventing the unwanted modes are as follows:

1. The voltage may be varied between limits which cannot excite unwanted modes. These limits may be controlled by and made dependent upon the settings of the circuit frequency control.

2. The high-frequency detector H which controls the applied voltage may be fed through selective wave filters J which reject the unwanted modes. This is illustrated in Fig. 1a.

3. The oscillator resonant circuit may be designed for example with the incorporation of suitably located dampers so as to prevent the generation of unwanted modes in sufficient power to operate the control circuits.

Alternatively, the coaxial resonant chamber may be terminated with a "filter-reflector" which prevents the coaxial line developing a high impedance except in a predetermined frequency range, and consequently prevents the production of unwanted modes. In a slightly modified form of the circuit a wave-guide filter may be used between the oscillator output and the crystal detector, thereby preventing unwanted frequencies reaching the crystal.

In practice it is desirable that time-constants for the operation of various parts of the system should be suitably related. In the case for example of the coaxial-line oscillator the voltage may be made to vary from 550 to 250 volts according to a saw-tooth wave-form law. As the voltage passes through the correct value, the valve will burst into oscillation and it is necessary that the total time-constant of the detector and voltage-control circuits should respond sufficiently rapidly to stabilise the voltage before the sweep has carried it beyond the correct operating value. On the other hand, in systems in which the high frequency is being modulated or subject to casual variations it is necessary to ensure that the detector time-constant is long enough to maintain the voltage steady throughout the modulation cycle. These two requirements may on occasion be incompatible and it may be necessary to arrange for the time constants to change value after the correct voltage has been selected. This can be accomplished in many known ways.

The sensitiveness of the control circuit determines exactly the nearness of approach of the voltage, under working conditions, to its optimum value. It is clearly desirable to keep the value of this voltage as close as possible to the optimum value consistent with reliable operation. The sensitiveness depends too on the relationship between oscillator output level and applied voltage, and if this level varies markedly with frequency or load it will be desirable to make the sensitiveness of the control circuit a function of these variables. Furthermore, for some forms of oscillator it is desirable to have a non-linear relationship between input to the control circuit and applied voltage so that maximum control is effected as soon as oscillations commence and no unwanted control is effected by small casual variations in the output.

It will be understood that the invention is not limited to the embodiment described by way of example, but that it is capable of many adaptations and modifications which will be apparent to those skilled in the art and which fall within the scope of the invention as defined in the appended claims.

What is claimed is:

1. In combination, an oscillator, a sweep voltage generator, means to apply the sweep voltage to cause the oscillator to sweep over a range of voltages which is likely to cause oscillation, means for rectifying the output of said oscillator and applying D. C. potential therefrom to said generator to arrest the sweep voltage and thus establish a constant control voltage which is applied to the oscillator while its output amplitude remains constant.

2. In combination, an ultra-high-frequency oscillator, a regulator circuit comprising a valve having a cathode, an anode and at least two grids, a source of potentials for said regulator circuit, means for negatively biasing the first grid, a sweep voltage generator comprising a condenser and a discharge lamp bridged in parallel between the anode and the negative pole of said source, a resistance to which the sweep voltage is applied, a variable tapping for applying voltage from said load resistance to said oscillator to cause it to sweep over a range of voltages which is likely to cause oscillation, means for rectifying the output of said oscillator and applying positive D. C. potential therefrom to said first grid, a potentiometer in the last mentioned connection ad-

justed to produce an anode current flow proportional to said D. C. potential, followed by a corresponding drop in the potential applied to said condenser to arrest the sweep voltage, whereby constant control voltage will be applied to the oscillator while its output amplitude remains constant.

3. In combination, an ultra-high frequency oscillator, having an electron collecting electrode, a power pack for supplying high tension current to said electrode, a regulator circuit comprising two valves each having a cathode, an anode and at least two grids, a source of potentials for said regulator circuit, means for negatively biasing the first grid of the first valve, a connection from the anode of said first valve to the second grid of the second valve, a sweep voltage generator comprising a fourth resistance bridged between the positive pole of said source and the last mentioned anode-grid connection and a condenser and a discharge lamp bridged in parallel between the last-mentioned anode-grid connection and the negative pole of said source, the sweep voltage thus generated being applied to said second grid of said second valve for amplification by the latter, a load resistance in the anode circuit of said second valve, a variable tapping from said load resistance to said power pack to apply the amplified sweep voltage to cause the oscillator to sweep over a range of voltages which is likely to cause oscillation, means for rectifying the output of said oscillator and applying positive D. C. potential therefrom to said first grid of said first valve, a potentiometer in the last mentioned connection adjusted to produce an anode current flow in said first valve proportional to said D. C. potential, followed by a corresponding drop in the potential applied to said condenser to arrest the sweep voltage, whereby constant control voltage will be applied to the power pack while the oscillator output amplitude remains constant.

4. In combination, an ultra-high-frequency oscillator having an electron collecting electrode, a power pack for supplying high tension current to said electrode, a regulator circuit comprising two valves each having a cathode, an anode and at least two grids, a source of potentials for said regulator circuit having its positive pole connected through a first resistance to the second grid of the first valve, a connection from said second grid through a second and a third resistance in series to the negative pole of said source, a variable tapping for connecting the cathode of said first valve with said third resistance, a connection from the anode of said first valve to the

second grid of the second valve, a sawtooth voltage generator comprising a fourth resistance bridged between the positive pole and the last mentioned anode-grid connection and a condenser and a discharge lamp bridged in parallel between the last-mentioned anode-grid connection and the negative pole of said source, the saw-tooth voltage thus generated being applied to the first grid of the second valve for amplification by the latter, a load resistance in the anode circuit of said second valve, a variable tapping from said load resistance to said power pack to apply the amplified sawtooth voltage to cause the oscillator to sweep over a range of voltages which is likely to cause oscillation, a crystal detector, a transmission line connecting the output of said oscillator to said crystal detector, a connection for applying positive D. C. potential from said crystal detector to said first grid of said first valve, a potentiometer in the last mentioned connection adjusted to produce the anode current flow in the first valve proportional to said D. C. potential, followed by a corresponding drop in the potential applied to said condenser to arrest the sweep voltage, whereby constant control voltage will be applied to the power pack while the oscillator output amplitude remains constant.

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