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OSCILLATION GENERATOR

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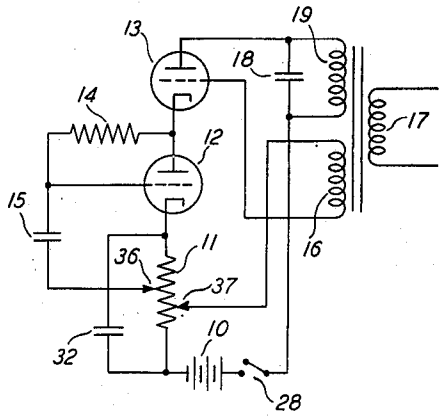


FIG. 1

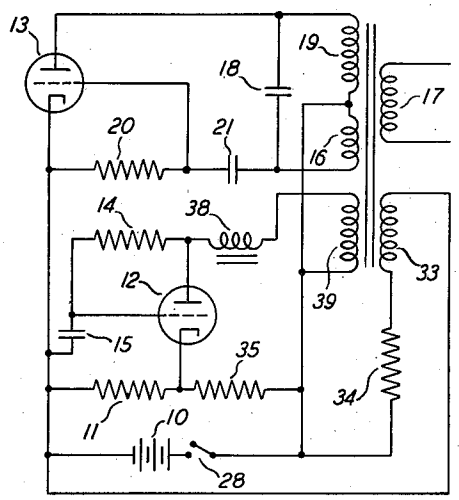


FIG. 2

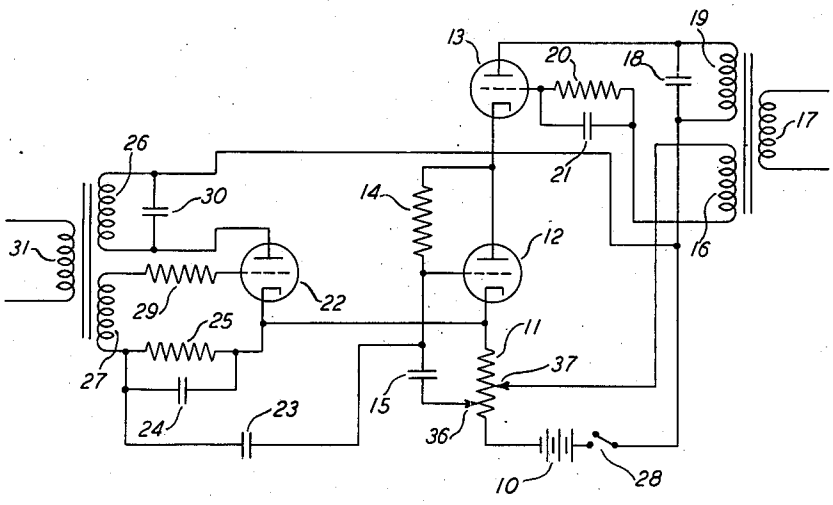


FIG. 3

INVENTOR.
HENRY M. HUGE
BY Fraddling and Kroat
ATTORNEYS.

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OSCILLATION GENERATOR

Henry M. Huge, Lorain, Ohio, assignor, by mesne assignments, to Lorain Products Corporation, Lorain, Ohio, a corporation of Ohio

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9 Claims. (Cl. 250—36)

1

This invention relates to vacuum tube oscillators and more particularly to oscillators capable of generating oscillations which periodically vary in amplitude or frequency or both.

One of the objects of this invention is to produce a signaling tone initially having a very small amplitude which gradually increases to a large amplitude.

It is a further object of my invention to generate an oscillation which simultaneously changes in amplitude and frequency over a given time interval.

Another object of my invention is to construct an oscillator in which the frequency of oscillation is changed by the variation in permeability of the magnetic core of one of the tuning elements.

A further object of this invention is to delay the beginning of oscillations in a vacuum tube oscillator for a specified time after the power supply is connected.

A still further object of this invention is to produce a signaling tone which starts at a low level, gradually increases to a high level, then stops entirely, repeating this cycle of operation at predetermined intervals.

It is also an object of this invention to construct an oscillator which requires a considerable time to build up its oscillations to their final value, but which will restart its oscillations at approximately the initial low level if the oscillations are momentarily stopped.

Other objects and a better understanding of my invention may be obtained by referring to the following specification and claims in connection with the accompanying drawings.

Figure 1 shows an embodiment of my invention for obtaining a time delay and a gradually increasing output signal.

Figure 2 is an embodiment of my invention in which the control tube is used to gradually change the oscillator frequency.

Figure 3 shows the application of an interrupter to the circuit of Figure 1, for obtaining a time delay and gradually increasing the amplitude of the output signal at spaced time intervals.

Referring now more particularly to Figure 1, there is shown schematically a vacuum tube oscillator circuit according to my invention in which triode 13 is connected as an oscillator by coupling plate winding 19 and grid winding 16 with each other. Triode 12 and resistor 11 are connected in the cathode circuit of tube 13, and resistor 14 and capacitor 15 cooperate to apply a changing grid potential to triode 12 which, in

2

turn, controls the rate of building up the amplitude of the oscillations in the circuit.

It is to be understood that although the control elements may be specifically referred to as vacuum-tube triodes, the scope of my invention is not limited in this respect, for it is apparent that other types of grid-controlled valves may also be used successfully.

In Figure 1, tube 13, together with capacitor 18 and windings 16 and 19 form an oscillator circuit. Tube 12 acts as an automatically variable resistance in series with the cathode of tube 13. The rate of change of cathode-to-plate resistance of tube 12 is automatically controlled by the charging of capacitor 15 through resistor 14.

To explain in greater detail the operation of my invention as shown in Figure 1, it will be assumed that the capacitor 15 has no initial charge. When the switch 28 to the source of direct current 10 is closed, direct current passes through winding 19, tubes 12 and 13, and resistor 11. Resistor 14 preferably has a high value compared with the other circuit resistances so the charging current of capacitor 15 passing through resistor 14 is small compared with the current flowing through the tubes. The plate current of tube 13 passing through resistor 11 causes the cathode of tube 12 to assume a positive potential with respect to its grid. The initial impedance of tube 12 is therefore large. The potential between the cathode and grid of tube 13 is equal to the sum of the potentials across tube 12 and resistor 11 plus the voltage induced in winding 16 by variations in the current through winding 19.

Winding 16 is connected regeneratively, that is, an increase in the current flowing through winding 19 induces a voltage in winding 16 which makes the grid of tube 13 more positive or less negative with respect to its cathode, so that, with sufficient regeneration to counterbalance the resistance of the circuit, oscillations can occur at the natural frequency of the circuit, determined chiefly by the inductance of winding 19 and the value of capacitor 18. With tube 13 in oscillating condition, the voltage across winding 16, induced from winding 19, is approximately 180° out of phase with the A. C. component of the voltage across tube 12. The effect of the resistance of tube 12 is therefore degenerative. I prefer to proportion the circuit elements so that under the initial conditions this degeneration is sufficient to prevent oscillations.

Capacitor 32 is used to by-pass the alternating current around resistor 11 in order to minimize the A. C. voltage supplied to the grid of tube 12.

With some circuit values, I am able to obtain satisfactory operation without the use of capacitor 32. As the capacitor 15 gradually becomes charged, the grid of tube 12 becomes less negative and the resistance of the tube decreases sufficiently to permit oscillations to start. The initial oscillations are of a low amplitude but gradually increase in amplitude until capacitor 15 reaches its final condition of charge.

By arranging windings 16, 17 and 19 on a saturable magnetic core, I am able to cause a change in frequency to accompany the increase of amplitude of the oscillations. This change in frequency is a result of a change in the permeability of the magnetic core material resulting from the change in magnetization. When the oscillator is to be used as an audio frequency signalling generator, this simultaneous change in amplitude and frequency imparts a distinctive character to the signal and in many instances is a highly desirable feature. If a constant frequency is required, windings 16, 17 and 19 may be placed on a core whose permeability is not appreciably varied by the change in magnetization, or for higher frequencies, air core inductors may be used.

The output signal is supplied from winding 17, which may be connected directly to a load or to an amplifier which will supply the load.

The circuit of Figure 1 does not include the usual grid leak and condenser to bias the grid of tube 13. No such biasing arrangement is necessary for protecting the tube because the grid is self-biased by the plate current to a sufficiently high value to protect the tube, and the additional resistance of tube 12 and resistor 11 also limits the current.

Resistor 11 performs two functions. First, it controls the time interval between the closing of switch 28 and the beginning of oscillations generated by tube 13. Second, it provides an adjustment for the bias of tube 13 through the adjustment of tap 37. In some cases the desired circuit operation may be obtained when resistor 11 is omitted.

The time delay between the closing of switch 28 and the beginning of oscillations is controlled by the charging of capacitor 15 through resistor 14. The adjustment of tap 36 on resistor 11 adjusts the time delay obtained before oscillations begin, without appreciably affecting the initial rate of increase of amplitude of the oscillations or the final amplitude of the oscillations. In general, I have found it desirable to employ a relatively high value for resistor 14 and thus use a small and inexpensive capacitor 15. By making capacitor 15 small, I also obtain an advantage in circuit operation. When switch 28 is opened, the current through resistor 11 decreases sharply, the charge on capacitor 15 makes the grid of tube 12 positive with respect to its cathode, and capacitor 15 discharges through tube 12. Capacitor 15 discharges rapidly to re-establish the initial circuit conditions, so that if switch 28 is reclosed soon after being opened, the circuit operation is similar to its operation under the initial conditions. If capacitor 15 is made too large it may retain a high enough voltage when switch 28 is reclosed to permit the immediate starting of oscillations at a relatively large amplitude.

The regenerative winding 16 is proportioned to give the desired rate of increase of the oscillations; it also influences the time delay between the closing of switch 28 and the beginning of the oscillations. This time delay is further adjusted by the adjustment of tap 37 on resistor 11.

In Figure 2, tube 13 oscillates continuously and control tube 12 is connected to vary the magnetization of the saturable inductive tuning element and thus to change the oscillator frequency without appreciably affecting its amplitude.

The oscillator connections of Figure 2 are somewhat different than in Figure 1. The windings 16 and 19 are connected in series and capacitor 18 is connected across both of them. Capacitor 21 couples the grid of tube 13 to winding 16, and grid leak 20 provides grid-current bias for the oscillator. The natural frequency of the oscillator is determined by the value of capacitor 18 and the inductance of the combined windings 16 and 19. The oscillator connections shown in the various drawings can for the most part be used interchangeably or replaced by other standard oscillator connections to produce the desired results.

As in Figure 1, the output is supplied from winding 17 either directly or through an amplifier.

The transformer in Figure 2 has windings 33 and 39 in addition to the windings shown in Figure 1. The direct current passing through winding 39 and tube 12 applies a controlled magnetizing force to the saturable core, varying its permeability and consequently changing the output frequency. Impedance 38 is used to limit the passage of alternating current through winding 39 because such current would constitute a load on oscillator 13. In some cases, the resistance of the tube 12 is sufficient to limit the alternating current and impedance 38 can be omitted.

The operation of control tube 12 in conjunction with resistors 11 and 14 and capacitor 15 is similar to the operation described in connection with Figure 1. A modification is introduced in Figure 2 by the provision of resistor 35 which causes a fixed biasing current to flow through resistor 11 in order to provide an increased stabilized bias. The effect of the control tube on the oscillator, however, is of a different nature. In Figure 1 it was used chiefly to control the amplitude of the oscillations and by so doing, it simultaneously controlled the frequency. In Figure 2, it is connected in such a manner that its chief effect is on the frequency of the oscillations.

The additional biasing winding 33 supplied from source 10 through resistor 34 may be used to premagnetize the saturable core to modify the effect of the control current through winding 39. To obtain a large frequency increase, the biasing winding 33 may be polarized and proportioned to substantially cancel the net magnetizing forces of windings 19 and 39 under the initial conditions.

When switch 28 is closed, tube 13 begins to oscillate. At first, the current through winding 39 is relatively small because of the high initial impedance of control tube 12. As capacitor 15 gradually becomes charged and the resistance of control tube 12 diminishes, the direct current through winding 39 increases. The effect produced by this gradual change in current through winding 39 depends to a great extent on the proportioning of the circuit elements. For example, it is possible to have the initial impedance of winding 19 at its maximum value, in which case the gradually increasing current through winding 39 produces an increase in frequency. By increasing the current through winding 33 to premagnetize the core to a suitable degree, it

is possible to decrease the frequency with increasing current through winding 39. To those skilled in the art it will be evident that various other effects can be obtained by suitable choice of the degree of premagnetization. In some cases the required variation may be obtained merely by the proper proportioning and polarizing of windings 19 and 39 so that winding 33 may be omitted.

The circuit of Figure 2 can be used to supply an output voltage varying in amplitude as well as frequency, if desired. To obtain this effect, it is merely necessary to supply the load from winding 17 through a frequency selective network.

The oscillator circuits shown in Figures 1 and 2 change the frequency or amplitude of the generated oscillations only while capacitor 15 is being charged. After a time, the charge on capacitor 15 reaches a steady state and the output of the oscillator remains unchanged until switch 28 is opened.

Figure 3 shows how an interrupter tube may be connected for producing a periodic repetition of the operation of the circuit shown in Figure 1. The interrupter can be applied in the same manner to the circuit of Figure 2.

Interrupter tube 22 in Figure 3 is an oscillator in itself; when it starts oscillating it tends to shut down the oscillations of tube 13. When tube 22 stops oscillating, the main oscillating circuit repeats its cycle of building up oscillations.

Winding 31 in Figure 3 is added to supply an additional output signal, provided by oscillator 22. Capacitor 30 and winding 26 set the frequency of the oscillations in this part of the circuit.

As has been previously mentioned, Figure 1 does not show any provision for grid current biasing. In Figure 3, as in Figure 2, grid leak 20 and condenser 21 have been added for this purpose. The grid current biasing of oscillator tube 13 in Figure 3 helps to produce circuit characteristics which may be highly desirable. The additional negative bias on the grid of tube 13 tends to reduce the D. C. component of plate current below the value of current which flows during the starting condition, thereby reducing the potential drop across resistor 11 and consequently reducing the charge on capacitor 15. Therefore, if the oscillation in the circuit of tube 13 is stopped by an external cause, the charge on capacitor 15 may be small enough to approximate the initial condition. The larger current flowing through resistor 11 will then cause the cathode of tube 12 to assume a positive potential with respect to its grid and the resistance of tube 12 will be sufficiently high to prevent the starting of oscillations by tube 13 until sufficient time has elapsed for capacitor 15 to charge up to the proper value.

Under the proper circuit conditions the oscillations of tube 13 can be stopped by lowering the grid potential of tube 12 by means of an impulse transmitted through capacitor 23. Then, as capacitor 15 is slowly recharged by current through resistor 14 and by the gradual return of the charge from capacitor 23, the oscillations again gradually build up to their maximum amplitude.

To explain the operation of the interrupter circuit, this circuit will be considered as a unit, ignoring the effect of the coupling capacitor 23. By ignoring the effect of capacitor 23, the tube 22 can be considered as an entirely independent oscillator unaffected by the condition of the main oscillator circuit.

Windings 26 and 27 are connected to produce

regeneration. The mutual inductance between these windings is considerably in excess of the minimum required to produce oscillations in the circuit. Resistor 25 and capacitor 24 provide the grid bias for the oscillator and are proportioned so that the reactance of capacitor 24 is very low at the frequency of the oscillations, and the time constant of resistor 25 and capacitor 24 is comparable with the desired period of interruptions. When switch 28 is closed, supplying power to this circuit, oscillations begin. These oscillations are violent because the amount of regeneration is large and the grid bias does not appear immediately, until the grid current has charged the relatively large capacitor 24.

Apparently as capacitor 24 is charged by the grid current passing through it, it is charged to a voltage greater than the grid bias voltage at which oscillations can be sustained. Once this excess voltage has been established, it is maintained for an appreciable period of time because of the long time constant of capacitor 24 and resistor 25. Under this condition, no plate current flows through tube 22 and the oscillations stop entirely. After the capacitor 24 has discharged through resistor 25 sufficiently to permit plate current to flow, the oscillations begin again and the cycle is repeated.

During the periods of zero plate current in tube 22 the oscillations in the circuit of tube 13 build up to their full amplitude, and when the oscillations begin in the circuit of tube 22, the grid side of capacitor 24 drops in potential as previously explained. This drop in potential causes part of the charge of capacitor 15 to pass through capacitor 23 to the grid of tube 22, with the result that the grid of tube 12 may become sufficiently negative to stop the oscillations in the circuit of tube 13. Then the operation of that part of the circuit is as has already been explained.

The output signal supplied from winding 31 is of a "chopped" nature, starting rapidly, remaining at an almost constant amplitude and then stopping suddenly. The relative lengths of the on and off periods of these oscillations can be controlled by the selection of suitable values for resistor 29. If the amount of regeneration is large and resistor 29 has a relatively low value, the oscillations stop very quickly after starting, and do not restart until capacitor 24 discharges sufficiently to allow the plate current of tube 22 to flow again. When the chopped output signal is not used as a separate output, the relative lengths of the on and off periods may be unimportant and resistor 29 may be omitted entirely. Furthermore, in this case the frequency of these oscillations need not be accurately tuned and capacitor 30 may be omitted, so that the natural frequency of the winding 26 will determine the frequency of oscillation.

The rapid charging of capacitor 24 transmits a sharp impulse through capacitor 23 to suddenly stop the oscillations of tube 13. If resistor 29 is made larger so that capacitor 24 charges slowly, a gradual change in bias is applied to tube 12 and the oscillations of tube 13 may be stopped gradually. Thus resistor 29 adds flexibility to the control arrangement, so that, for example, an undulating output signal may be produced in winding 17.

The ratio between the sizes of capacitors 23 and 15 has a considerable effect on the nature of the interruptions. If capacitor 23 is made small in comparison with capacitor 15, the im-

pulse from tube 22 may not completely stop the oscillations, but merely diminish their amplitude, after which they gradually build up again. If capacitor 23 is made larger, the voltage on output winding 17 may be held to zero for some time after being cut off by the impulse from interrupter 22. However, in the latter case, the discharge of capacitor 24 through resistor 25 has a greater effect in accelerating the rate of increase of the output voltage on winding 17.

Although Figure 3 shows how the interrupter is applied to the circuit of Figure 1, the interrupter may be applied in like manner to the circuit of Figure 2. When the interrupter circuit is used to produce a periodic repetition of the operation of the circuit of Figure 2, the action of the interrupter is substantially the same as when applied to the circuit of Figure 1. The impedance of control tube 12 is periodically varied by the action of the interrupter 22 and the output signal is correspondingly varied.

It will be apparent to those skilled in the art that other methods of coupling the circuit of tube 22 with the circuit of tubes 12 and 13 might be used with similar results. For example, resistor 14 and capacitors 15 and 23 may be omitted and the grid of tube 12 connected directly to the grid side of capacitor 24 or to an intermediate position on resistor 25. Furthermore, various modifications shown in any one of the drawings may be applied to the other figures to adapt my invention to meet specific operating requirements.

It is to be understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and scope of the invention as hereinafter claimed.

I claim as my invention:

1. An oscillator circuit comprising, in combination, an oscillator tube having at least an anode, a cathode and a control element, a control tube having at least an anode, a cathode and a control element, an output circuit having a regenerative winding, circuit means for connecting the anode of the control tube to the cathode of the oscillator tube, means for connecting the output circuit between the anode of the oscillator tube and the cathode of the control tube, means for connecting the control element of the oscillator tube to the cathode of the control tube through said regenerative winding, a timing circuit, and means for exciting the control element of the control tube from the timing circuit.

2. An oscillator circuit comprising, in combination, an oscillator tube having at least an anode, a cathode and a control element, a control tube having at least an anode, a cathode and a control element, an output circuit having a regenerative winding, circuit means for connecting the anode of the control tube to the cathode of the oscillator tube, a cathode biasing means for connecting the cathode of the control tube to a point of reference potential, means for connecting the output circuit between the anode of the oscillator tube and the cathode of the control tube, means for connecting the control element of the oscillator tube to the cathode of the control tube through said regenerative winding, a timing circuit, and means for exciting the control element of the control tube from the timing circuit, said timing circuit extending from the anode of the control tube to the cathode biasing means and including a resistor and a capacitor connected in series with each other, said control element of the control tube being connected to the timing circuit at a point intermediate the capacitor and the resistor.

3. An oscillator circuit comprising, in combination, an oscillator tube having at least an anode, a cathode and a control element, a control tube having at least an anode, a cathode and a control element, an output circuit having a regenerative winding, circuit means for connecting the anode of the control tube to the cathode of the oscillator tube, means for connecting the output circuit between the anode of the oscillator tube and the cathode of the control tube, means for connecting the control element of the oscillator tube to the cathode of the control tube through said regenerative winding, a timing circuit extending from the anode to the cathode of the control tube and including a resistor and a capacitor connected in series with each other, the control element of the control tube being connected to a point intermediate said capacitor and resistor, and interrupter circuit means connected across said capacitor to modify the voltage impressed upon the control element of the control tube.

4. An oscillator circuit comprising, in combination, an oscillator tube having at least an anode, a cathode and a control element, a control tube having at least an anode, a cathode and a control element, an output circuit having a regenerative winding, circuit means for connecting the anode of the control tube to the cathode of the oscillator tube, means for connecting the output circuit between the anode of the oscillator tube and the cathode of the control tube, means for connecting the control element of the oscillator tube to the cathode of the control tube through said regenerative winding, a timing circuit extending from the anode to the cathode of the control tube and including a resistor and a capacitor connected in series with each other, the control element of the control tube being connected to a point intermediate said capacitor and resistor, and interrupter circuit means connected across said capacitor to modify the voltage impressed upon the control element of the control tube, said interrupter circuit means comprising an interrupter tube having at least an anode, a cathode and a control element, a resonant circuit having regenerative winding means, said resonant circuit being connected to the anode of the interrupter tube, said regenerative winding means being connected between the cathode and the control element of the interrupter tube, self-biasing means, circuit means for connecting the regenerative winding means and the self-biasing means between the cathode and the control element of the interrupter tube, and coupling means for connecting the self-biasing means to the control element of the control tube.

5. An oscillator circuit adapted to be energized from a source of direct current, comprising in combination, first and second valves each having an anode, a cathode and a control element, a nonlinear inductive element having first and second winding means, first circuit means for connecting the anode of the second valve to the cathode of the first valve, second circuit means extending from the anode of the first valve and to the cathode of the second valve for connecting said first winding means and said first and second valves in series with each other and with the source of direct current, third circuit means for connect-

ing the control element of the first valve to the cathode of the second valve through said second winding means, a circuit extending from the anode to the cathode of the second valve and including a resistor and a capacitor connected in series with each other with their junction connected to the control element of the second valve, said second valve comprising a degenerative impedance in the circuit of the first valve and cooperating with the said non-linear inductive element to vary both the amplitude and frequency of oscillations produced by the first valve.

6. An oscillator circuit comprising, in combination, an oscillator tube having an anode, a cathode and a control grid, a control tube having an anode, a cathode and a control grid, a resonant circuit having a regenerative winding, first circuit means connecting the resonant circuit in series with the anode-cathode circuits of the oscillator tube and the control tube, second circuit means extending from the cathode of the oscillator tube to its control grid and including said anode-cathode circuit of said control tube and said regenerative winding, the alternating voltage across the control tube opposing that across the regenerative winding to control the oscillations in the resonant circuit.

7. An oscillator circuit comprising, in combination, an oscillator tube having an anode, a cathode and a control grid, a control tube having an anode, a cathode and a control grid, a resonant circuit having a non-linear inductive element and having a regenerative winding, first circuit means connecting the resonant circuit in series with the anode-cathode circuits of the oscillator tube and the control tube, second circuit means extending from the cathode of the oscillator tube to its control grid and including said control tube and said regenerative winding, the alternating voltage across the control tube opposing that across the regenerative winding to control the amplitude and frequency of the oscillations in the resonant circuit.

8. An oscillator circuit comprising, in combination, first, second, and third valves, each having an anode, a cathode, and a grid, first resonant circuit means having first regenerative winding means connected between the grid of the first valve and the cathode of the second valve for exciting oscillations in the first valve, the anode of the second valve being connected to the cathode of the first valve in a series circuit including the first resonant circuit means and the anode-cathode circuits of the first and second valves, a circuit extending from the anode to the cathode of the second valve and including a resistor and a capacitor connected in series with each other, means for connecting a point intermediate the resistor and capacitor to the grid of the second valve, second resonant circuit means connected in the anode-cathode circuit of the third valve and having second regenerative winding means connected between the grid and the cathode of the third valve, grid-current biasing means connected in series with the second regenerative winding means whereby the third valve produces interrupted oscillations, coupling means for coupling the grid-current biasing means to the grid of the second valve, said second valve comprising an impedance in the circuit of the first valve to control the oscillations thereof in response to changes in the voltage across the grid-current biasing means.

9. An oscillator circuit comprising, in combination, first, second, and third valves, each having an anode, a cathode, and a grid, first resonant circuit means having a non-linear inductive element and having first regenerative winding means connected between the grid of the first valve and the cathode of the second valve for exciting oscillations in the first valve, the anode of the second valve being connected to the cathode of the first valve in a series circuit including the first resonant circuit means and the anode-cathode circuits of the first and second valves, a circuit extending from the anode to the cathode of the second valve and including a resistor and a capacitor connected in series with each other, means for connecting a point intermediate the resistor and capacitor to the grid of the second valve, second resonant circuit means connected in the anode-cathode circuit of the third valve and having second regenerative winding means connected between the grid and the cathode of the third valve, grid-current biasing means connected in series with the second regenerative winding means whereby the third valve produces interrupted oscillations, coupling means for coupling the grid-current biasing means to the grid of the second valve, said second valve comprising an impedance in the circuit of the first valve to control the amplitude and frequency of the oscillations in the first valve in response to changes in the voltage across the grid-current biasing means.

HENRY M. HUGE.

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