

March 5, 1940.

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2,192,205

OSCILLATION GENERATOR CIRCUIT

Filed March 30, 1937

2 Sheets-Sheet 1

Fig. 1

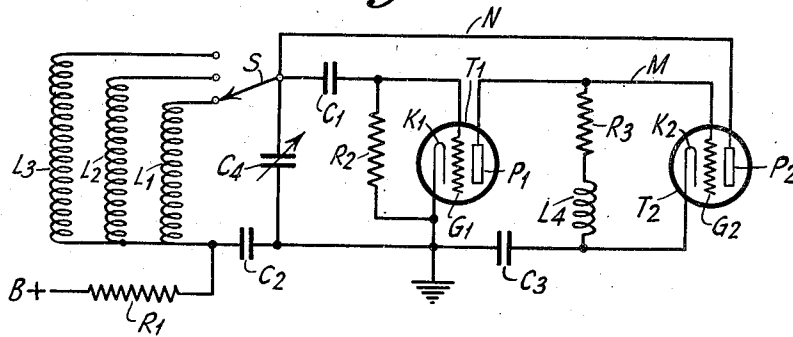


Fig. 2

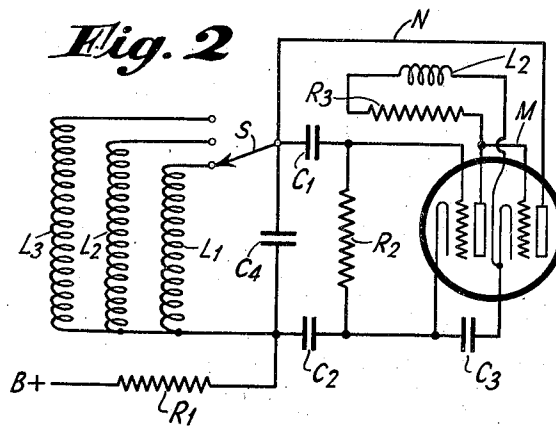
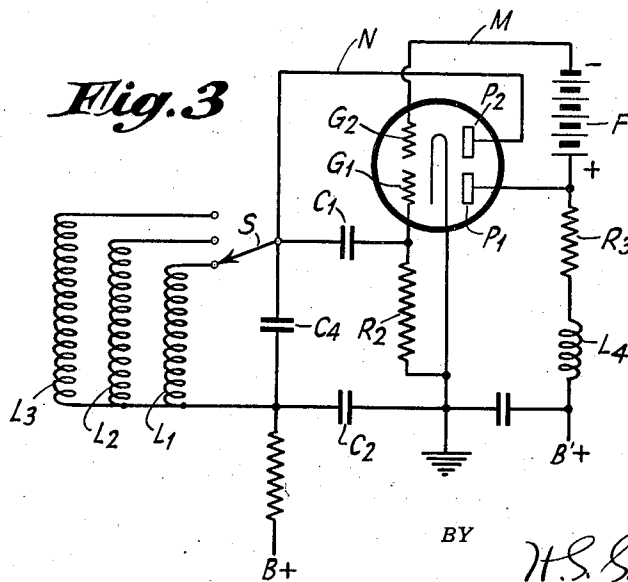


Fig. 3



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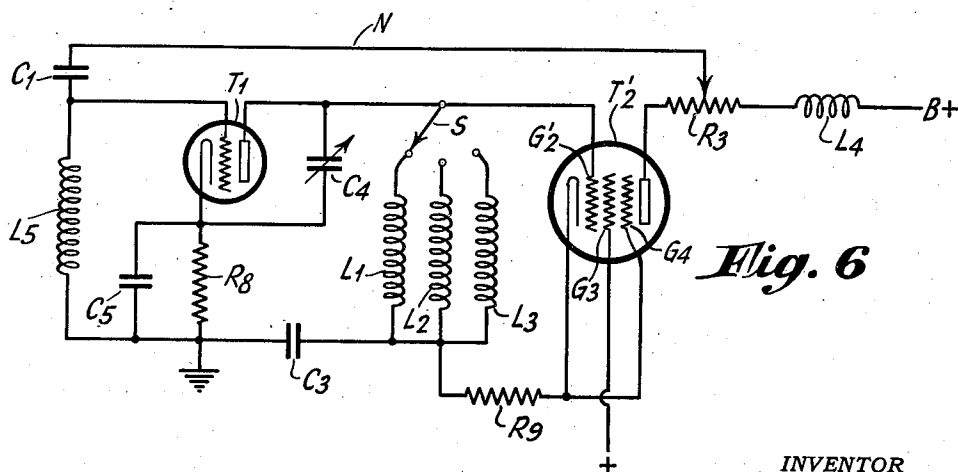
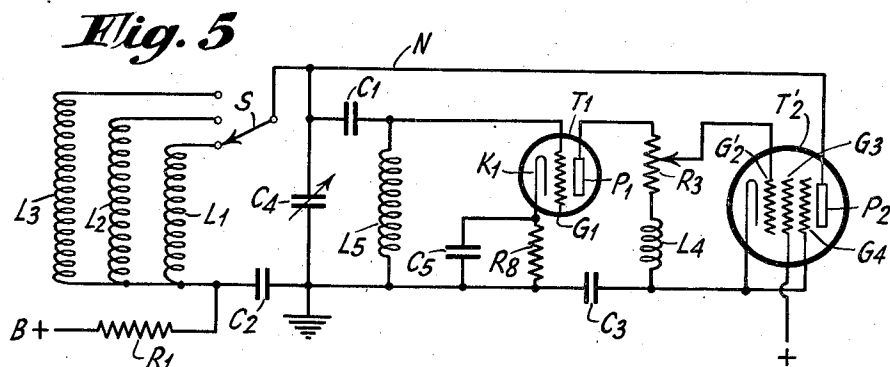
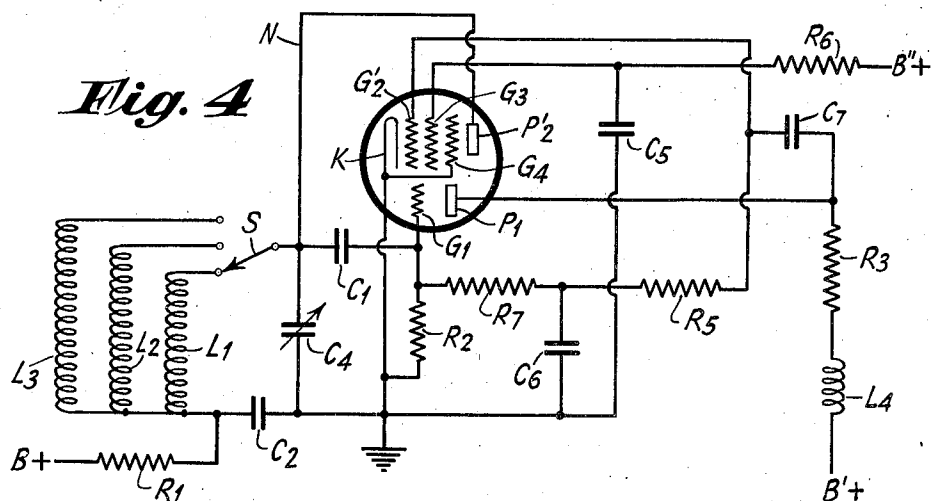
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2 Sheets-Sheet 2



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OSCILLATION GENERATOR CIRCUIT

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Application March 30, 1937, Serial No. 133,753

11 Claims. (Cl. 250—36)

This invention relates to oscillation generator circuits, and more particularly to such circuits as the "two-terminal" oscillator type. By the expression "two-terminal" oscillator, as understood in engineering practice, is meant a generator employing only a single tuned circuit whose two terminals are required to be connected to the generator for producing an operative structure.

Heretofore, in oscillator circuits designed to cover various frequency ranges, it has been necessary to switch a plurality of contacts in order to change from one frequency range to another. Such arrangements, besides being relatively expensive and cumbersome, are rather complicated and introduce undesirable energy losses. The present invention, inter alia, overcomes the foregoing disadvantages and provides a relatively simplified oscillation circuit which requires that only one contact be changed in order to switch from one frequency range to another.

Accordingly, one of the objects of the present invention is to provide a simplified oscillator wherein a minimum of switching of tuned circuits is required for obtaining a number of different frequency ranges.

Another object is to provide a simplified regenerative type of two-terminal oscillator wherein a vacuum tube is employed to replace the usual feed-back coil.

A further object is to provide a multi-tube regenerative oscillator in which direct coupling is employed between the output electrode of one tube and the input electrode of the succeeding tube, and use made of this direct coupling to provide bias for said input electrode.

A still further object is to provide a two-terminal oscillation generator which can function efficiently in the ultra high frequency range as well as at lower frequencies.

A feature of the invention resides in the use of an automatic amplitude regulator for providing a constant amplitude of oscillations over a desired range of frequencies.

According to one embodiment of the invention, the tubes of the oscillator may be operated over substantially linear portions of their respective grid voltage-grid current characteristics, thus producing oscillations which are substantially free from undesired harmonics.

Other objects, features and advantages will appear from a reading of the following description, taken in conjunction with the accompanying drawings, wherein Figs. 1 to 6, inclusive, illustrate different embodiments of an oscillation generator circuit constructed in accordance with the prin-

ciples of the present invention. In these figures, like parts are indicated by like reference numerals.

Referring to Fig. 1 in more detail, there is shown a two-terminal multi-tube high frequency oscillator comprising a pair of tubes T_1 and T_2 . Although tubes T_1 and T_2 are here shown as being of the triode type, it is to be distinctly understood that, if desired, such tubes may have additional electrodes. Vacuum tube T_1 includes, among its electrodes, a grid G_1 , a cathode K_1 and an anode P_1 . Coupled to the grid G_1 and cathode K_1 is a tuned oscillatory circuit comprising an inductance L_1 having in shunt therewith a variable condenser C_1 . A switch S is provided for enabling, alternatively, the selection of any one of a plurality of other coils L_2 , L_3 etc., for co-operating with the condenser C_1 for obtaining a change in the frequency range of the oscillator. The usual grid-leak and condenser combination here shown by the reference numerals R_2 and C_1 provide the automatic bias for the input electrode G_1 of the tube. Conductively coupled to the anode P_1 through a direct connection M is a grid G_2 of a vacuum tube T_2 whose anode P_2 is coupled back to the input circuit L_1 , C_1 through connection N for providing feed-back of energy. The feed-back of energy from the output electrode of tube T_2 to the input electrode of tube T_1 is in such phase and of such magnitude as to overcome the losses in the circuit and produce oscillations. Putting it another way, it may be said that the voltage gain of the two tubes T_1 and T_2 is unity or greater between grid G_1 of tube T_1 , and the anode P_2 of tube T_2 .

Directly connected to the connection M , there is shown a resistance R_3 which acts as a load for the anode P_1 , and simultaneously provides grid bias for the grid G_2 . An inductance L_4 is arranged in series with R_3 and is of such value as to correct for the phase shift occurring in the load circuit R_3 . A radio frequency by-pass condenser C_3 connects the cathodes of the two tubes together, in the manner indicated in the drawing. The usual source of potential indicated at $B+$ is connected to the lower terminal of coil L_1 for maintaining the anodes P_1 and P_2 of the tubes at a positive potential relative to their respective cathode. The path of the positive source $B+$ for the anodes of the tubes may be traced through resistance R_1 , through inductance L_1 , switch S , and feed-back path N to the anode P_2 . The positive polarizing potential for the anode P_1 is obtained through tube T_2 , over the cathode K_2 and its connection to the lower terminal of inductance

L₄, and resistance R₃. It will be obvious that there will be a difference in the magnitude of the polarizing potentials applied to the anodes P₁ and P₂ due mainly to the voltage drop in the tube T₂. In one embodiment actually used in practice, the voltage applied to the source B+ was 250 volts. The magnitude of the voltage applied to the anode P₁ will be less than that applied to the anode of tube T₂, with respect to ground or the negative terminal of the anode supply, the difference varying in accordance with the amount of grid bias on the electrodes of the tubes. A radio frequency by-pass and blocking condenser C₂ is connected between the anode source B+ and the cathode of the tube T₁ for preventing a direct path for the current from the positive source B+ to ground. Condenser C₂ also completes the tuned circuit between the lower end of C₄ and L₁, L₂, L₃, etc. This condenser C₂ in conjunction with R₁ forms a filter isolating the oscillator circuit from other circuits which may be connected on the same power supply system.

The operation of the circuit is as follows. Any voltage appearing across the tuned circuit L₁, C₄ is impressed across the grid G₁ and the cathode K₁ of the tube T₁, whereupon it develops a voltage on the anode P₁ substantially 180° out of phase with the original voltage which is then transmitted to the grid G₂ by the connection M. The tube T₂ functions as an amplifier and produces on the anode P₂ a voltage which is again reversed substantially 180° with respect to the voltage on the grid G₂, but now in phase with the original voltage on grid G₁. It will thus be seen that the tube T₂ serves both as an amplifier and as a phase inverter. By suitably selecting the constants of the circuit, any desired degree of amplification of the original exciting impulse may be obtained.

Fig. 2 illustrates an identical circuit arrangement as that shown in Fig. 1, the electrodes of both tubes being contained within a single envelope. Since the connections of Fig. 2 are similar in every respect with those of Fig. 1, and the operation of the oscillator is the same, it is not believed necessary to repeat what has been said before. In one oscillator actually constructed in accordance with the circuit of Fig. 2, there was used an RCA type 6C8 dual triode. With such a tube, oscillations as high as 38 megacycles were obtained. This frequency is given by way of example, merely to indicate the possibilities of the circuit, but it does not represent the limit to which the oscillator of the invention can be operated.

In a dual tube where a common cathode is employed for the two grids and their respective anodes, such as in the RCA type 6N7, a circuit such as shown in Fig. 3 may be used instead of that shown in Fig. 2. Besides using a common cathode, Fig. 3 differs from Fig. 2 mainly in the use of a bucking battery F inserted in the lead M, the battery being so polarized as to provide the correct operating bias for the grid shown in the upper section of the envelope of the tube. An additional source of anode supply B'+ is employed to supply potential to the anode of the lower portion of the tube, which anode corresponds to P₁ of Fig. 1. The reason why another anode battery is required for P₁ in this instance is because the electron paths are no longer in series as is the case in Figs. 1 and 2. The bucking battery F is required to overcome the positive potential on anode P₁, inasmuch as the grid G₂ must be maintained at a negative potential with

respect to the common cathode. The operation of this circuit is substantially identical with that of Figs. 1 and 2.

Fig. 4 illustrates another embodiment of an oscillation generator in accordance with the principles of the present invention. The operation of this circuit is substantially the same as that of the other figures with the addition of an automatic amplitude regulator feature described hereinafter. The oscillator of this feature employs a single electron discharge device of the Radiotron type 6F7 consisting of a combination triode and variable mu pentode, although it will be appreciated that, if desired, two separate tubes may be employed. The automatic amplitude regulator feature consists of a connection from the grid G₁ of the triode portion of the tube to the grid G'₂ of the pentode portion. This connection includes a resistance-condenser filter network R₇, C₆ and a resistor R₅. The pentode screen grid portion of the tube is used in order to obtain a wide range of control of the voltage amplification of this portion of the circuit, because of the automatic amplitude regulator feature. It should be noted that the pentode portion of this tube includes a screen grid G₃ and a suppressor grid G₄, the screen grid being supplied with a suitable positive potential from a source of supply B''. The condenser C₇ serves to isolate the anode P₁ from the grid G'₂ for direct current.

The automatic amplitude regulator feature functions as follows: Assuming that the oscillation generator is generating oscillations of a certain amplitude, then a voltage will appear across the resistance R₂ due to the current drawn by the grid G₁. This voltage will be polarized negatively with respect to the cathode K, and will charge a condenser C₅ to the peak value of this negative voltage through the resistor R₇. This voltage appearing on condenser C₅ is then passed on to the grid G'₂ so that the potential appearing on this last grid is essentially the same as that on the grid G₁. This amount of potential on the grid G'₂ will allow the tube to function with a certain voltage amplification. If the oscillator now tends to oscillate more strongly, a larger potential will be developed across the resistance R₂ which, in turn, is passed to the condenser C₅ charging it more negatively than before, and thus a more negative potential will in turn be passed on to grid G'₂. Because of the action of the variable mu pentode portion of the tube, the gain of this portion of the circuit will be reduced from that formerly obtained when the oscillation generator was generating voltage of lower amplitude, thus lowering the amount of feed-back voltage transferred from the anode P'₂ back over connection N to the grid G₁. This lowered feed-back potential will then result in a lower amplitude of oscillations which will be similar to that initially started in the circuit. Conversely, if the amplitude falls below the original assumed level, the gain of the pentode portion of the tube is increased, thus restoring the voltage amplitude of the energy on grid G₁ to the predetermined level. In this way, the oscillation generator functions to produce a constant amplitude of oscillations as the losses of the circuit vary.

Fig. 5 shows still another embodiment of the invention which in most respects is quite similar to the circuit of Fig. 1.

In Fig. 5, however, the grid G₁ is constantly biased negatively to a point on its grid-voltage grid-current characteristic, such that the voltage

swing due to the alternating current voltage impressed on it will never allow grid current to flow. The drawing of current by the grid, which is here avoided, ordinarily causes the generation of harmonics as is occasioned in the circuits of Figs. 1, 2, 3 and 4. To prevent the occurrence of harmonics, there is employed in Fig. 5 a resistor R_3 , by-passed by a condenser C_5 , which is common to the anode P_1 —cathode K_1 circuit of tube T_1 . The voltage drop across the resistor R_3 is impressed on the grid G_1 through the choke inductance L_5 . Putting it another way, the grid G_1 of tube T_1 is here biased to function as a class A amplifier.

The tube T_2 is shown in this Fig. 5 to be a variable mu screen grid pentode whose grid G_2 is conductively coupled to the anode P_1 of the preceding tube through an adjustable tap on resistance R_3 . The adjustable tap is provided to allow the adjustment of the circuit so that the amount of feed-back voltage from the anode P_2 back to the grid G_1 over lead N is less than the bias voltage across resistor R_3 . The voltage drop across resistor R_3 insures that the grid G_2 is so biased that the tube T_2 functions as a class A amplifier. In the event that the voltage drop across the portion of the resistor R_3 , which is included in the G_2 cathode circuit of tube T_2 , is too small to insure class A operation of this tube, an additional resistor-condenser combination similar to R_3 , C_5 may be included in the cathode circuit of the tube T_2 . Although tube T_2 has been described as a variable mu tube, it will be understood that the circuit is not limited to such type of tube since any other tube, such as a triode, or tetrode, etc., may be employed with or without the variable mu feature. Outside of what has been said before, concerning the prevention of harmonics, the operation of the oscillation generator is the same as that hereinabove described in connection with Fig. 1. It will be obvious, of course, that the tubes T_1 and T_2 can be combined within one envelope to form a single tube such as the RCA type 6P7.

Fig. 6 is similar to Fig. 5, except that the single tuned circuit comprising the inductance coil L_1 , L_2 , or L_3 , etc., and the condenser C_4 , is located in the anode circuit of tube T_1 instead of in the grid circuit. The variable tap for controlling the amount of feed-back is now in the anode circuit of tube T_2 instead of in the grid circuit, as shown in Fig. 5. A resistance R_3 is included in the common circuit between the cathode of tube T_2 and the anode of tube T_1 . The voltage drop across this resistor provides the operating bias for the grid of tube T_2 . In all other respects, the circuit operation is substantially similar to what has been described above in connection with the other figures.

An inspection of all the figures will show that it is only necessary to move the single pole switch S to engage a single contact, in order to select any desired frequency range which may be characteristic of a particular coil L_1 , L_2 , or L_3 , etc. This is possible because one terminal of each of these coils is permanently connected to the circuit while the other terminal is connected to a contact of the switching mechanism S.

Although the invention has been described with particular reference to circuits employing two separate electron discharge device paths, either in separate envelopes or combined in a single envelope, it is to be distinctly understood that the invention is not limited to such particular arrangements since, if desired, any even

multiple of two electron discharge device paths may be employed.

What is claimed is:

1. A two-terminal oscillation generator comprising a pair of electron space paths, each including a grid, an anode, and a cathode, an electrically conductive connection extending from the anode of one path to the grid of the succeeding path, a connection extending between said cathodes, said last connection being conductive solely for alternating current energy, and a feed-back connection extending from the anode of said last path to the grid of the previous path for feeding back the alternating current energy in the anode circuit of said last path, a parallel tuned frequency controlling circuit for said system, said circuit being coupled between the grid and cathode of one of said space paths.

2. A two-terminal oscillation generator for the generation of high frequency oscillations over a plurality of selective frequency ranges, comprising a pair of electron space paths, each including a grid, an anode, and a cathode, an electrically conductive connection extending from the anode of one path to the grid of the succeeding path, a connection extending between said cathodes, said connection being conductive solely for alternating current energy, and a feed-back connection including a condenser serially inserted therein extending from the anode of said last path to the grid of the previous path for feeding back the alternating current energy in the anode circuit of said last path, a variable condenser coupled between the grid and cathode of one of said space paths, a plurality of inductance coils of different values each having a terminal permanently connected, electrically, to one armature of said variable condenser and another terminal connected to a contact, a switch connected to the other armature of said variable condenser and adapted to engage any one of said contacts for selectively coupling any one of said inductance coils in parallel relationship to said variable condenser, whereby said oscillation generator may generate oscillations of a frequency range determined by said condenser and selected coil.

3. A system in accordance with claim 2, characterized in this that said electron space paths are confined within a single evacuated envelope.

4. A system in accordance with claim 2, characterized in this that said electron space paths are confined within individual evacuated envelopes.

5. A two-terminal oscillation generator for the generation of high frequency oscillations over a plurality of selective frequency ranges, comprising an even plurality of electron space paths, each including a grid, an anode, and a cathode, a connection including a condenser serially inserted therein connecting together said cathodes, a direct current conductive connection extending from the anode of one path to the grid of the succeeding path, and a capacitive feed-back connection extending from the anode of said last path to the grid of the previous path for feeding back the alternating current energy in the anode circuit of said last path, a circuit for each path for maintaining the average grid potential at some definite negative value, a variable condenser coupled between the grid and cathode of one of said space paths, a plurality of inductance coils of different values each having a terminal permanently connected, electrically, to one armature of said variable condenser and another terminal connected to a contact, a switch connected

to the other armature of said variable condenser and adapted to engage any one of said contacts for selectively coupling any one of said inductance coils in parallel relationship to said condenser, whereby said oscillation generator may

5 generate oscillations of a frequency range determined by said condenser and selected coil.

6. A system for the generation of high frequency oscillations comprising first and second electron discharge paths, each path having an anode, a grid, and electron emitting means, an output circuit from the anode of said first path connected to the grid of said second path, a parallel tuned frequency controlling circuit for said system, said tuned circuit having an inductance and a condenser connected together in parallel arrangement, a connection from one terminal of said tuned circuit to the grid of said first discharge path, an electrically conductive connection from said same terminal to the anode of said second discharge path, a connection from the other terminal of said tuned circuit to the electron emitting means of said first path, a connection between the electron emitting means of said first and second paths, and a path for direct current energy from said output circuit to said last connection, a single source of polarizing potential for said anodes, and a connection from the positive terminal of said source to said last terminal of said tuned circuit, whereby the anode of said second discharge path is energized through said inductance, and the anode of said first discharge path is energized at a lower potential through the space of the second discharge path.

7. A system for the generation of high frequency oscillations comprising first and second electron discharge paths, each path having an anode, a grid and means for emitting electrons, an output circuit comprising a direct connection devoid of concentrated impedance from the anode of said first discharge path to the grid of said second discharge path to energize same, and a feed-back circuit from the anode of said second discharge path to the grid of said first discharge path for feeding back the alternating current energy in the anode circuit of said second path, whereby said paths are in series relation, and a bias circuit for the grid of said second path including a resistor from said direct connection to the electron emitting means of said second path, whereby said direct connection functions simultaneously to energize said last grid and to provide a bias therefor, a connection between the electron emitting means of said two paths, a common source of polarizing potential for said anodes, and a connection from the positive terminal of said source to one of said anodes, whereby the other anode is energized at a lower potential through the space of the path of the former anode.

8. A system for the generation of high frequency oscillations comprising first and second electron discharge paths, each path having an anode, a grid and means for emitting electrons, an output circuit comprising a conductive connection from the anode of said first discharge path to the grid of said second discharge path to energize same, and a feed-back circuit from the anode of said second discharge path to the grid of said first discharge path for feeding back the alternating current energy in the anode circuit of said second path, and a bias circuit for the grid of said second path including a resistor from said

75 conductive connection to the electron emitting

means of said second path, whereby said conductive connection functions simultaneously to energize said last grid and to provide a bias therefor, and a tuned frequency controlling circuit for said system, said tuned circuit comprising an inductance and a condenser connected together in parallel arrangement, at least one of said last elements being variable, a connection from one terminal of said tuned circuit to the grid of said first discharge path, and a connection from the other terminal of said tuned circuit to the electron emitting means of said first path, a connection conductive solely for alternating current energy between the electron emitting means of both said paths, and a source of polarizing potential for said anodes having one of its terminals connected to only one of said anodes.

9. A system for the generation of high frequency oscillations comprising first and second electron discharge paths, each path having an anode, a grid, and electron emitting means, an output circuit from the anode of said first path connected to the grid of said second path, a parallel tuned frequency controlling circuit for said system, a connection from one terminal of said tuned circuit to the grid of said first discharge path, an electrically conductive connection from said same terminal to the anode of said second discharge path, a capacitive connection from the other terminal of said tuned circuit to the electron emitting means of said first path, a connection between the electron emitting means of said first and second paths, and a path for direct current energy from said output circuit to said last connection, a single source of polarizing potential for said anodes, a connection from the positive terminal of said source to said last terminal of said tuned circuit, and a connection from the negative terminal of said source to the electron emitting means of said first path, whereby the anode of said second discharge path is energized through said tuned circuit, and the anode of said first discharge path is energized at a lower potential through the space of the second discharge path, said tuned circuit comprising a condenser and any one of a plurality of inductance coils of different values each having a terminal permanently connected, electrically, to one armature of said condenser and another terminal connected to a contact, a switch connected to the other armature of said condenser and adapted to engage any one of said contacts for selectively coupling any one of said inductance coils in parallel relationship to said condenser, whereby said oscillation generator may generate oscillations of a frequency range determined by said condenser and selected coil.

10. A two-terminal oscillation generator for the generation of high frequency oscillations over a plurality of selective frequency ranges, comprising a pair of electron space paths within a single envelope, said paths being constituted by a cathode, a first grid, an anode, a second cathode, a second grid, and a second anode, in the order named; a capacitive connection between said cathodes; a direct connection between said first anode and second grid; a resistance in series with an inductor connected between said first anode and second cathode; a feed-back connection from said second anode to said first grid; a bias resistor between said first grid and said first cathode; a condenser between said first grid and first cathode; a plurality of inductance coils of different values each having a terminal permanently connected, electrically, to one armature of

said condenser and another terminal connected to a contact; a switch connected to the other armature of said condenser and adapted to engage any one of said contacts for selectively coupling any one of said inductance coils in parallel relationship to said condenser, whereby said oscillation generator may generate oscillations of a frequency range determined by said condenser and the selected coil.

11. A two-terminal oscillator of high frequency oscillations comprising first and second electron discharge paths, each path having an anode, a grid and a cathode, an output circuit comprising a conductive connection from the anode of said first discharge path to the grid of said second discharge path to energize same, and a feed-back circuit from the anode of said second discharge path to the grid of said first discharge path for feeding back substantially all of the alternating current energy in the anode circuit of said second

path, and a bias circuit for the grid of said second path including a resistor from said conductive connection to the cathode of said second path, a portion of said resistor being located in said conductive connection, whereby said conductive connection functions simultaneously to energize said last grid and to provide a bias therefor, and a tuned frequency controlling circuit for said system, said tuned circuit comprising an inductance and a condenser connected together in parallel arrangement, a connection from one terminal of said tuned circuit to the grid of said first discharge path, and a connection from the other terminal of said tuned circuit to the cathode of said first path, a connection between said cathodes, said connection being conductive solely to alternating current, and a source of polarizing potential for said anodes.

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