May 24, 1938. E. B. MOULLIN 2,118,414

THERMIONIC OSCILLATION GENERATOR

Filed July 19, 1934

Fig. 1

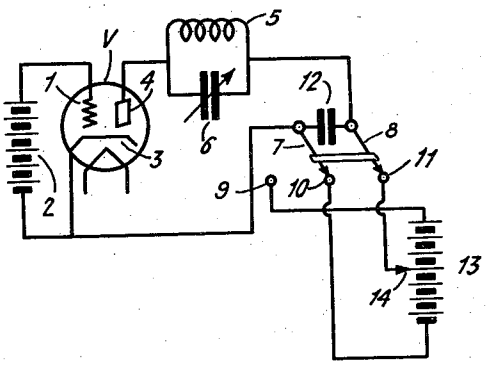


Fig. 2

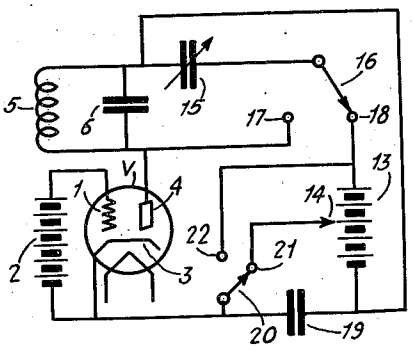


Fig. 3

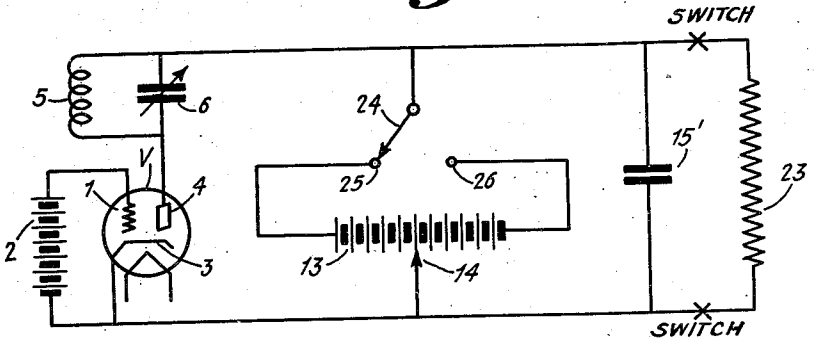


Fig. 4

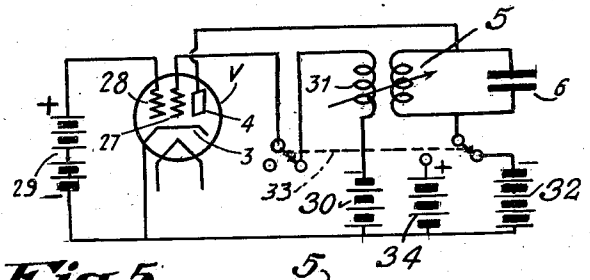
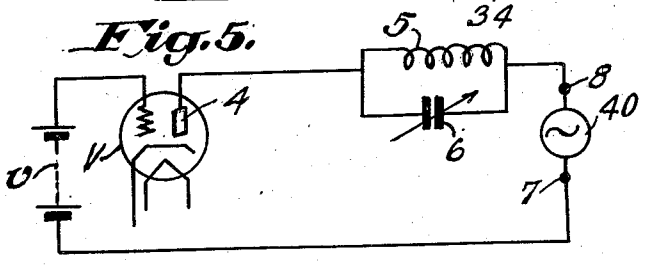


Fig. 5.



INVENTOR
ERIC BALLIOL MOULLIN
BY H. S. Snower
ATTORNEY

Patented May 24, 1938

2,118,414

UNITED STATES PATENT OFFICE

2,118,414

THERMIONIC OSCILLATION GENERATOR

Eric Balliol Moullin, Oxford, England, assignor to Radio Corporation of America, a corporation of Delaware

Application July 19, 1934, Serial No. 735,985
In Great Britain July 24, 1933

16 Claims. (Cl. 250—36)

This invention relates to electron discharge oscillation generators and more specifically to electron discharge device oscillation generators of the so-called dynatron type, i. e., of the type in which oscillations are generated by reason of secondary emission in a thermionic valve instead of by reason of energy fed back through a back coupling circuit external to the valve.

So-called dynatron thermionic oscillators are well known per se, and in general such oscillators are operated with a valve having both grid and anode at substantial positive potentials relative to the cathode.

According to the main feature of this invention, an electron discharge device oscillator of the dynatron type comprises a valve, means for applying such potentials to said valve that said valve commences to generate oscillations by secondary emission effects in the well known way, said potentials including a positive potential for the anode, and means intended for operation after oscillation has commenced for substituting for the initial positive potential of the anode a negative potential.

The above feature of the invention is based upon the discovery that although a dynatron type of thermionic valve oscillator will not commence to generate oscillations with its anode at a negative potential relative to its cathode, if once the oscillations are started, as in the usual way, by biasing the anode positively to the cathode, the anode potential may then be brought to a negative value relative to the cathode and nevertheless oscillation generation will continue, and, moreover, continue with an efficiency which is markedly better than that obtained in the usual known arrangements with a valve having a positively biased anode. The precise results obtained will be set forth below more in detail in connection with the description of a practical embodiment of the invention.

It may be noted that, in carrying out this feature of the invention, it is not necessary to reduce the positive anode potential gradually to zero, and then to reverse it, for it has been found that it is possible to change the anode potential suddenly from about 25 volts positive to 25 volts negative without disturbing the operation, and thereafter the anode voltage can be brought to about 180 to 200 volts negative. In other words, there is no objection to a sudden change from positive anode potential to negative anode potential, but the initial positive potential must not be too great or oscillation will not start.

According to another feature of the invention, which feature is a modification of the main feature, the valve employed is provided with an auxiliary grid which is interposed between the main grid and the anode, and which acts as an auxiliary anode of grid form. With this arrangement the necessary positive potential for starting is applied to the auxiliary grid-like anode, the main anode being either maintained at a negative potential all the time and the auxiliary anode connected to the main anode after oscillations have commenced, or alternatively, the main anode may have an initial zero or positive potential and the auxiliary anode also an initial positive potential, and, when oscillations have started, the main anode may be switched over to a negative potential before the positive potential on the auxiliary anode is removed, the auxiliary anode being again connected to the main anode during "running".

It may be noted that anode current flows during only a portion of the positive half cycle. Since the purpose of the grid is to cause current to impinge on the anode and to catch the returning stream of secondary emission (the primary emission falling on the grid being of no value), the grid current flowing during the negative half cycles and part of the positive half cycles, results in wasted energy without any benefit to the action. The invention, therefore, envisages the provision of means for switching off the grid voltage during the negative half cycles and, if desired, also during a suitable portion of the positive half cycles. It should be understood that the proposal for switching off grid voltage, as above set forth, applies both to the case where the valve employed is a triode, or has a main anode and an auxiliary anode.

It has been found that dynatron oscillators, in accordance with this invention, are very stable in frequency and it is believed that this is due to the fact that, in carrying out this invention, the space charge conditions within the valve are better from the point of view of frequency stabilization. It is known that a good deal of variation of frequency in thermionic valve generators is due to the interelectrode capacity of the valve being altered by the presence of space charges. In carrying the present invention into practice, electrons will be present in the space between anode and grid during only a portion of the positive half cycles, for the result of making the anode negative is that anode current flows for only brief periods. In this way the capacity troubles due to space charges are to a large extent avoided or reduced.

From the foregoing it will be appreciated that since oscillation can be started by any transient impulse which momentarily makes the anode positive, theoretically oscillations could be started by inducing in the anode coil (i. e., the coil in the anode circuit) a pulse of any wave form and of sufficient magnitude, or by giving an initial charge of sufficient magnitude to the oscillatory condenser, i. e., the condenser in the anode tuned circuit.

It is of advantage so to arrange matters that the emission of the dynatron valve is caused to be effectively cut off during negative half cycles and, according to a further feature of the invention, a thermionic oscillator of the dynatron type and, in accordance with the invention as hereinbefore set forth, includes a dynatron oscillator valve having an auxiliary grid adjacent the cathode thereof, means being provided for causing the said grid to vary in potential substantially in phase with the variations in the anode potential of said valve, the whole arrangement being such that, as a result of the variations in potential in the auxiliary grid, the electron emission is substantially cut off during negative half cycles.

A convenient way of obtaining the required variations in potential of the auxiliary grid is by inductive back coupling from a coil in the anode circuit.

The present invention should not be confused with known back coupled thermionic oscillation generators, there being the fundamental difference that in generators in accordance with the present invention the fluctuations in potential of the auxiliary grid occur substantially in phase with the fluctuations in potential of the anode, whereas, of course, in ordinary known back coupled oscillators the variations of the potential of the grid to which back coupling potentials are applied, occur in anti-phase with the variations of the anode potential.

In one way of carrying out this invention a thermionic valve, known commercially as a Mazda AC 2HL valve, is employed. This valve has an independently heated cathode (i. e., the cathode is of the indirectly heated type) and planar electrodes. The cathode heater requires a current of one ampere, the amplification factor is 75, and the internal impedance is 11,500 ohms.

The cathode is heated by passing alternating current of the value stated, namely 1 ampere, through the heater. If a potential of +130 volts is applied to the grid relative to the cathode, and the anode potential is varied, the following characteristic curve relating anode current in milliamperes (ordinates) with anode potential (abscissae) in volts positive to the cathode is obtained. If the anode potential is brought up from zero to about 15 volts, the anode current rises from zero to about 2 milliamperes. Further increase of the anode potential from about 15 volts up to about 24 volts causes the anode current to fall away to zero at about 24 volts positive anode potential. A further increase of anode potential from about +24 volts to about 100 volts causes the anode current to rise in the opposite direction, reaching a maximum of about 10 milliamperes in a direction opposite to the previous maximum of 2 milliamperes, this second maximum occurring at about 100 volts anode potential. Further increase of anode potential from 100 volts up to about 123 volts causes the anode current to fall away again to a second zero point at about 123 volts. Further increase of anode potential beyond 123 volts causes the anode current to rise again in the opposite direction (the first direction), the anode current reaching about 8 milliamperes at about 140 volts anode potential. Thereafter the curve flattens off, the anode current being about 10 milliamperes at 200 volts anode potential and about 10.5 milliamperes at 225 volts anode potential. Throughout the variations of anode potential giving the curve above described, the summation of grid current and anode current remains constant at about 12 milliamperes. If the anode potential be increased from zero upwards, oscillation starts when said anode potential is about 20 volts positive. It has now been discovered, and in this discovery lies the basis of the present invention, that if the anode potential be brought to zero and then changed to a negative value, oscillation continues and the output current obtained increases steadily as the anode voltage is reduced and then made negative until a point is reached when oscillations cease abruptly. With the particular valve referred to above, this point occurred with an anode potential of −208 volts, i. e. at a point when the anode is 78 volts more negative with respect to the cathode than the grid is positive with respect thereto.

The efficiency obtained when oscillations are generated with a negative anode, is substantially higher than that obtained in the ordinary known dynatron arrangement with a positive anode. For a practical tested case, and in which a valve as above specified having 130 volts positive on its grid was employed, a parallel tuned circuit in series with a source of anode potential being in the anode circuit of said valve, the efficiency at a working frequency of 1,000,000 cycles per second was about 4% with the anode voltage zero (relative to the cathode) but the said efficiency rose in accordance with a substantially straight line curve to a value of about 25% when the anode voltage was about −200 volts relative to the cathode. In the case for which the stated efficiency values were obtained, the measured circuit resistance at the relevant frequency was 8 ohms, the power factor $\frac{1}{130}$, and the condenser in the parallel tuned circuit was 150 micromicrofarads capacity. More detailed results obtained with a Mazda AC 2HL valve are given in the table below:—

Ia *m*A	Ig *m*A	Va V	I *m*A	Anode in *m*W	Grid in *m*W	Total in *m*W	I^2R *m*W	*n*
−2	19	+20	95	−40	2480	2440	70	2.9
−2.4	19	+40	85	−96	2480	2384	58	2.5
−1.7	17	0	112	0	2220	2220	100	4.5
−1.5	14.6	−40	142	60	1900	1960	160	8.2
−1.5	14.2	−80	175	120	1850	1970	245	12.4
−1.6	13.9	−100	190	150	1810	1970	290	14.7
−1.6	13.8	−120	205	192	1800	1992	336	16.9
−1.72	13.5	−160	234	275	1750	2025	436	21.5
−1.8	13.3	−190	252	347	1730	2077	510	24.6
−1.83	13.2	−200	259	366	1720	2086	530	25.5
0	11.0	−208	0	0	1420	1420	0	0

These results were obtained when the valve had in its anode circuit a parallel tuned circuit having a capacitative branch of 150 micromicrofarads and an inductive branch consisting of 120 microhenries inductance, the total circuit resistance being 8 ohms. The circuit power factor was $\frac{1}{130}$ and the grid was biased at 130 volts positive to the cathode. The anode battery was shunted by a large condenser acting as a by-pass for the working frequency.

In the table, the column Ia*m*A is the total anode

current in milliamperes; the column $I_g mA$ is the grid current in milliamperes; the column $Va V$ is the anode voltage relative to the cathode; the column $I mA$ is the current through the condenser branch of the tuned circuit; the column "Anode in mW" is the output energy in milliwatts of the anode battery; the column "Grid in mW" is the output energy in milliwatts of the grid battery; the column "Total in mW" is the sum of these two outputs in milliwatts; the column "I^2RmW" is the ohmic resistance energy in milliwatts; and the column n is the efficiency.

In carrying out the invention with a valve as specified above, the anode potential would first be raised to about 20 volts positive and then reduced and brought negative to a value of about —200 volts negative relative to the cathode.

To put the matter in another way, in carrying out the present invention a dynatron oscillator is caused to start oscillating in the usual well known way and the anode is then brought to a negative value, whereby oscillations are still continued but with a considerably improved efficiency. This efficiency in the practical example is, it will be noted, low as compared with an ordinary back coupled triode oscillator but it is relatively high as compared with the efficiency ordinarily obtained with dynatron oscillators. The dynatron type of oscillator offers substantial practical advantages, particularly in the matter of frequency stability, because with such type of oscillator there is no problem (as occurs with the back coupled type of oscillator) of properly phasing the grid voltage. For many practical purposes therefore, for example for small short wave radio transmitters for use on shipboard, the invention offers considerable practical advantages.

Measurement of the power factor in the circuit employed in the specific numerical example given above has been utilized as a basis from which to deduce the peak value of the A—C potential across the circuit, and it has been found that the difference between this peak voltage and the mean anode value is almost constant. When the mean anode voltage was zero the peak potential of the anode was +170 in the said specific example, and when the mean voltage was —200 the peak potential was +180, so that in this condition anode current is flowing for only about half the positive half cycle and is zero throughout the negative half cycle. This means that the anode current will be very rich in harmonics, and if these have a disadvantageous effect on the fundamental frequency, the effect can be substantially removed by connecting in or associating with the anode circuit, tuned circuits which act as acceptor circuits to the major harmonic frequencies present, though the anode circuit as a whole is tuned to the working frequency. The removal of harmonic components of anode potential by the inclusion in an anode circuit of one or more acceptor circuits tuned to undesired harmonics is not part, per se, of this invention.

Referring to the drawing, Figs. 1 to 5 illustrate different embodiments of the invention. In Fig. 1, V is a triode having its grid 1 positively biased by a battery 2 connected between the grid 1 and the cathode 3. The anode 4 is connected through a tuned circuit 5, 6 to one blade 8 of a double pole throw over switch having two blades 7, 8 and three contacts 9, 10, 11 so arranged that, in one position of the switch (that shown), the two blades 7, 8 make connection respectively with the central one 10 of the said three contacts and the contact 11,—while in the other position of the switch, the blade 7 contacts with the contact 9, the other blade 8 contacting with the contact 10. A by-pass condenser 12 is connected between the blades of the switch and the blade 7 is connected to the cathode 3. Of the three contacts 9, 10, 11, contact 9 is connected to the positive terminal of an anode battery 13, contact 11 is connected to an intermediate tapping 14 on said battery (this tapping giving a suitable "starting" positive potential to the anode), and the contact 10 is connected to the negative terminal of said battery. For starting, the switch is put into the position shown and after starting is thrown over to the other position.

In another arrangement illustrated in the accompanying Fig. 2, a valve V, having a positively biased grid 1 as before, has its anode 4 connected through a coil 5 (which forms part of the anode oscillatory circuit 5, 6) to one terminal of a condenser 15 whose other terminal is connected to the blade 16 of a single pole throw over switch, one contact 17 of which is connected to the anode and the other contact 18 of which is connected to the positive terminal of an anode battery 13. The negative terminal of the anode battery is connected to the end of the anode coil 5 remote from the anode and also through a by-pass condenser 19 to the cathode 3. The cathode is connected to the blade 20 of a second single pole throw over switch, one contact 21 of which is connected to an intermediate point 14 on the anode battery 13, and the other contact 22 of which is connected to the positive terminal of said battery. Initially, the switch blade 16 is put into the position shown on contact 18 and the condenser 15 thus charged, the switch blade 20 being left on the intermediate battery contact 21. For starting, the switch blade 16 is moved quickly over on to contact 17 and the charged oscillatory condenser 15 thus connected across the anode coil 5. There will therefore occur, in the oscillatory circuit, damped oscillations having a peak voltage exceeding the negative bias of the anode. (The damped oscillations will be of the working frequency but this is of no importance.) When the voltage of the damped discharge reverses for the first time, near the peak, the anode potential will become positive and self-oscillation will start. After starting, the switch blade 20 may be moved on to contact 22. This arrangement may be said to embody an impulse method of starting.

In another arrangement illustrated in the accompanying Fig. 3, the anode 4 of the valve V is connected to the cathode 3 through an oscillatory circuit 5, 6, and a condenser 15' shunted by a high resistance 23. A switch blade 24 is connected to the junction of the circuit 5, 6 and the condenser 15'. This switch blade can be moved to contact with either of two contacts 25 or 26, the former being connected to the positive terminal and the latter to the negative terminal of the battery 13. An intermediate point 14 on the battery 13 is connected to the cathode and the grid is positively biased as shown. For starting, the switch blade 24 is moved to the position shown and then thrown over to its other position for running. The resistance 23 serves to maintain a conductive path between anode and cathode during the short "open circuit" period when the switch is being moved from one position to another, and in practice when the

oscillator is "running" this resistance would be open circuited (as indicated by the cross) so as to avoid loss of energy therein. Similar means (not shown) may be provided in the arrangements of Figs. 1 and 2 for ensuring continuity of circuit during momentary "open" switch positions.

In the modification shown in the accompanying Fig. 4, the dynatron oscillator valve V is constituted by a valve having four electrodes, namely a cathode 3, an auxiliary grid 27 of wide or open mesh and placed very close to the cathode, a second grid 28 of wide mesh and also placed as close as practicable to the cathode but on the other side thereof remote from the first mentioned grid, and an anode 4. The two grids should be so arranged that the first or inner grid 27 is of large magnification with respect to the second or outer grid 28 (regarding the second grid as an anode) and the valve as a whole is so designed that with the intended potential on the second grid 28 the said grid can just cause the full emission to flow from the cathode at the designed filament current.

In "running", the connections and adjustments of the circuit are as follows:—

The anode is connected through a parallel tuned circuit 5, 6 to the negative terminal of a source of potential 32 whose positive terminal is connected to the cathode 3. A second source of potential 29, having its positive terminal towards the second grid 28, is connected between the said second grid 28 and the cathode 3, and a third source of potential 30, having its positive terminal connected to the cathode, is connected in series with a coupling coil 31 between said cathode and the first or inner grid 27. The coupling coil 31 is coupled to the coil 5 in the anode tuned circuit. For "starting up", the bias potential is removed from the inner grid 27 and the coupling coil 31 is uncoupled from the anode tuned circuit coil 5, the anode being connected to the positive terminal of a source 34 all by means of a switch 33. When oscillation has started, (*a*) the potential of the anode is made negative with respect to the cathode, the negative potential preferably being such that oscillation is near the point of stopping, (*b*) the coupling coil is fairly loosely coupled to the anode tuned circuit so that when the inner or first grid 27 is positive to the cathode there will be little increase of emission because the potential of the outer grid 28 is already sufficient to produce saturation while when the said inner grid 27 is negative to the cathode there will tend to be a decrease in emission current, (*c*) the inner grid 27 is given a negative bias and the coupling between the coupling coil and the anode tuned circuit increased. These two last mentioned adjustments should be made together until a very small amount of rectified current appears or is on the verge of appearing. When the oscillator has been correctly adjusted, the emission current will be of full value during most of the positive half cycle of the wave of potential fluctuation of the inner or first grid (and therefore of the anode which is in phase therewith) but during the negative half cycle, the emission will be cut down substantially to zero. It will, of course, be obvious that the coupling coil 31 must be coupled to the anode tuned circuit coil 5 in a particular sense, namely, that sense which will cause the potentials of the anode and of the inner or first grid 27 to vary substantially cophasically.

In the arrangements illustrated, batteries are shown as providing the operating potentials, but obviously other suitable potential sources may be used.

Since the dynatron will operate whether its anode be positive or negative, it is possible to permit the anode potential to vary slowly and continuously between positive and negative values so as to modulate the output. If desired, therefore, an anode battery or other direct current constant anode potential source may be replaced by a low frequency alternator. For example, in Fig. 1 the battery 13 could be omitted and the terminals of a low frequency alternator 40 connected to points 7 and 8 (note Fig. 5). Since the alternator voltage changes at a rate which is very slow as compared to the oscillation frequency of the dynatron, the output of the dynatron at any given instant will be sensibly that which would result were the alternator replaced by a battery of potential and polarity corresponding to the instantaneous potential and polarity of the alternator at that instant. If the peak voltage of the alternator be made greater than that at which oscillation ceases—be this potential positive or negative—then the output will be zero during those portions of the cycle of alternating voltage over which the potential at which oscillation ceases is exceeded. In this way an interrupted continuous wave output can be obtained without any need to provide rectifiers.

What is claimed is:

1. A thermionic oscillator of the dynatron type comprising a thermionic valve having an anode, cathode, and a grid electrode, a parallel tuned oscillatory circuit coupled between said anode and cathode, sources of unidirectional potential applied to said electrodes of such values that the valve commences to generate oscillations by secondary emission effects, including means for applying a positive potential to said anode, and switching mechanism adapted for operation after oscillation has commenced for substituting, for the initial positive potential on said anode, a negative potential therefor, said negative potential being less than the peak value of the alternating current potential engendered in said oscillatory circuit, whereby anode current flows during only a portion of the positive half cycle of said alternating current potential and said valve continues to generate oscillations by secondary emission effects.

2. A thermionic oscillator of the dynatron type comprising a valve having an anode, cathode, main grid, and an auxiliary grid interposed between said main grid and said anode, a tuned oscillatory circuit arranged to be connected between said anode and cathode, sources of potential applied to said electrodes of such value that said valve commences to generate oscillations by secondary emission effects, including means for applying a positive potential to said auxiliary grid and to said anode with respect to said cathode, and switching mechanism adapted for operation after oscillation has commenced for removing the positive potential applied to said anode and for maintaining said auxiliary grid and said anode at a negative potential with respect to said cathode, whereby said valve continues to generate oscillations by secondary emission effects.

3. A thermionic oscillator of the dynatron type comprising a valve having an anode, cathode, main grid, and an auxiliary grid interposed between said main grid and said anode, a tuned

oscillatory circuit arranged to be connected between said anode and cathode, sources of potential applied to said electrodes of such value that said valve commences to generate oscillations by secondary emission effects, said potentials including means for applying a positive potential to both said anode and said auxiliary grid and a potential not less than zero to said main grid, and switching mechanism adapted for operation after oscillation has commenced for changing the potential applied to said anode from a positive to a negative value and then removing the potential on said auxiliary grid and connecting said auxiliary grid to a source of negative potential, whereby said valve continues to generate oscillations by secondary emission effects.

4. An oscillator in accordance with claim 2, and wherein a feed back path is provided between said anode and said main grid for causing the latter to vary in potential substantially in phase with the variations of the anode potential, whereby electron emission is substantially cut-off during negative cycles of oscillation due to variations of potential on said main grid.

5. An oscillator in accordance with claim 2, and wherein a feed back path is provided between said anode and said main grid for causing the latter to vary in potential substantially in phase with the variations of the anode potential, whereby electron emission is substantially cut-off during negative cycles of oscillation due to variations of potential on said main grid, said feed back path comprising two inductively coupled coils, one of said coils being provided in said tuned anode oscillatory circuit and the other in said main grid circuit.

6. An electron discharge device oscillator comprising an electron discharge device having an anode, a cathode and a control electrode, a source of potential for said control electrode and a source of potential for said anode of such values that the device commences to generate oscillations by secondary emission effects, said last source having positive, negative, and intermediate terminals, and switching means in said anode circuit between said anode and cathode for alternatively connecting said anode to said intermediate terminal and said cathode to said negative terminal, or said anode to the negative terminal and said cathode to the positive terminal.

7. An electron discharge device oscillator comprising an electron discharge device having an anode, a cathode and a control electrode, a tuned oscillatory circuit arranged to be connected between said anode and cathode, a source of potential for said control electrode and a source of potential for said anode of such values that the device commences to generate oscillations by secondary emission effects, said last source having positive, negative, and intermediate terminals, said anode being conductively connected to said negative terminal, means for producing, at least momentarily, on said anode a peaked voltage of a positive value exceeding the negative bias thereon, and switching means for connecting said cathode either to said intermediate or said positive terminal whereby said device continues to generate oscillations by secondary emission effects.

8. An electron discharge device oscillator comprising an electron discharge device having an anode, a cathode and a control electrode, a source of potential for said control electrode and a source of potential for said anode of such values that the device commences to generate oscillations by secondary emission effects, said last source having positive, negative, and intermediate terminals, said anode being conductively connected to said negative terminal and switching means for connecting said cathode either to said intermediate or said positive terminal, an oscillatory circuit coupled to said anode comprising an inductance and a condenser, and means for connecting said condenser either in parallel with said inductance, or in series with said inductance and to said positive terminal.

9. An electron discharge device oscillator comprising an electron discharge device having an anode, a cathode, a first grid and a second grid, a source of potential for maintaining said second grid at a positive potential with respect to said cathode, a second source of potential for maintaining said anode at a positive potential with respect to said cathode whereby said device generates oscillations by secondary emission effects, a tuned circuit between said anode and said last source, a third source of potential having its positive terminal connected to said cathode, and a switch in series with said tuned circuit for disconnecting said anode from said second source and connecting same to the negative terminal of said third source after oscillations have commenced, an inductance coil for magnetically coupling said first grid to said tuned circuit, a fourth source of potential in series with said coil for maintaining said first grid at a negative potential with respect to said cathode, and switching means for disconnecting said first grid from said last source.

10. An oscillator of the dynatron type comprising an electron discharge device having an anode, cathode and a grid electrode, a parallel tuned circuit of inductance and capacitance arranged to be connected between said anode and cathode, means for applying potentials to said grid and anode which are positive with respect to the cathode for causing said device to generate oscillations by secondary emission effects, means for applying a potential to said anode which is negative with respect to said cathode, and a switch for disconnecting said anode from said positive potential and for connecting said anode to said negative potential after oscillations have commenced, said inductance and capacitance having such values that there is produced an alternating potential across said tuned circuit whose peak amplitude exceeds the negative potential applied to said anode by said last means by an amount sufficient to produce secondary emission of electrons from said anode, said first means maintaining said grid at a positive potential higher than the instantaneous potential of said anode during at least a part of the time when secondary emission is produced, whereby intermittent pulses of current flow through said tuned circuit during at least a portion of said interval of secondary emission in opposition to the instantaneous potential on said anode with a consequent increase of the circulating energy in said tuned circuit by an amount per cycle equal to the dissipation per cycle.

11. An oscillator in accordance with claim 10, including an auxiliary electrode, and means coupling said auxiliary electrode and anode to reduce the flow of current to said grid between occurrences of secondary emission from said anode.

12. The method of increasing the efficiency of a multi-electrode electron discharge device dyna-

tron oscillator having a positive potential on two of its electrodes and functioning by means of secondary emission of electrons from one of its electrodes which comprises altering the positive potential of said one electrode after oscillations have commenced to an intermittent positive potential in order to produce intermittent pulses of secondary emission therefrom, and feeding back energy from said one electrode to another electrode in said device of a value and sign sufficient to reduce energy dissipation in said device between occurrences of said pulses of secondary emission.

13. A dynatron oscillation generator for generating a frequency of the order of 1,000,000 cycles comprising an electron discharge device having anode, cathode and grid planar electrodes, a parallel tuned oscillatory circuit of a capacitor and an inductor coupled between said anode and cathode, said capacitor having a capacity of 150 micromicrofarads, said inductor having an inductance of 120 microhenries, the resistance of said parallel tuned circuit at the operating frequency being 8 ohms, sources of unidirectional potential applied to said electrodes of such values that the device commences to generate oscillations by secondary emission effects, including means for applying a positive potential of 130 volts to said grid and a positive potential of 20 volts to said anode relative to said cathode, and switching means adapted for operation after oscillations have commenced for changing the potential on said anode from 20 volts positive to 200 volts negative relative to said cathode, the peak value of the positive half cycle engendered due to said oscillatory circuit and applied to said anode being 180 volts positive relative to said cathode when the unidirectional potential being applied to said anode is 200 volts negative, whereby anode current flows during only said positive half cycle and said device continues to generate oscillations by secondary emission effects.

14. A dynatron oscillation generator comprising an electron discharge device having anode, cathode and grid electrodes, a parallel tuned oscillatory circuit coupled between said anode and cathode, sources of unidirectional potential applied to said electrodes of such values that the device commences to generate oscillations by secondary emission effects, including means for applying a positive potential to said grid and a less potential to said anode relative to said cathode, and switching means adapted for operation after oscillations have commenced for changing the initial positive potential on said anode to a predetermined negative potential, said parallel tuned oscillatory circuit having such constants that the peak value of the alternating potential engendered across it after said switching means has operated is greater than the value of the negative potential applied to said anode, whereby anode current flows during only the positive half cycle of said alternating potential, the difference between said peak value and the mean value of negative potential applied to said anode being substantially equal to the difference between the peak value of said alternating current before said switching means operated and the mean value of positive potential applied to said anode.

15. The method of operating a dynatron oscillation generator having anode, cathode and grid electrodes, and an anode tuned circuit which comprises applying positive potentials of such values to said anode and grid relative to said cathode as to produce oscillations by secondary emission effects, changing the potential applied to said anode from a positive value to a negative value relative to said cathode after oscillations have commenced, and maintaining the peak value of alternating current engendered in said anode tuned circuit greater than the said negative value, whereby anode current flows after said change during only a portion of the positive half cycle of said alternating current.

16. The method of increasing the efficiency of a multi-electrode electron discharge device dynatron oscillator having a positive potential on two of its electrodes and functioning by means of secondary emission of electrons from one of its electrodes which comprises altering the positive potential of said one electrode after oscillations have commenced to an intermittent positive potential in order to produce intermittent pulses of secondary emission therefrom.

ERIC BALLIOL MOULLIN.