

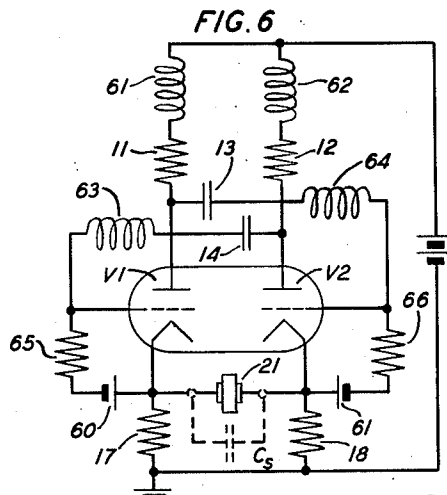
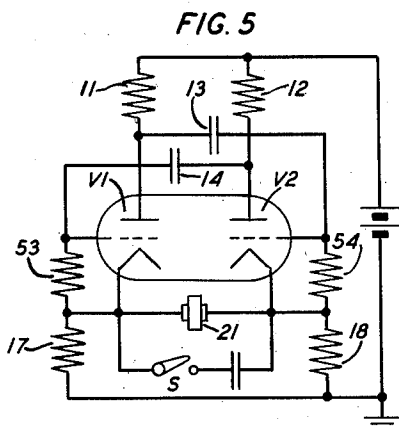
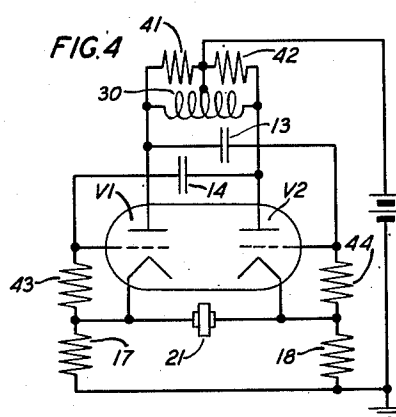
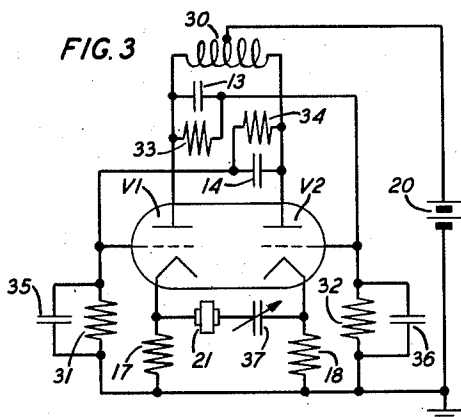
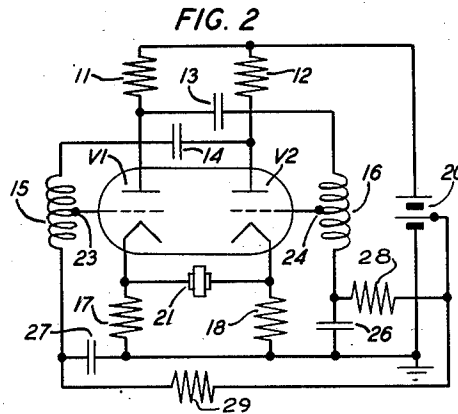
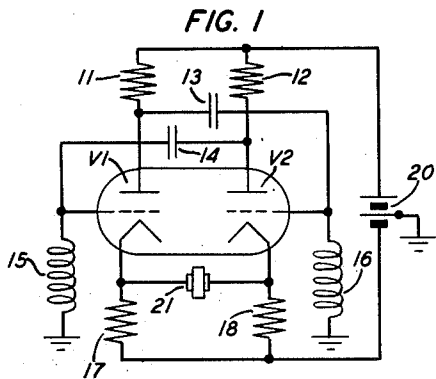
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CATHODE CRYSTAL COUPLED OSCILLATOR

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CATHODE CRYSTAL COUPLED OSCILLATOR

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1 Claim. (Cl. 250—36)

The present invention relates to oscillators and, more particularly, to a cathode controlled oscillator.

The object of this invention is to provide an improved form of oscillator and one particularly adaptable for stable high frequency operation.

In the oscillator of the present invention, a pair of electron discharge devices or vacuum tubes is connected in multivibrator type fashion with cross-coupling between the anode of each tube and the control grid of the conjugate tube. However, unlike conventional multivibrators, here each cathode circuit includes relatively large individual cathode resistances which provide degeneration and prevent the positive feedback provided by the cross-coupling loop from sustaining oscillations. As a further modification on conventional multivibrators, the present arrangement also includes coupling between the two cathode circuits. This coupling acts within an operating frequency range as a second feedback path between the two tubes to provide additional positive feedback and also to limit the degenerative effect of the cathode resistances by providing a low impedance shunt path. The combined effect of the two feedback loops is sufficient to sustain oscillations within the operating range. In a preferred embodiment, the cathode coupling comprises a crystal whose series resonant frequency fixes with a high degree of stability the operating frequency of the oscillator.

One important advantage possessed by this arrangement is that, unlike the conventional multivibrator, it permits convenient operation with very little, or, in some cases, no grid current. This results in faster feedback action which combined with the increased loop gain made possible by two positive feedback paths acting together makes feasible very high frequency operation.

Another important advantage is the greater measure of control effected by use of two separate feedback loops. The second or cathode feedback loop acts in the manner of a vernier to control the total loop gain. Relatively coarse adjustments of the gain provided by this loop permits close control of the critical region of oscillation. As a result, the influence of the frequency selective properties of the cathode coupling is enhanced in the frequency control of the oscillator.

Various modifications of this basic circuit are possible for special applications and several will be described hereinafter.

The invention can be more clearly understood from the following description taken in conjunction with the accompanying drawing in which:

Fig. 1 shows an illustrative embodiment of the basic circuit of the invention which is particularly designed for high frequency operation;

Figs. 2, 3 and 4 show various modifications of the oscillator of Fig. 1;

Fig. 5 shows an illustrative embodiment more particularly adapted for low frequency operation; and

Fig. 6 shows another embodiment adapted for harmonic operation.

Referring now to the drawings, in the arrangement of Fig. 1, the electron discharge devices V1 and V2 are connected almost in the manner of a conventional multivibrator oscillator. Each of their associated anode or plate resistors 11 and 12 is coupled to the control grid electrode of the conjugate device by way of the coupling capacitors 13 and 14, respectively. The control grid electrodes are connected across the grid neutralizing inductances 15 and 16. The cathodes are connected through the relatively large resistances 17 and 18, respectively, to

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the negative terminal of the potential source or battery 20 of which the positive terminal is connected to anode resistors 11 and 12 and of which some intermediate point is grounded to provide a potential on the cathode which is negative with respect to the control grid to facilitate the flow of plate current. Additionally, the two cathodes are coupled by means of a series resonant element 21, which in this particular case, in accordance with a preferred embodiment of the invention, is shown as a crystal. To secure balanced push-pull operation, corresponding circuit elements of the two stages are made substantially equivalent.

The behavior of this circuit can best be understood by first considering the circuit in the absence of the coupling crystal 21 and then including the effect introduced by addition of this coupling. With the crystal 21 absent, the two cathodes are not coupled and, except for the gain of each stage being modified by the degenerating action of the large cathode resistors 17 and 18, the circuit resembles a conventional multivibrator. One important difference is the inclusion of the inductances 15 and 16 in the grid circuit of each stage for neutralizing the effect of stray capacitances of the grid and its associated plate circuit in the operating range. As is shown in the arrangement of Fig. 5, these inductances are unnecessary for low frequency operation and can then be replaced with large grid-leak resistors. As in the case of multivibrators, the cross-coupling between the plate of one tube and the grid of the conjugate tube provides a positive feedback path. In the conventional multivibrator the feedback supplied by this cross-coupling is made sufficient to sustain oscillations. In the present instance, however, the degenerating cathode resistors 17 and 18 are made sufficiently large with respect to their corresponding plate resistances 11 and 12 that the loop gain of each stage is insufficient without additional coupling to sustain oscillations. The additional coupling needed is secured in accordance with the invention by providing a second frequency discriminative path between the two cathodes as by the addition of the crystal 21 between the two cathodes to provide a second feedback loop for each stage. This coupling provides a path which, at the resonant frequency of the crystal, is essentially series resonant and of low impedance. As a result, the alternating-current components of plate current no longer will flow through the large degenerating cathode resistors but instead will flow by way of the crystal. For purposes of analysis, the crystal can be considered a resistance equal to the series resonant impedance with the center of this resistance effectively at ground potential. In calculating the gain of each stage at the resonant frequency, the effective cathode resistance will then be one-half the series resonant impedance. The large loop gain made possible by the arrangement of the present invention permits the use of low activity crystals which have relatively high series resonant impedances and are not generally acceptable for commercial use. With such crystals, the circuit would be adjusted to be near self-excitation without the crystal. The addition of the crystal can be made to control the oscillation frequency even if the crystal has a relatively high series resonant impedance. By simple modifications to be described hereinafter, this oscillator can be made to draw no appreciable grid current which might otherwise limit the speed of operation. This factor, together with the high gain, makes possible fast-starting operation and very high frequency oscillations.

It is a further advantage that the frequency of oscillation can be easily varied over rather wide ranges by providing means in the cathode coupling path for varying the series resonant frequency of the coupling. Since the oscillation frequency of this circuit is primarily determined by the resonant frequency of this coupling, convenient adjustment to a desired frequency is made possible. In Fig. 3, there is shown an arrangement of this sort.

If desired, overtone operation of the circuit can be achieved by tuning the neutralizing inductances 15 and 16 properly against the stray capacitances. The circuit can be made to operate the crystal even at overtone harmonics for which the crystal does not exhibit a positive reactance. In such cases, the minimum impedance determines the frequency of oscillation.

Fig. 2 shows one possible modification of the circuit of Fig. 1. One change has been to tie one end of the cathode resistors to ground and to operate the control grids at a positive potential by connecting the control grids to an intermediate tap on the potential 20 through the resistances 28 and 29. Blocking capacitances 26 and 27 are provided in the control grid circuits. Additionally, in this arrangement the control grids of the two stages V1 and V2 are connected to taps 23 and 24 on the neutralizing inductances, respectively, to reduce the grid swing and the harmonic distortion.

Fig. 3 shows another modification of the basic circuit in which the resonant frequency of the path coupling the two paths is made variable by insertion therein of the variable capacitance 37 in series with the crystal 21. This arrangement embodies additional modifications. It is to be understood that the various modifications shown are not necessarily limited in their use to the particular circuit arrangement being used for its illustration. In this case, neutralization of stray capacitances is achieved by utilizing an inductive load 30 in place of the plate resistances used in the previously described arrangements. The plate voltage is supplied by way of the midtap of this coil. In this way, the mutual coupling between the two halves of the plate coil permits use of a smaller inductance than is required in the circuits shown previously. Additionally, the inductive load results in a greater part of the voltage of the potential source being available at the plate of each device. Additionally, the cross-couplings include a direct-current path which is achieved by shunting the coupling capacitances 13 and 14 with the resistances 33 and 34, respectively, and one of the parallel arrangements of resistance 31 with capacitance 35 and of resistance 32 with capacitance 36 are provided between each control grid and ground. The value of these grid-circuit elements should be chosen to provide flat transmission with frequency within the desired operating range for the cross-coupling.

In Fig. 4 there is shown a modification of the circuit of Fig. 3. In this circuit, damping resistors 41 and 42 are provided across the halves of the inductance 30 to minimize transient effects. Additionally, each of the grid-leak resistances 43 and 44 is placed between the control grid and cathode of one stage to clamp the signal peaks at zero grid-cathode voltage.

In Fig. 5 there is shown another modification of the high frequency circuit shown in Fig. 1, adapted particularly for low frequency operation. In this case, it is unnecessary to neutralize the stray capacitances since a low frequency crystal is to be used and instead the grid circuit of each stage is provided with one of the grid-leak resistors, placed between the control grid and the cathode to clamp the signal peaks at zero grid-cathode voltage. Additionally, this circuit can be made relatively

rich in harmonics by closing the switch S to add a capacitance 55 across the crystal 21 providing such harmonics have frequencies in the pass-band of the interstage coupling networks.

Fig. 6 shows another arrangement especially adapted for harmonic operation in which the bandwidth of the interstage couplings has been widened for better transmission of the overtone frequencies. Inductances 61 and 62 have been added in the plate-cathode paths of their corresponding stages, and inductances 63 and 64 inserted in the plate-grid cross-coupling. The grid-leak resistors 65 and 66 as before are inserted between cathode and control grid, and, additionally, the potential sources 60 and 61 have been inserted in the grid circuits to provide the grid-bias voltages. By proper choice of the grid bias, it is possible to prevent the flow of grid current and insure quick starting operation necessary to realize very high frequency oscillations. The higher frequency energy is transferred between cathode circuits by the shunt capacitance C_s of the crystal.

It is to be understood that the above-described arrangements are merely illustrative of the principles of the invention. Numerous other arrangements may be devised by one skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

In a cathode controlled oscillator, a pair of electron discharge devices each having an anode, a cathode, and a control grid, a potential source having a positive and a negative terminal, an inductance and a capacitance in series circuit coupling the anode of each device to the control grid of the other device, means comprising resistance and inductance for coupling the anode of each device to the positive terminal of the potential source, circuit means having an impedance greater than the impedance of said first-mentioned coupling means for coupling the cathode of each device to the negative terminal of the potential source, grid biasing means including a source of electrical potential and a resistor connected between the control grid and cathode of each device, means including a crystal coupling the two cathodes, and a net capacitive reactance shunting said crystal.

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