

Dec. 29, 1936.

A. M. BRAATEN

2,066,027

CONSTANT FREQUENCY GENERATOR

Filed April 18, 1933

2 Sheets-Sheet 1

Fig. 1

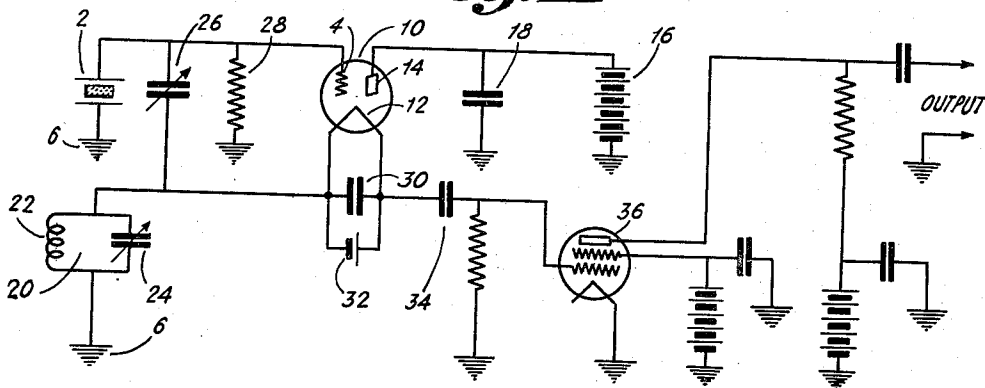


Fig. 2

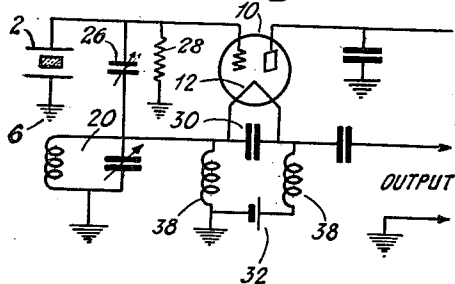


Fig. 3

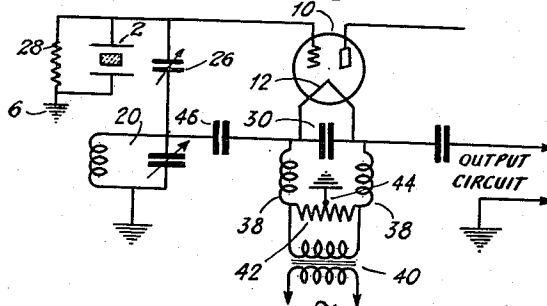
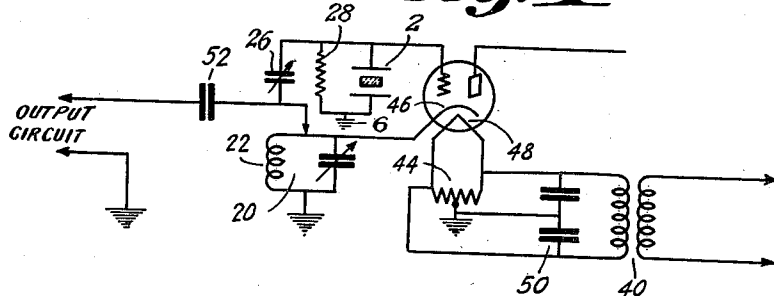


Fig. 4



INVENTOR
ARTHUR M. BRAATEN
BY *H. S. Hoover*
ATTORNEY

Dec. 29, 1936.

A. M. BRAATEN

2,066,027

CONSTANT FREQUENCY GENERATOR

Filed April 18, 1933

2 Sheets-Sheet 2

Fig. 5

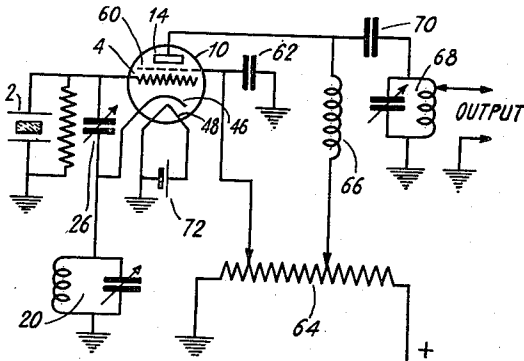


Fig. 6

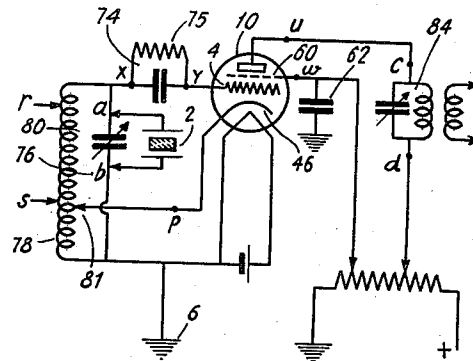


Fig. 7

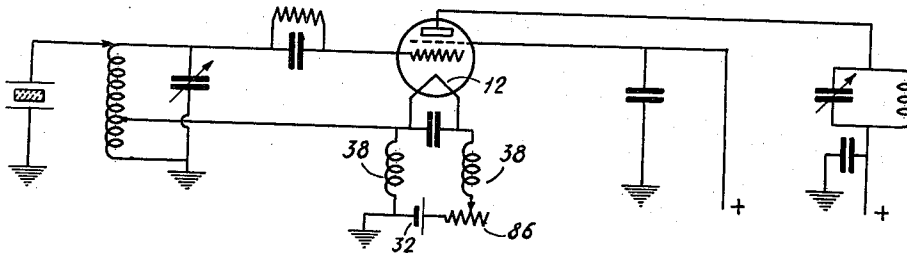
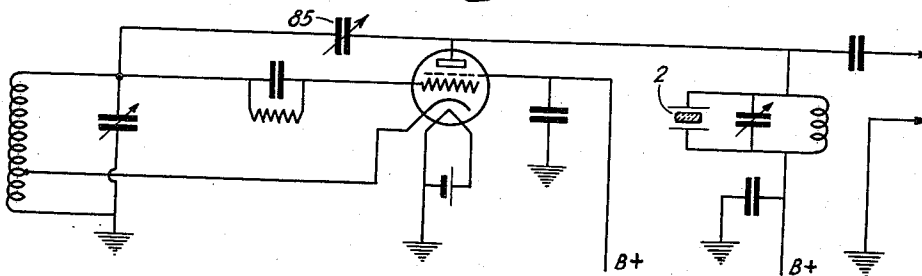


Fig. 8



INVENTOR
ARTHUR M. BRAATEN
BY *H. S. Swann*
ATTORNEY

UNITED STATES PATENT OFFICE

2,066,027

CONSTANT FREQUENCY GENERATOR

Arthur M. Braaten, Riverhead, N. Y., assignor to
Radio Corporation of America, a corporation
of Delaware

Application April 18, 1933, Serial No. 666,680

6 Claims. (Cl. 250—36)

This invention relates to electrical oscillation generators of the vacuum tube or electron discharge device type which are frequency controlled by means of an electromechanical vibrator such as a piezo-electric crystal.

In accordance with the teachings of Cady and Pierce it has heretofore been the practice to use piezo-electric crystal elements or magnetostriction devices as frequency controlling means for vacuum tube oscillation generators. In the case of the crystal controlled circuit, the crystal, as taught by Cady and Pierce, is customarily connected between the grid or control electrode and filament or cathode, or, between the grid and plate or anode electrode of the oscillator tube. The plate, in the circuits of the prior art, is at a high radio-frequency potential with respect to ground as a result of which the frequency of oscillation is readily influenced by plate voltage variations as well as by load reaction.

Consequently, the principal object of my present invention is to provide improved electromechanically controlled oscillator circuits which are less subject to frequency variation ordinarily due to changes in supply voltage, load reaction, temperature, vibration and the like. To carry out this object I prefer to connect the frequency controlling device such as a piezo-electric crystal between two electrodes of the vacuum tube or electron discharge device forming part of the oscillation generator and to connect the anode electrode, either the plate or the screen grid acting as a plate, as will be described more fully later, to ground through a suitable circuit which maintains the anode at zero radio-frequency potential. I allow the filament or cathode to fluctuate in potential at a frequency corresponding to the frequency of the piezo-electric crystal by isolating said filament or cathode from ground by means of a high frequency impedance circuit connected between the cathode and ground. In the event that a heater type of cathode is used, I connect the impedance element, which preferably exhibits resonant effects and has inductance and capacity, between the cathode electron emitting surface and ground, the heating element being preferably grounded. In connection with the cathode circuit, a further feature of my invention resides in the novel way of deriving output energy from the oscillation generator which I do preferably by connecting the output circuit to the cathode or to the impedance between the cathode and ground.

My present invention is explained in greater

detail hereinbelow with the aid of the accompanying drawings, wherein,

Figure 1 illustrates a preferred form of my invention wherein a frequency controlling crystal is connected between the control grid and ground of an electron discharge device oscillation generator and output energy is derived from the cathode thereof which fluctuates in potential through the action of a tuned impedance;

Figures 2, 3, and 4 are modified cathode heating circuits which may be used in the circuit shown in Figure 1;

Figure 5 is a modification of my present invention wherein output energy is taken from the usual plate of a vacuum tube, whose normal function is, however, taken by the screen grid which is so connected as to act as a grounded plate or anode; and,

Figures 6, 7, and 8 are modifications of the system shown in Figure 5.

Turning to Figure 1, a piezo-electric crystal or frequency controlling electromechanical vibrator 2 is connected between ground 6 and the grid or control element 4 of electron discharge device 8 having, within a hermetically sealed container 10, a direct current energized filament or cathode 12 and an anode or plate 14. The plate 14 is maintained at ground radio-frequency potential by the action of by-passing condenser 18 and is supplied with direct current plate potential from a source 16 which, of course, may be a rectifier with the usual potentiometer placed thereacross. Between the cathode 12 and ground there is connected an impedance 20, here shown in the form of a circuit having inductance and capacity and, more specifically, a circuit formed of an inductance coil 22 tuned by means of a variable condenser 24 so as to exhibit electrical parallel resonance effects.

For oscillation generation to occur, since the plate 14 is maintained at ground radio-frequency potential, the filament 12 must fluctuate in potential at a frequency corresponding to the frequency of vibration of the crystal 2. The correct potential fluctuation at proper phasal conditions is obtained when the circuit 20, connected between the cathode and ground, is tuned to a frequency slightly below that of a crystal. That is to say, the circuit comprising inductance coil 22 and condenser 24 must be capacitive at the operating frequency. Under these circumstances the crystal 2 will act as an inductive reactance. The feed back occurs through the grid-filament capacity of the tube 10. This feed back may

be augmented by the addition of a variable condenser 25.

Grid bias may be maintained through the action of grid leak resistor 28. The coupling capacitor 26 is used preferably only in those cases where there is insufficient capacity between the grid 4 and cathode 12.

Both ends of the filament are maintained at like radio frequency potential through the action of by-passing condenser 30 shunting the direct current heating source 32 for the cathode. Output energy may be taken through blocking condenser 34 and fed to the screen grid buffer amplifier 36, the output of which may be utilized for frequency controlling a transmitter, for use in a heterodyne type of receiver, or for frequency determination and measurement purposes.

In the arrangement shown in Figure 1, since the plate is at all times at substantially zero radio-frequency potential, the applied direct current plate voltage variations have a minimum effect on the oscillation frequency and consequently by the use of this circuit it will be found that oscillations of extreme frequency stability will be obtained.

To prevent frequency variations due to vibration, the tube, crystal, and associated circuits may be mounted upon a massive concrete block in turn placed upon relatively small resilient cushions, or suspended by springs. Any building vibrations will be dissipated in the cushions or springs due to the inertia effects of the concrete mass.

In place of the isolated filament battery 32 of Figure 1, a grounding connection for the battery 32 may be utilized providing a circuit such as shown in Figure 2 is made use of. There the heating battery is isolated by means of choke coils 38 from the cathode 12, the choke coils acting to prevent the radio-frequency grounding of the cathode 12. Incidentally, the impedance 20 may be replaced by an inductance whose natural frequency is below that of the crystal 2, or, it may be replaced by a resistor with suitable distributed capacity.

The cathode 12 may be energized by means of alternating currents supplied from a transformer 40 as shown in Figure 3. The secondary of the heating transformer may be shunted by a resistor 42 grounded at an intermediate point 44 so as to eliminate or reduce hum. The impedance or tuned circuit 20 in this case should be blocked off from the cathode by means of a blocking condenser 46 of high impedance to the heating currents but of low impedance to currents of the frequency of oscillation of tube 10. Also, in the arrangement shown in Figure 3, choke coils 38 should be provided to prevent radio-frequency grounding of the filament or cathode 12. Choke coils 38 may be omitted in Figure 3 providing the secondary of heating transformer 40 has a low distributed capacity to ground or between it and the other portion of the heating transformer.

An alternate method of energizing the cathode of the circuit shown in Figure 1 is illustrated in Figure 4. Here the cathode is formed into two portions, a heated, electron-emitting surface 46, and, a heating element or filament 48. The heating element is supplied with alternating current from transformer 40 paralleled by the grounded resistor 44 to reduce hum. If desired, the capacity bridge 50 may also be provided. When using the arrangement shown in Figure 4, the heated surface or electron-emitting surface of the cathode, which for oscillation generation

purposes is the cathode, fluctuates in potential at a frequency corresponding to the frequency of the electromechanical vibrator used for frequency control. As indicated in Figure 4, output energy may be taken from the tuned circuit 20, through blocking condenser 52. The high potential side of blocking condenser 52 may be tapped as shown across the entire coil 22 or may be connected at any point along coil 22 depending upon the loading it is desired to place upon the oscillation generator.

To further reduce the effects of load reaction, the circuit shown in Figure 5 may be used to good advantage.

There the electron discharge device or vacuum tube 10 is provided with an additional electrode in the form of a screen grid 60 which is grounded for radio-frequency currents by the action of by-passing condenser 62. By-passing condenser 62 and grounding condenser 18 of Figure 1, when very high frequencies are involved, may be chosen so as to series resonate with the portion of the electrode lead with which they are connected so as to insure maintaining their respective electrodes at ground radio frequency potential. Referring again to Figure 5, output energy is then taken from the plate or anode electrode 14, although for oscillation generation purposes the grounded screen 60 serves as a plate or electrode for the oscillation generating circuit consisting of the crystal, screen grid 60, grid 4, heated surface 46, and tuned circuit 20. Plate and screen grid potentials may be derived from a potentiometer 64 supplying the plate with potential through a choke coil 66. Output energy is derived from a tuned output circuit 68 connected to the plate through a blocking condenser 70. Also, in the arrangement shown in Figure 5, to still further enhance frequency stability, the heated element 48 or the filament heater is supplied with unidirectional current from a unidirectional source 72.

Modifications of the system wherein the screen grid is used as an anode or plate and wherein the electromechanical frequency-controlling vibrator is in the form of a piezo-electric crystal, are shown in Figures 6, 7, and 8. In Figure 6, the screen grid 60 is grounded for radio-frequency by means of by-passing condenser 62 but is polarized from potentiometer 64 so as to act as a plate. Grid bias for control grid 4 is obtained through the action of grid leak resistor and condenser combination 74 connecting the grid to a parallel tuned circuit 76 having an inductance coil 78 and a tuning condenser 80. The piezo-electric frequency-controlling crystal 2 is connected across the tuning condenser 80 or between the grid 4 and ground 6. The heated surface 46 of the cathode is connected to a point 81 along the coil 78 so that the heated surface fluctuates in potential at a frequency corresponding to the frequency of operation of the piezo-electric crystal 2. Output energy is taken from the parallel tuned plate or anode circuit 84 which is coupled to the oscillating circuit formed of the crystal, screen grid, control grid, and cathode surface 46, only by the electron stream within the tube 10. As a consequence of this construction, load reaction has a minimum effect upon the frequency of operation.

The arrangement shown in Figure 7 differs from the circuit of Figure 6 in that the cathode is not of the indirectly heated type but consists of the direct current energized filament 12. As in Figure 2, the filament 12 of Figure 7 is maintained at a high radio-frequency potential be-

cause of the action of choke coils 38 which, however, conduct heating energy to the filament 12 from the source 32, the heating energy being controlled in value through the action of variable resistor 86.

Referring again to Figure 6, the crystal 2, although connected across points *a*, *b*, or across the condenser 80, need not be limited to that position. The crystal can be connected across points *x* and *y* or in parallel with the grid leak resistor condenser combination 74 and exert its frequency controlling effect. Or, the crystal can be connected to *a* to replace the condenser grid leak combination 74 in which case the grid leak resistor should be connected across the points *y*, *p*. The grid leak resistor 75 of the circuit 74 may be connected across the points *y*, *p*, and the crystal 2 connected across the points *r*, *s* on the inductance coil 78 of the tuned circuit 76. Also, the crystal can be connected between the screen grid or point *w* and point *y*. As a further modification, the piezo-electric crystal 2 can be connected across points *c* and *d* in which case a variable condenser 85 for feed back purposes should be connected between the plate or point *u* and point 6, or between point *u* and point *x*. One form of this arrangement is shown in Figure 8.

As already indicated to some extent, the various features of my present invention are not limited to piezo-electric crystal control but may be incorporated in magnetostriction controlled oscillation generators or tuning fork oscillation generators. Consequently, my present invention is not to be limited to the illustrations given hereinabove, but is to be given the full scope and breadth indicated by the appended claims.

Having thus described my invention, what I claim is:

1. A constant frequency electrical oscillation generator comprising the combination of an electron discharge device having within a hermetically sealed container an anode, a cathode, and a control electrode, a frequency controlling and determining element connected between two of said electrodes for stabilizing the frequency of oscillations generated by said device, means for maintaining said anode electrode at ground radio-frequency potential, an impedance connected between said cathode and ground acting to cause said cathode to fluctuate in potential at a frequency corresponding to the frequency of vibra-

tion of said electromechanical vibrator, and an output circuit connected with said impedance.

2. Apparatus as claimed in claim 1 characterized by the fact that said impedance has inductance and capacity having an electrically resonant period approaching that of said frequency controlling and determining element.

3. Apparatus as claimed in claim 1 wherein said impedance is in the form of a circuit exhibiting electrical parallel resonance effects whereby said cathode fluctuates in potential at a frequency corresponding to the natural period of said frequency controlling and determining element and whereby oscillation generation takes place by virtue of capacity between said cathode and control grid and wherein in addition there is provided means for supplying heating energy to said cathode, said heating energy supply means having impedance of such value as not to ground said cathode for desired oscillatory energy.

4. In combination, an electron discharge device having an anode electrode, a grid electrode and a cathode electrode, an electromechanical vibrator connected between two of said electrodes, means for grounding said anode electrode for radio-frequency, a high frequency impedance connected between said cathode and ground whereby said cathode fluctuates in potential at a frequency corresponding to the frequency of vibration of said electromechanical vibrator, and, an output circuit connected between said cathode and ground.

5. A constant frequency generator comprising an electron discharge device having an anode electrode, a grid electrode, and a cathode, said cathode comprising a heated surface electrode and a heating element, an electromechanical vibrator connected between two of the electrodes of said device, a high frequency impedance connected between said heated surface electrode and ground, whereby the heated surface electrode fluctuates in potential at a frequency corresponding to the frequency of vibration of said electromechanical vibrator, and an output circuit connected with said high frequency impedance.

6. Apparatus as claimed in the preceding claim wherein said high frequency impedance has inductance and capacity.

ARTHUR M. BRAATEN.