PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Crystal-controlled Thermionic Valve Oscillator

I, Dr. KURT HEEGNER, of 7, Elisenstrasse, Berlin-Steglitz, Germany, a Citizen of Germany, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

It is well known to use a piezo-electric crystal for the purpose of maintaining constant the frequency of an thermionic valve oscillator. In the usual schemes, however, the frequency depends on the electrode capacities of the valve and other electrical values so that the problem to excite the piezo-electric resonator in a defined constant natural frequency is not solved. This natural frequency is arrived at if the electrodes of the crystal resonator are short-circuited. Different approximate solutions of the problem of exciting the short-circuit frequency have already been proposed. One of these is obtained according to Fig. 1 by inserting in the anode lead of the valve V a closed circuit consisting of the crystal Kr, a coil La and a suitable resistance Ra, and inductively coupling the coil with the grid circuit C_g L_g tuned to the short-circuit frequency of the crystal. If d_g is the decrement of the grid circuit, d_k is the decrement of the crystal, f_g is the natural frequency of the grid circuit, f_o is the short-circuit frequency of the crystal and f is the actual oscillation frequency.

The departure of f from the desired value f_o is equal to

$$f - f_o = (f_g - f_o)\,\frac{d_k}{d_g}.$$

If $\frac{d_k}{d_g} = 10^{-2}$ and if $\frac{f - f_o}{f_o}$ is desired not to surpass 10^{-6}, the electric circuit requires to be adjusted with an exactitude $\frac{f_g - f_o}{f_o} = 10^{-4}$. It is practically impossible to maintain this exactitude over an appreciable length of time.

When a higher damping is imparted to the oscillatory circuit, the requisite accuracy of its frequency becomes less, but the back-coupling effect decreases accordingly, so that for maintaining the oscillations tubes are required with correspondingly greater steepness.

According to the invention the difficulty is overcome by coupling crystal and oscillatory circuits in such a manner that by an increase in the damping an increase in the back-coupling is effective. In order, however, with a coupling of this kind to obtain the correct phase, there are required, two tunable electric circuits, which may be coupled with the crystal circuit either in direct fashion or through the medium of a valve.

This may be accomplished, according to the invention, by connecting each pole of the crystal to the cathode of the valve via an oscillatory circuit, consisting of a coil and a condenser in series and by connecting the point between coil and condenser of one oscillatory circuit to the anode of the valve and the corresponding point of the other oscillatory circuit for the purpose of back-coupling the crystal to the grid of the valve.

An embodiment of the invention is illustrated in Fig. 2. One pole of the crystal Kr is connected to the cathode of the valve V via an impedance Z_1 and, in parallel to it, via condenser C_1 and L_1, the other pole of the crystal via Z_2, C_2 and L_2. The point between L_1 and C_1 is connected to the anode of the valve, the point between L_2 and C_2 to the grid. The anode battery E is laying in series with coil L_1.

It is possible to permute L_1 and C_1 against each other and to permute correspondingly L_2 and C_2.

The coupling impedances Z_1 and Z_2 should possess a preponderant ohmic component in order to damp the electric circuits in the desired fashion. The impedance should be selected in such fashion that disturbing waves, which may be caused by the electrode capacity of the crystal, are suppressed. One of the impedances may be dispensed with if the other is made smaller. It is also possible to dispense with both impedances if a resistance is put in parallel to the crystal.

The exact tuning of the electric circuits to the crystal frequency may be performed as follows: The impedance Z_2 is replaced by an ohmic resistance, which is of the order of the ohmic resistance of coil L_2. When in this connection the oscillations cease, a suitable resistance should be put in parallel to the crystal. The tuning of the series element (C_2, L_2) may then be recognised on the minimum of the anode current of the valve. The crystal circuit (Z_1, Kr, Z_2) is then replaced by a low ohmic coupling resistance, and the circuit (L_1, C_1) tuned to the circuit (L_2, C_2).

It is advantageous to replace the single grid valve V by a screening grid valve Vs (Fig. 3) in order to make the inner resistance of the valve large in comparison with the reactance of L_1. Further screening means are essential at higher frequencies. An arrangement of this kind, is shown in Fig. 3. The earthed screen S embraces the screen-grid valve V_s and the elements connected to the grid up to but excluding the crystal K_r which possess nearly earth potential. In order to show possible variations of the scheme coil L_2 is connected to the grid via a condenser B_2 and also coil L_1 to the anode via a condenser B_1, grid leak resistance R_g and anode choke D_r being provided.

A two-valve arrangement is shown in Fig. 4. The circuit L_1 C_1 Z_1 is tranferred to the grid of valve V_1, and replaced by the anode resistance R_a. The junction point of circuit L_2 C_2 is connected, instead of to the grid of valve V_1, to the grid of a second valve V_2, the anode of which is connected to the junction point of circuit L_1, C_1. Also here the impedance Z_2 may be dispensed with when Z_1 is made small or the crystal is shunted by a resistance. Tube V_2 may be advantageously replaced by a screen grid valve.

A subsequent amplifying stage of the transmitter may be coupled with the oscillator described above by connecting the impedance Z_1 to the input grid of the amplifier.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:

(1). An electronic valve oscillator controlled by a piezo-electric crystal, characterised in that each pole of the crystal is connected to the cathode of the valve via an oscillatory circuit consisting of a coil and a condenser in series and that the point between coil and condenser of one oscillatory circuit is connected to the anode of the valve, the corresponding point of the other oscillatory circuit being connected to the grid for the purpose of back-coupling the crystal to the grid of the valve.

(2). An electronic valve oscillator according to claim 1, characterised in that each pole of the crystal is more-over connected to the cathode of the valve directly via a damping resistance.

(3). A modification of the valve oscillator controlled by a piezo-electric crystal according to claim 1, characterised in that one pole of the crystal is connected to the cathode of the valve via an oscillatory circuit consisting of a coil and a condenser in series and that the point between coil and condenser of this oscillatory circuit is connected to the grid of a second valve and in that a second oscillatory circuit consisting of a coil and a condenser in series, the point between coil and condenser of which is connected to the anode of said second valve, is connected between the grid and the cathode of the first valve, the anode of which is connected to an anode resistance and to the second pole of the crystal.

(4). An electronic valve oscillator according to claim 3, characterised in that the two oscillatory circuits are shunted each by damping resistance.

(5). An electronic valve oscillator according to claims 1 and 2, characterised in that a screen grid valve is used.

(6). An electronic valve oscillator according to claim 3, characterised in that the second valve is a screen grid valve.

(7). An electronic valve oscillator, characterised in that an earthed screen shields the valve and the circuits connected to the grid of the valve.

(8). An electronic valve oscillator substantially as hereinbefore described and as illustrated according to the accompanying drawings.

Dated this the 29th day of December, 1933.

DR. KURT HEEGNER.

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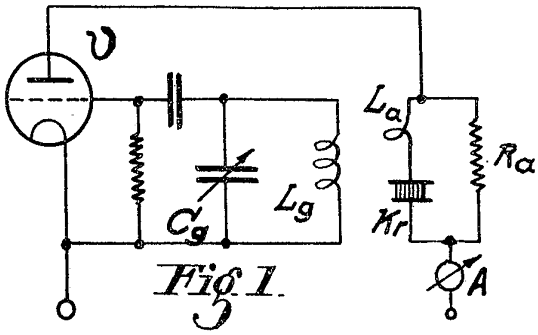

Fig. 1.

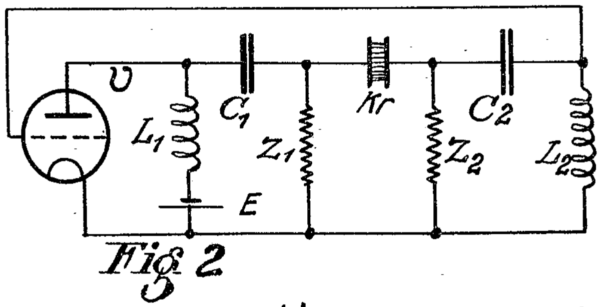

Fig. 2

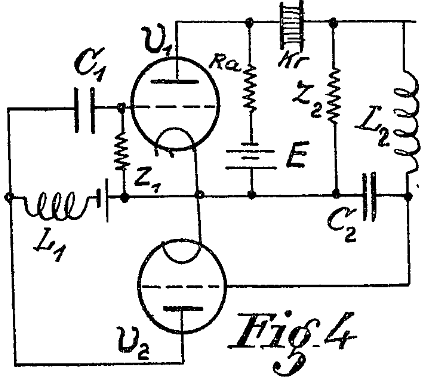

Fig. 4

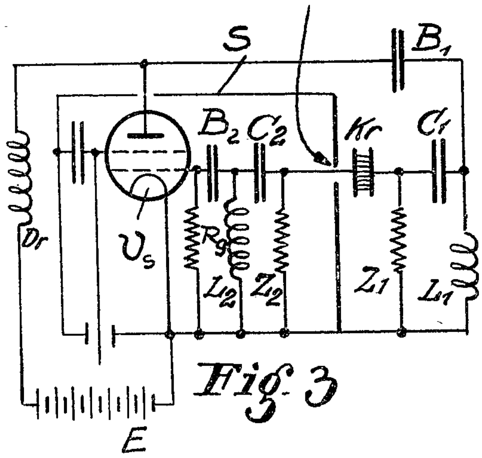

Fig. 3