March 12, 1946. M. ARTZT 2,396,224

OSCILLATION GENERATOR

Filed June 16, 1943

Fig. 1.

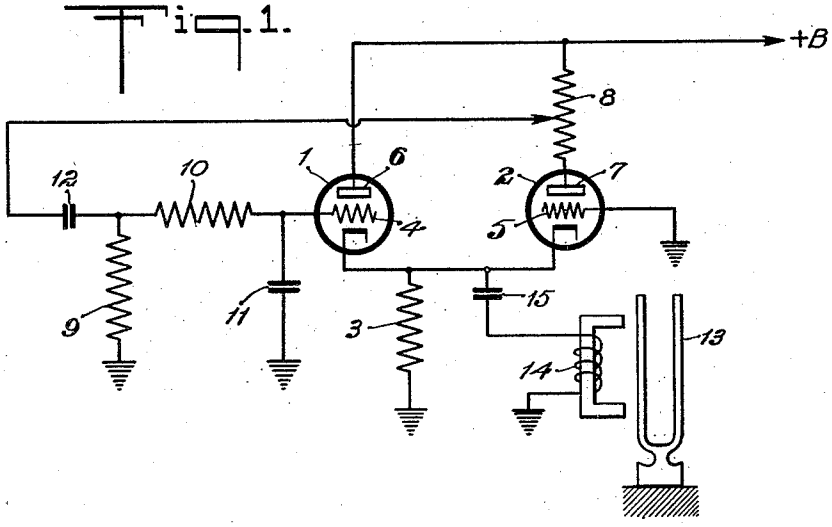


Fig. 2.

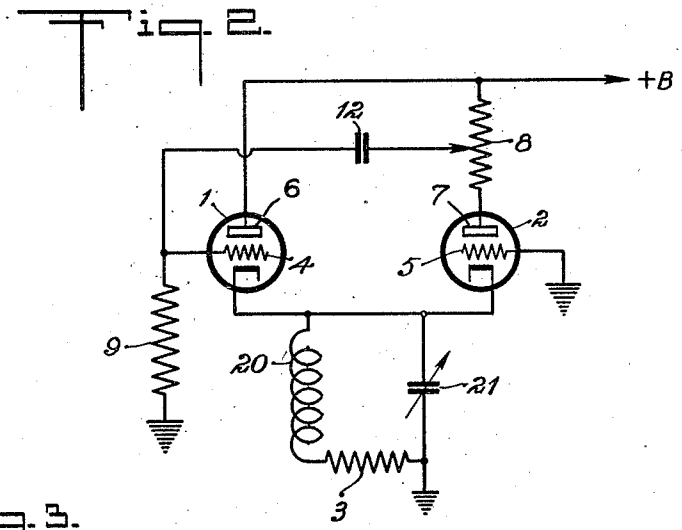
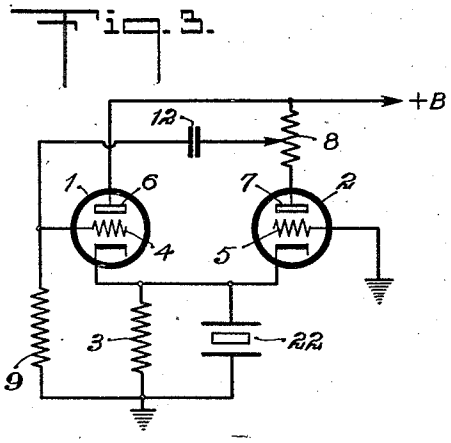


Fig. 3.



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OSCILLATION GENERATOR

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10 Claims. (Cl. 250—36)

This invention relates to oscillation generators, and more particularly to improvements which facilitate the maintenance of a high degree of stability in an oscillation generator.

My invention is applicable to oscillation generators in which resonance is obtained by a combination of resistance and capacitance. The invention is also applicable to generators in which resonance is obtained by means of a tuning fork, or a tank circuit consisting of parallel-connected inductance and capacitance elements, or still again by means of a piezo-electric crystal or other electromechanical vibrator.

When investigating the properties of oscillation generators of the prior art, it has been found that those of the type having resistance-capacitance resonators, hereinafter called RC oscillators, are particularly subject to adverse influences unless they are properly shielded. For example, if an oscillator is to deliver a frequency in the low range, say between 20 and 200 cycles, and if a high value of grid leak is used, say 8 megohms or more, the system is quite sensitive to hum pick-up. If the oscillator is set near 30, 60, 90, 120, or 180 cycles, it will tend to lock up or synchronize itself to hum. This is not necessarily true of fixed frequency oscillators, or where the network resistors are of less than one megohm in value. However, oscillators of the type having inductive and capacitive tanks, hereinafter called LC oscillators, are not so susceptible to adverse external influences. In the RC oscillators of my invention as herein disclosed, the ease with which they lock in or synchronize with a control frequency is turned to advantage, instead of being a nuisance difficult to eliminate.

It is an object of my invention to provide an oscillator having improved frequency stability.

Another object of my invention is to provide an improved tuning fork controlled electronic oscillator.

Still another object is to provide an oscillator in which improved frequency stability is obtained by means of a piezo-electric crystal.

A further object of my invention is to simplify the design of a tuning fork in association with an oscillation generator.

One feature of simplification to be found in my invention, according to one of the embodiments thereof, resides in the use of only one magnet instead of two in association with a frequency-controlling tuning fork. This one magnet is associated with both input and output circuits of the oscillation generator.

Conventional circuits as used to drive a tuning fork employ two magnetically polarized coils, one in the plate circuit of a tube and the other in the grid circuit. The fork acts as a mechanical coupling between grid and plate, and is sustained in oscillation by taking drive power from the tube. In any tuning fork, the best frequency constancy is reached at very low amplitudes, and the true fundamental frequency exists only when the amplitude of oscillation is infinitesimal. Any excess of drive power will force the fork to a lower frequency, just as overswinging a pendulum will lengthen the period of oscillation. With the usual circuits for driving a fork, considerable overdrive is needed to make the system self-starting and, as a result, the frequency varies with changes in drive effort. Nearly all previous work on fork drive amplifiers has been directed towards making this drive power constant.

My invention will now be described in more detail, reference being made to the accompanying drawing, in which:

Fig. 1 shows an oscillation generator circuit arrangement having tuning fork control and embodying the fundamental features of my invention;

Fig. 2 shows an embodiment in which the resonant unit comprises a parallel tuned inductance and capacitance; and

Fig. 3 shows still another modification of the invention in which the resonant element is a piezo-electric crystal.

Referring first to Fig. 1, I show therein, by way of illustration, two electron discharge tubes 1 and 2, the cathodes of which are interconnected and are provided with a common cathode resistor 3 leading to ground. The tubes 1 and 2 also contain grids 4 and 5 respectively and anodes 6 and 7 respectively.

A source of direct current operating potential indicated as +B is connected between ground and the anode 6. This same source is connected through a potentiometer 8 to the anode 7 in tube 2.

The input circuit for tube 1 includes two resistors 9 and 10 in series between the grid 4 and ground. A capacitor 11 is in shunt with resistors 9 and 10. A feedback circuit includes blocking condenser 12 which is connected between a tap on potentiometer 8 and the junction between resistors 9 and 10.

The grid 5 in tube 2 is directly connected to ground and derives its bias potential by virtue of a potential drop developed in resistor 3.

As shown in Fig. 1, the oscillator derives its resonance stability from the operation of a tun-

ing fork 13 having associated therewith an electromagnet 14. The winding of this magnet is connected between ground and one side of a capacitor 15. The other side of capacitor 15 is connected to the two cathodes of the tubes 1 and 2. The elements 14 and 15, therefore, constitute a series resonance circuit in shunt with resistor 3 tuned to the fork frequency. The magnet 14 has a very low Q, making the tuning board.

The gain control of the oscillator is set just below the point of self-oscillation with the fork blocked mechanically. On relieving the block, the system builds up into oscillation at very low amplitude, with the RC oscillator completely locked in on the fork. The oscillator is held back in frequency to the fundamental of the fork because a great excess of power is needed to overdrive the fork at a frequency higher than its fundamental. This large increase in power is not available from the extremely low voltage across resistor 3. Consequently, the fork oscillates at a lower amplitude than with other drive systems, and at a frequency much nearer to its fundamental resonance.

The optimum conditions for frequency stability are obtained by adjusting the RC circuit to a frequency slightly above the fork frequency, but not too far above. For example, if a 480 cycle fork were to be used, then the RC circuit should resonate between the limits of 481 to 485 cycles. Within these limits the fork frequency remains very constant indeed and no appreciable departure from 480 cycles can be observed, so long as the drive voltage is kept at a low value.

In a working embodiment of the apparatus as shown in Fig. 1, it was demonstrated that the frequency stability was greatly improved over conventional tuning fork drives. The actual voltage across the coil of magnet 14 was less than one volt rms, where at least five volts were required in previous embodiments using this same fork and drive coil in order to produce self-starting. The heretofore used feedback coil connected to the control grid 4 has been dispensed with in the instant embodiment of my invention. Thus the design of the fork mounting has been simplified.

Increasing the gain control by adjustment of the potentiometer 8 until the drive voltage across the magnet 14 is doubled lowers the fork frequency ten parts per million. This same percentage change in drive with the old system changed the frequency over two hundred parts per million.

This control action is not so satisfactory in an LC oscillator, because the tank therein acts as a large flywheel, and will not readily lock in step with the fork. The entire flywheel effect should be furnished by the fork itself. An RC oscillator drive best meets this requirement.

Referring now to Fig. 2, I show a modification of the circuit arrangement of Fig. 1 in which the tuning fork is replaced by a tuned tank circuit comprising an inductive element 20 in parallel with a capacitor 21. In one sense the circuit of Fig. 2 might be considered an LC oscillator, but it does not possess the undesirable characteristics mentioned in the preceding paragraph because the flywheel effect is confined to the cathode circuit. Preferably, the inductance 20 is in series with a cathode resistor 3 leading to ground. The foregoing description of Fig. 1 applies to a large extent to Fig. 2, like parts being given the same reference numerals in the two figures. It will be noted, however, that no resistor 18 such as shown in Fig. 1 is required in the circuit of Fig. 2.

In the operation of the generator shown in Fig. 2, it will be apparent that the tank circuit 21 provides a zero phase shift at resonance so that regeneration is direct, the plate voltage in tube 2 being coupled to the grid 4 in tube 1. Here any change in tank impedance at resonance will not seriously affect the gain of the amplifier. The circuit oscillates at the point of zero reactance for the tank, whether this is at the point of maximum impedance or not, for only at this point is the sum of all phase displacements zero. Some resistance tuning by varying the value of resistor 3 is possible and may in some cases be resorted to for optimum results. The operation of the circuit arrangement of Fig. 2 will be well understood by those skilled in the art in view of the foregoing description.

Referring now to Fig. 3, I show still another embodiment of my invention in which certain of the elements appearing in Figs. 1 and 2 are also shown with like reference numerals.

In Fig. 3, frequency stability is derived from the use of a piezo-electric crystal 22 which is connected in shunt with the cathode resistor 3 between ground and the cathodes of the tubes 1 and 2.

Since the piezo-electric device 22 possesses both inductance and capacitance, it is obvious that it may well be substituted for the tank circuit 21, 22 in Fig. 2. In other respects, the circuit arrangement of Fig. 3 is substantially the same as that of Fig. 2 and hence its operation will be well understood by those skilled in the art.

Other embodiments of my invention may readily be understood as comprehended within the scope thereof.

I claim:

1. An electronic oscillator cooperatively associated with a resonator for maintaining constant the frequency of the oscillations generated, said oscillator comprising two electron discharge devices each having triode electrodes, the cathodes of which are interconnected, a conductive impedance in circuit between said cathodes and ground, a non-inductive feedback circuit intercoupling the anode of one discharge device and the grid of the other discharge device, a direct ground connection for the grid of said one discharge device, and means in circuit between said cathodes and ground and coupling said resonator to the circuit of said oscillator in such manner that the oscillator is caused to be locked in step with the natural period of vibration of said resonator and said resonator is also driven thereby.

2. The combination according to claim 1 in which said resonator is constituted as a tuning fork, and said coupling means comprises a single electromagnetic device with respect to which at least one tine of the fork functions as an armature, whereby interchange of mechanical and electrical energy is effected.

3. The combination according to claim 1 in which said resonator is constituted as a parallel-tuned inductance-capacitance.

4. The combination according to claim 1 in which said resonator is piezo-electric.

5. A resistance-capacitance oscillator in combination with a tuning fork for maintaining constant the frequency of the oscillations generated, said oscillator having two triode discharge tubes the space paths of which are supplied with operating potentials from a direct current source, a non-inductive feedback circuit connected between

the anode of the first tube and the grid of the second tube, a direct ground connection for the grid of the first tube, a common cathode resistor connecting the cathodes of both tubes to ground, a series resonant circuit in shunt with said cathode resistor and having said tuning fork disposed as an armature to a polarized inductive element therein, means in said feedback circuit having a time constant such that the oscillations generated in said tubes tend to drift toward a frequency slightly higher than the natural frequency of said tuning fork when driven at low amplitude, the interaction between said tuning fork and the inductive element of said resonant circuit being effective to drive the fork and to maintain said oscillator in synchronism therewith.

6. An RC-oscillator comprising two discharge tubes each having a cathode, an anode and a grid and operating circuits therefor, including a resistor connecting both cathodes to ground, a potentiometer in the output circuit of one of said tubes, an adjustable tap on said potentiometer, a feedback circuit connected between said tap and ground and constituted as a series capacitance and resistance, the grid of the second tube being coupled to said output circuit through said capacitance, a direct ground connection for the grid of the first tube, a frequency stabilizing device having a series-resonant circuit in shunt with said cathode resistor, and a tuning fork constituted as an armature for a magnetic circuit which includes the core of an inductive winding in said series resonant circuit.

7. An RC-oscillator according to claim 6 and further characterized that said feedback circuit possesses a time constant equivalent to a frequency slightly above the natural frequency of said tuning fork when the latter is driven at low amplitude.

8. In combination, an oscillation generator comprising two electron discharge devices of the triode type having their cathodes interconnected, a cathode-to-ground impedance common to said cathodes, a vibratory element, a single magnetic device associated with said element and arranged to translate electrical energy into mechanical vibrations of said element and vice versa, said magnetic device being included in a partly capacitive circuit which shunts said cathode-to-ground impedance, means including a non-inductive feedback circuit coupling the anode of one said discharge device to the grid of the other said discharge device for causing the frequency of the generated oscillations to exceed slightly the natural frequency of said vibratory element, if uncontrolled thereby, and means for so limiting the amplitude of electrical output energy derived from said generator and applied to said magnetic device for driving said vibratory element that the amplitude of mechanical vibrations produced in said vibratory element is maintained at an optimum value for frequency stabilization, and said generator is locked in step with said vibratory element.

9. An RC-oscillator comprising two discharge devices, means including a feedback circuit having a time constant value determined by a suitable choice of capacitive and resistive elements in series, said feedback circuit being arranged to derive control potentials from the output of one said device and to apply them to the grid of the other said device for maintaining phase opposition between oscillations to be generated in one device relative to those in the other, a direct ground connection for the grid in the one said device, a cathode resistor connecting the cathodes of both said devices to ground, a tuning fork, and means having series inductance and capacitance in shunt with said cathode resistor for providing a coupling between said oscillator and the mechanical motion of said tuning fork, said tuning fork being disposed in the relation of an armature to the field of said inductance for causing the fork to vibrate and for causing the fork to control the frequency of the oscillations generated.

10. An RC-oscillator comprising two discharge tubes and operating circuits therefor, including a resistor connecting the cathodes of both tubes to ground, a piezo-electric device connected in shunt with said resistor and chosen to produce resonance at the frequency of the oscillations to be generated, a potentiometer in the output circuit of one of said tubes, an adjustable tap on said potentiometer, a feedback circuit containing series capacitance and resistance connected between said tap and ground, the grid of the second tube being coupled to said output circuit through said capacitance, said feedback circuit having a time constant value which tends to develop oscillations in said tubes at a frequency slightly higher than the natural frequency of said piezo-electric device, and a direct ground connection for the grid of the first tube.

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