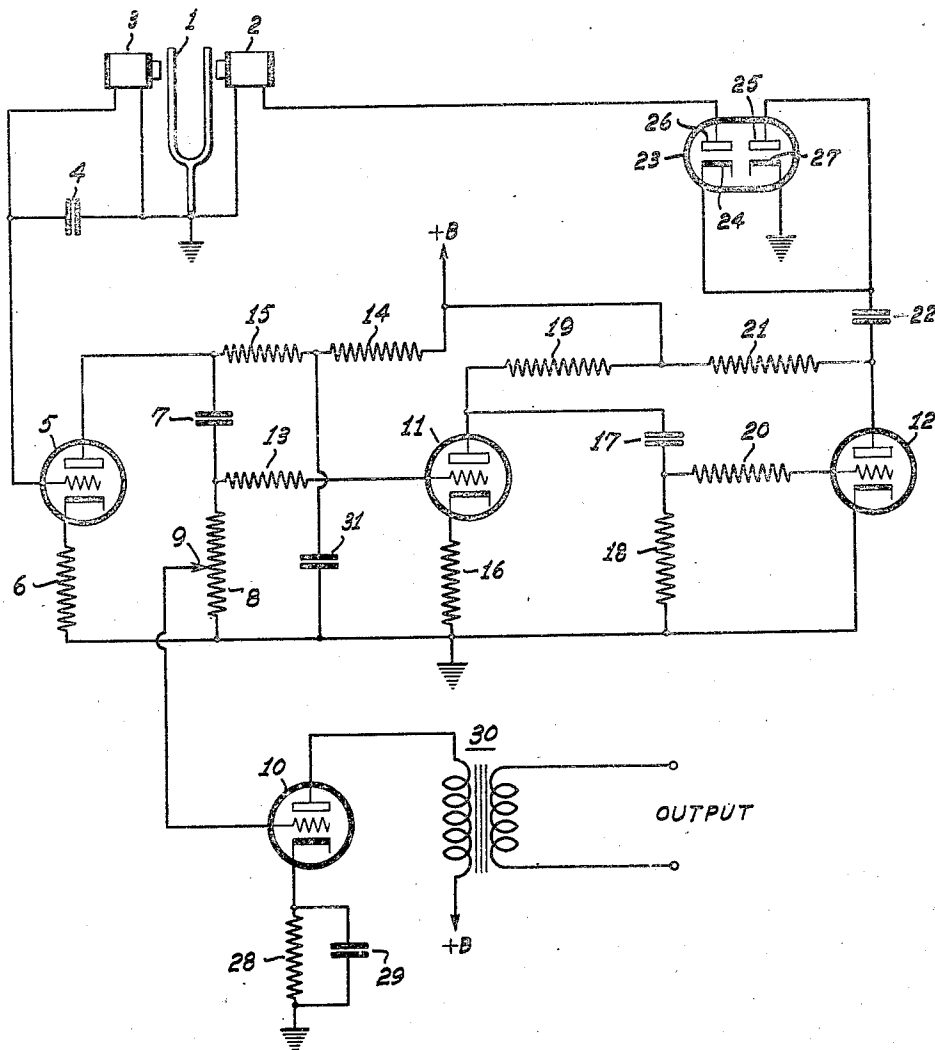


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LOW FREQUENCY OSCILLATOR
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LOW FREQUENCY OSCILLATOR

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This invention relates to low frequency oscillation generators and particularly to a circuit arrangement for stabilizing the frequency of oscillations generated by a mechanical vibrator.

A primary object of the present invention is to provide a source of oscillations of constant frequency and constant amplitude.

Another object is to provide such a source which is particularly adapted for use in the audio frequency range below ten thousand cycles.

A further object is to provide a system for generating oscillations of constant frequency and constant amplitude which is compact and substantially unaffected by temperature changes.

A further object is to provide a low frequency electrical source of constant frequency and constant amplitude of output which may be operated from the standard power supply systems regardless of the usual fluctuations in voltage encountered in such a system.

A still further object of our invention is to provide a low frequency oscillation generator with means including limiters whereby the driving potentials applied for vibrating a tuning fork shall be maintained substantially constant.

Heretofore tuning forks have been operated in circuits which fed a sine wave into the drive coil. This requires Class A operation of all circuits between the pick-up and drive coils of the fork. Replacing tubes is likely to alter, to some extent, the gain in this circuit. As a result, more or less drive will be supplied to the fork and its amplitude of oscillations increased or decreased accordingly. Besides the change in output voltage resulting from the new value of drive, the frequency of the fork oscillations will be altered somewhat.

As a means of overcoming these disadvantages, various limiters and pulse drive circuits have been developed. A feature of our invention resides in the means relating to the pulse drive circuit.

Our invention will now be described in more detail, reference being made to the accompanying drawing, the sole figure of which represents diagrammatically a preferred embodiment.

Referring to the drawing, we show a tuning fork 1 having a drive coil 2 and a pick-up coil 3. The vibration frequency of the tuning fork may be whatever is desired. One terminal of each of the coils 2 and 3 is grounded and preferably the tuning fork itself is grounded. Capacitor 4 in combination with the inductance of coil 3 forms a tank circuit in which A. C. potentials are generated. These potentials are applied to the control grid in a triode-discharge tube 5 which operates as an amplifier. The cathode of tube 5 is

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connected to ground through a cathode resistor 6.

The output circuit of tube 5 includes a capacitor 7 and a potentiometer 8 on which is a tap 9 for taking off output potentials to be applied to the control grid of an amplifier tube 10. Operating potential for the tube 5 as well as for other discharge tubes 10, 11, and 12 may be derived from any suitable direct current source (not shown), the positive terminal of which is merely indicated as +B. The negative terminal of this source is to be considered grounded.

Discharge tubes 11 and 12 are arranged to be operated as limiter tubes. The control grid in tube 11 is connected to the junction between capacitor 7 and potentiometer 8 through a grid resistor 13. Since anode potential is fed from the positive terminal of the D. C. source to the anode of tube 5 through resistors 14 and 15, it follows that a potential drop in resistor 15 will vary with the phase of the oscillations amplified by tube 5. Resistor 14 and capacitor 31 in combination serve as a high impedance to the flow of A. C. energy through the D. C. source. The oscillations in the output circuit of tube 5 are, therefore, applied to the control grid in tube 11. When this tube is not biased to cut off, it is arranged to be conductive and to have a grid-cathode voltage which is slightly positive. The output from tube 11 is, therefore, one of which is substantially of square-wave formation.

The circuit of tube 11 includes a cathode resistor 16 connecting the cathode to ground. Operating potential is applied to the anode from the D. C. source through anode resistor 19.

It was stated above that discharge tube 12 as well as discharge tube 11 are operated as limiter tubes. That is to say, when either of these tubes is rendered conductive, it becomes fully conductive, i. e., its grid-cathode voltage is slightly positive. The control potentials applied to the grids are of sufficient amplitude to completely block these tubes on the negative portion of the cycle. Accordingly, tube 12 is arranged to be controlled by output potentials from tube 11 which alternately charge and discharge capacitor 17. The potential drop in the grid resistor 18 is complementary to that in the anode resistor 19, and varies with the charge on capacitor 17. The control grid in tube 12 is connected through a resistor 20 to the junction between capacitor 17 and resistor 18.

The cathode of tube 12 is directly grounded. Its anode is connected to the positive terminal of the D. C. source through a resistor 21. The terminal of resistor 21 adjacent the anode in tube

12 is also connected to one terminal of a coupling capacitor 22. The other terminal of capacitor 22 is connected to the cathode 24 in one section of a twin diode tube 23 and also the anode 25 in the other section of this tube. The anode 26 in the left hand section of tube 23 is connected to ground through the winding of the tuning fork driving coil 2. The cathode 27 in the right hand section of tube 23 is directly grounded.

The amplifier tube 10 is used to deliver output energy of substantially pure sine wave characteristic to a utilization device. The cathode of tube 10 is connected to ground through a cathode resistor 28. This resistor is shunted by a capacitor 29. The output circuit of tube 10 includes the primary winding of a transformer 30, this winding being connected to the positive terminal of the D. C. source. The secondary winding of transformer 30 delivers the output to any desired utilization device.

In the operation of our invention, it will be observed that the limiting action of tubes 11 and 12 is such that the output potentials delivered across the capacitor 22 are sharply defined. When the anode current of tube 12 is cut off, capacitor 22 charges to the value of the D. C. source through resistor 21 and the space path between electrodes 25 and 27 in the diode rectifier tube. The time constant of this circuit is adjusted to be short as compared with the period of tuning fork 1. This is necessary in order to insure that even in the steady state, capacitor 22 shall charge fully to +B potential while tube 12 is non-conductive.

When tube 12 is conductive, capacitor 22 discharges through the parallel combination of resistor 21 and the space path of tube 12 in series with the space path between electrodes 24 and 26 of the rectifier tube 23 and the drive coil 2 of fork 1. Thus one pulse is supplied to the drive coil 2 for each cycle of the fork frequency.

It is important to note that the energy in the driving pulse applied to the coil 2 is proportional to the supply voltage derived from the D. C. source, the capacity of the capacitor 22, and the ratio

$$\frac{R_1}{R_1 + R_b}$$

where R_1 is the resistance of resistor 21, and R_b is the resistance of the space path in tube 12 in the conducting state. Variations of R_b with different tubes of the same type at zero bias have been found to be relatively small. These variations are, therefore, effectively rendered negligible if the value of R_1 is chosen to be several times that of R_b .

The D. C. operating potential applied to the tube 12 has been indicated as being the same as that which is applied to tube 11. It is not essential, however, that the same voltages should be used with respect to these two tubes.

It will be well understood by those skilled in the art that the parameters of the circuit herein shown and described may be adjusted so that the amplitude of the driving potentials applied to the coil 2 may be set at an optimum value for avoidance of overdrive while maintaining the substantially sine wave characteristic of output energy from the pick-up coil 3. The sine wave shape of the output is maintained in the amplifier tube 5. Accordingly, a substantially pure sine wave is delivered through the potentiometer tap 9 to the input circuit of tube 10. However, a portion of the output from tube 5 is also utilized in supply-

ing the control potentials for the limiter tubes whereby the feedback potential is obtained by rectification in tube 23.

Various modifications of the circuit arrangement herein shown and described may be made without departing from the spirit and scope of the invention itself.

We claim:

1. In a low frequency oscillation generator wherein the frequency is controlled by a mechanical vibrator, a system of electron discharge devices including an amplifier stage, two limiter stages and a full wave rectifier stage, magnetic driving and pick-up means associated with said vibrator, the input circuit of said amplifier stage being subject to control by potentials induced in said pick-up means, capacitors each intercoupling the output and input circuits of successive stages, resistive impedances in circuit with each said capacitor, one of said capacitors being connected between the anode of the second limiter stage and certain electrodes of said rectifier stage, this particular capacitor in combination with one of said impedances forming a time constant circuit the charging time of which is limited to a minor fraction of a cycle of the oscillations to be generated, and this capacitor being arranged to discharge rapidly through a circuit which includes the space path of said second limiter stage, one portion of said rectifier stage, and said magnetic driving means, and a circuit for feeding unilateral pulses of the other polarity from the rectifier means to ground.

2. The invention as claimed in claim 1 and including electronic means for amplifying a component of output energy derived from said amplifier stage, thereby to obtain useful output energy from said generator.

3. In a low frequency oscillation generator of the type having a mechanical vibrator for controlling the oscillation frequency, electromagnetic means for exciting said vibrator, electromagnetic means for deriving output potentials from said vibrator, a concatenated chain of electron tube stages, the first stage having an input circuit under control of said output potentials from the vibrator, and two succeeding stages being characterized as limiter stages, a full wave rectifier having its unidirectional paths oppositely faced to receive and to block the half cycles of alternating current potentials derived from the second of said limiter stages, a capacitor connected on one side to the anode of the second said limiter stage and on the other side to both unidirectional paths of said rectifier, said capacitor in association with the impedance of its discharging circuits constituting means for limiting the duration of each pulse which is applied to said electromagnetic exciting means to a fraction of one of said half-cycles, and ground connections for the output from each of said unidirectional paths, one of said ground connections being arranged to traverse the winding of said electromagnetic exciting means.

4. The invention as claimed in claim 3 and including a potentiometer in the output circuit of the first of said concatenated tube stages, and means for deriving useful output energy from an adjustable tap on said potentiometer.

5. An electronic oscillator in combination with a resonator for maintaining constant the frequency of the oscillations generated, said oscillator comprising a plurality of electron discharge devices each having input and output electrodes and connections to a source of direct current for

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energizing the same, means for deriving periodic pulses from said resonator whereby one of said discharge devices in a first stage is controlled, means coupling the output of the first stage to a second stage and thence to a third stage of said discharge devices, means for so adjusting the transconductance of the discharge devices of the second and third stages that they function as limiters, rectifying means receptive to the output of the third stage for directing the energy pulses of each polarity into a separate path, one of which paths includes a device for exciting said resonator, a capacitor intercoupling said third stage and said rectifying means, said capacitor constituting means for limiting to a fraction of a half cycle the duration of said energy pulses as applied to the excitation of said resonator, and means including an amplifier for deriving useful oscillatory energy of substantially pure sine wave characteristic, the last said means being directly coupled to the output circuit of said first stage.

6. Apparatus for stabilizing the amplitude and frequency of vibration of a tuning fork comprising an electronic circuit having an amplifier stage, first and second limiter stages and a full wave rectifier having two unilateral space paths, said stages being concatenated in the order named and said second limiter stage having an anode circuit, a circuit including said rectifier and a capacitor for supplying electro-mechanical excitation to said tuning fork, said capacitor being connected to charge through one unilateral space path of said rectifier and to discharge through the other unilateral space path thereof, and means for limiting the discharge period of said capacitor to a fractional part of a half cycle of the tuning fork's oscillation, said means including an impedance in the anode circuit of the second limiter stage.

7. An oscillation generator comprising a resonant system, a vacuum tube having input and output electrodes and said input electrode subjected to voltages set up by said resonant system, limiting apparatus coupled to the output electrode of said tube and having an output circuit, a condenser, a rectifier coupled to the output circuit of said limiting apparatus and connected to said condenser to charge once during each cycle of the wave output of said limiting apparatus, and a further rectifier connected to said condenser to discharge said condenser through said resonant system once during each cycle of the wave output of said limiting apparatus, the charging and discharging times of said condenser being so adjusted as to occupy periods which are substantially shorter than a half cycle of the resonant frequency of said resonant system.

8. An oscillation generator comprising a resonant system, a vacuum tube having a pair of its electrodes subjected to voltages set up by said resonant system, limiting apparatus coupled to another pair of electrodes of said tube, a condenser, means including one unidirectional space path in a twin diode discharge tube, said tube being coupled to the output circuit of said limiting apparatus whereby said condenser is fully charged once during each cycle of the wave output of said limiting apparatus, and circuit means including the other unidirectional space path in said diode discharge tube for discharging said

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condenser through said resonant system once during each cycle of the wave output of said limiting apparatus, the charging and discharging times of said condenser being so adjusted as to occupy periods which are substantially shorter than a half cycle of the resonant frequency of said resonant system.

9. An electromechanical resonant system in combination with a vacuum discharge tube having input and output electrodes, a circuit for subjecting said input electrodes to voltages set up by said resonant system, a limiter coupled to said output electrodes, a condenser, a twin diode rectifier having its cathode of one space path and its anode of the other space path connected to one side of said condenser, a circuit connection from the other side of said condenser to the output side of said limiter, and circuit components whereby said condenser is caused to be fully charged once during each cycle of the wave output from said limiter, and is caused to be discharged through a path which includes an element of said resonant system, the values of said circuit components and of said condenser being so chosen as to effect charging and discharging times of the condenser which are substantially less than half cycles of the wave set up by said resonant system.

10. The combination according to claim 9 wherein said electromechanical resonant system is constituted as a tuning fork having electromagnetic pick-up and driving coils.

11. For use in supplying pulse excitation to a tuning fork, an electronic circuit having an amplifier stage, two limiter stages, each said stage having electrode elements, a capacitor and a full wave rectifier having two space paths each provided with a cathode and an anode electrode, said stages being concatenated and said capacitor being connected between the output circuit of the second limiter stage and unlike electrodes of the two space paths in said rectifier, means providing electromechanical pick-up of energy from said tuning fork for applying controlling voltage to said amplifier stage, a discharge circuit connected to said condenser and including electromechanical means for applying energy to said tuning fork, the space path of the second limiter stage and one of said space paths of said rectifier and a power supply system connected through impedances to the electrode elements of said stages, said impedances being of predetermined values such that excitation pulses in response to said controlling voltage applied through said one space path of said rectifier to said tuning fork are limited in amplitude by the energy stored in said capacitor, and in duration by the impedance of said discharge circuit.

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