

May 15, 1951

W. H. BLISS
RELAXATION OSCILLATOR

2,553,165

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2 Sheets-Sheet 1

Fig. 3

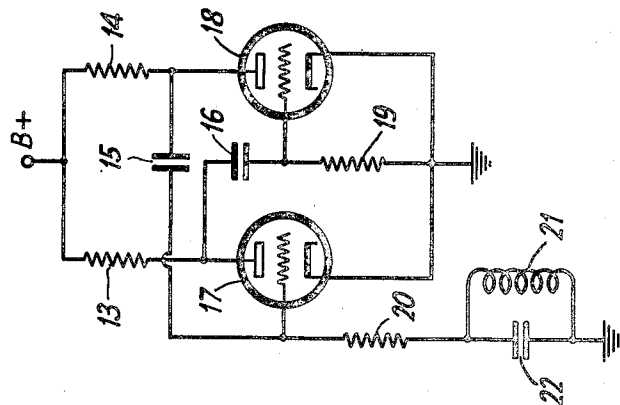


Fig. 2

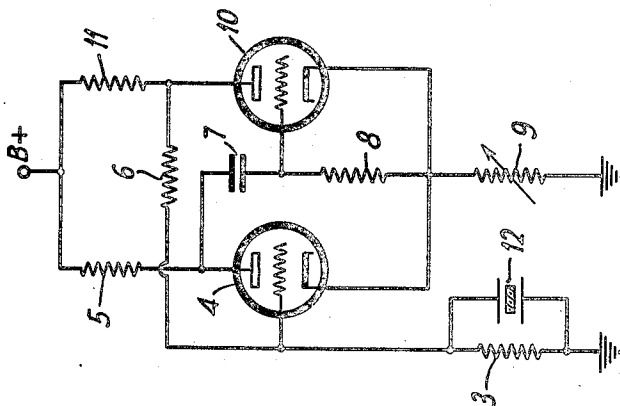
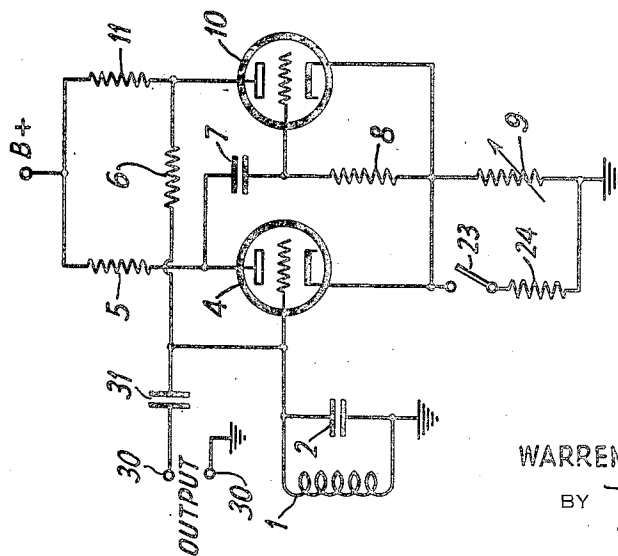


Fig. 1



INVENTOR
WARREN H. BLISS

BY *W. H. Bliss*
ATTORNEY

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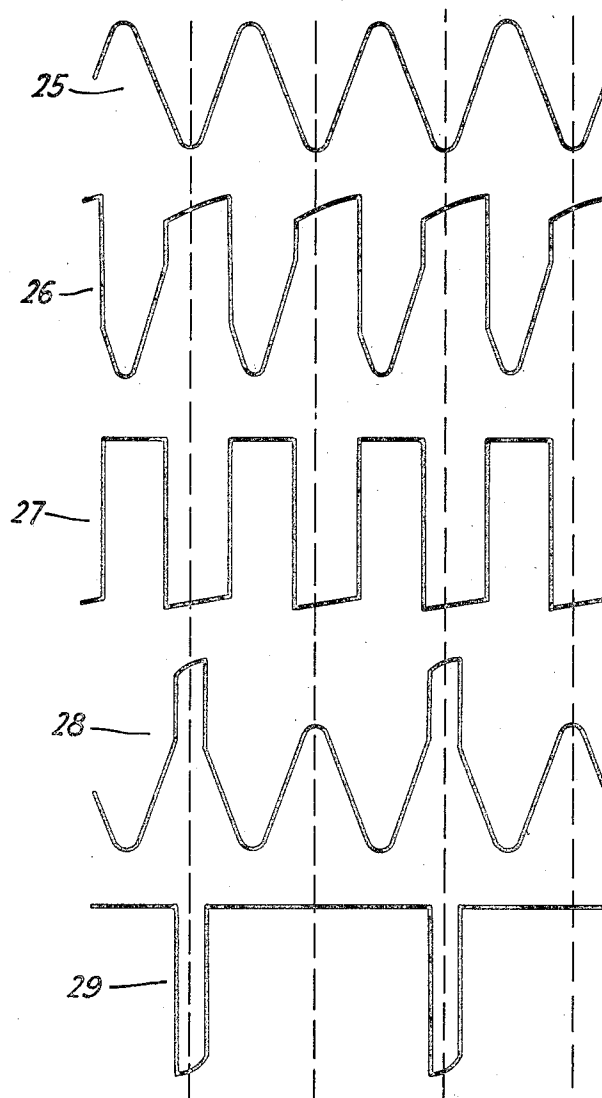
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Fig. 4



INVENTOR
WARREN H. BLISS

BY *H. G. Snow*
ATTORNEY

UNITED STATES PATENT OFFICE

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RELAXATION OSCILLATOR

Warren H. Bliss, Riverhead, N. Y., assignor to
Radio Corporation of America, a corporation
of Delaware

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5 Claims. (Cl. 250—36)

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This invention relates to relaxation oscillators. It deals with a type of oscillator wherein a resonant tank circuit is coupled to an electronic circuit arrangement in such manner that the pulses of energy necessary to maintain oscillations in the tank circuit are derived from two discharge devices which have a flip-flop action. The flip-flop action is in turn synchronized from the sine wave of the tank circuit.

Accordingly it is an object of my invention to provide a relaxation oscillator of novel type which is capable of sustaining oscillations by itself but which is maintained stable in frequency by the aid of a frequency controlling tank circuit or the equivalent thereof.

It is another object of my invention to provide a relaxation oscillator the frequency of which is to be maintained constant by means of a resonant circuit coupled thereto, said resonant circuit being energized from the output of the relaxation oscillator proper.

In the performance of a relaxation oscillator such as herein disclosed a similarity will be observed to that of a spring driven clock movement in combination with a swinging pendulum. The pendulum controls the rate, or timing of the clock movement.

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

Fig. 1 shows a preferred embodiment; Figs. 2 and 3 illustrate modified versions; and Fig. 4 shows a series of curves representing generated wave shapes.

Referring first to Fig. 1 I show therein a resonant tank circuit comprising inductance 1 in parallel with a capacitor 2. This combination is connected between ground and the control grid of a triode tube 4. The cathodes of tube 4 and of a second tube 10 are interconnected and are normally connected to ground through an adjustable resistor 9. This resistor, however, may be at times shunted by a circuit of relatively low resistance comprising a starting resistor 24 in series with a starting switch 23. The switch 23 is used for starting the oscillatory condition in the circuit. A peculiarity of this circuit arrangement is that resistor 9 is preferably chosen to have a relatively high ohmic value, so that the relaxation oscillator is not self-starting.

Energizing potential from a D. C. source indicated as B+ (and having a grounded negative terminal) is shown connected to the anodes of the two tubes 4 and 10, the connections being

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made through resistors 5 and 11 respectively. The anode and cathode of tube 4 are interconnected through a time constant circuit comprising a capacitor 7 in series with a resistor 8. The junction between elements 7 and 8 is connected to the grid of tube 10. The anode of tube 10 is connected through a resistor 6 to the grid of tube 4.

The circuit arrangement as hereinabove described might be looked upon as closely related to a multivibrator circuit. It does not, however, operate in the manner of a conventional multivibrator. It is asymmetric in operation and may be referred to as a flip-flop or univibrator circuit. The operation may be better explained as follows:

To start oscillations, switch 23 is momentarily closed for the purpose of rendering tube 4 conductive. Normally this tube would stand in a non-conductive state by virtue of the voltage drop through resistor 9 due to the normally conductive state in tube 10. Resistor 9, as previously stated, is chosen to have a relatively high ohmic value primarily for the purpose of holding tube 4 non-conductive, particularly until oscillations are to be generated.

Upon closing the switch 23 the bias on tube 4 is reduced to such an extent that tube 4 starts to conduct. The coupling between the anode of tube 4 and the grid of tube 10 causes tube 10 to be biased to cut-off in response to the conductive state in tube 4. This condition persists while condenser 7 discharges through resistor 8, thus holding triode 10 non-conductive. When condenser 7 discharges sufficiently, the grid of triode 10 rises above the cut-off value and the initial states of conduction and nonconduction in the respective tubes are restored. This completes the first cycle of the relaxation oscillator and the second cycle starts as soon as condenser 7 recharges through resistor 5. The triodes will continue to oscillate at a frequency dependent mostly on the values of resistors 5, 8 and 9 and condenser 7.

If coil 1 and condenser 2 are of such values as to resonate at approximately the same frequency as the relaxation oscillations then this sine-wave tank circuit will be excited by the pulses of energy fed to it from the anode of triode 10 by way of resistor 6. As the sine-wave oscillations build up in the tank circuit comprising coil 1 and condenser 2, the relaxation oscillations in triodes 4 and 10 will become completely synchronized to the natural frequency of said tank circuit, since the latter will con-

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trol the instant when the conduction of tube 4 is initiated for each cycle of the relaxation circuit.

If resistor 9 is increased in value after the oscillations have built up, then a better degree of stability is obtained. This is because the triggering of triode 4 is controlled solely by the tank circuit 1, 2 and the relaxation oscillator (which is a "single-shot" trigger device) becomes a flip-flop circuit having one stable and one unstable status of conduction. Under this mode of performance tube 4 leans toward a non-conducting state and tube 10 toward a conducting state for the stable portion of each cycle, whereas an unstable condition or active state exists when tube 4 is conducting and tube 10 non-conducting. The stable state is terminated by tube 4 being triggered by the positive rise in voltage of the tank circuit 1, 2. During the unstable or active state a pulse of energy is supplied to the tank circuit from the anode of tube 10. The tubes then flop back to the stable state to wait for the next triggering. In this manner the sine-wave tank circuit of coil 1 and condenser 2 directly control the pulses of energy which drive it.

The modification shown in Fig. 2 differs from that of Fig. 1 chiefly in respect to the substitution of a piezo-electric device 12 for the tank circuit 1, 2. In order to provide a conductive circuit between the grid of tube 4 and ground a resistor 3 is connected across the terminals of the piezo-electric device. The mode of operation of the oscillator circuit arrangement shown in Fig. 2 will be apparent from the foregoing description of operation of the circuit of Fig. 1. The output may be taken off at any suitable point, the same as in Fig. 1, although output terminals are not shown in Fig. 2. The adjustable resistor 9 may be manually controlled if desired to reduce its ohmic value for purposes of starting. Otherwise, the same starting switch 23 in series with a resistor 24 may be included in the circuit of Fig. 2 if desired.

Referring to Fig. 3, the modification therein shown is also similar to the embodiment shown in Fig. 1, but in this case the tubes 17 and 18 are associated more in accordance with the arrangement of a conventional multivibrator. It will be noted that the anode of tube 18 is coupled to the grid of tube 17 through a capacitor 15. Also the anode of tube 17 is coupled to the grid of tube 18 through a capacitor 16. The cathodes of the two tubes 17 and 18 are directly grounded, so that it is necessary to supply grid resistors 19 and 20 for the two tubes respectively. Anode potential is supplied to the two tubes through resistors 13 and 14.

In the circuit of Fig. 3 the grid of tube 17 is connected to ground through a resistor 20 in series with an inductive element 21 and the latter is in shunt with a capacitor 22. The elements 21 and 22 form a tank circuit which is used for stabilizing the frequency of oscillations of the multivibrator.

In the operation of the circuit arrangement shown in Fig. 3, the values of the components of the multivibrator circuit proper may be so chosen as to cause oscillations to be produced in harmonic relation to the frequency to which the tank circuit 21, 22 would resonate.

Referring now to Fig. 4, I show therein a series of wave forms which illustrate the characteristics of the wave energy to be obtained at various points of the several circuit arrangements,

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more especially that of Fig. 1. Line 25 is the sine-wave voltage developed by the oscillator and deliverable across the terminals 30. Lines 26 and 27 are wave forms appearing on the anodes of the triodes 4 and 10 respectively. The vertical portions of these wave forms indicate instants of triggering. The upper portions of the wave form 26 indicate the times when triode 4 is completely cut off and is non-conducting and the lower portions of this wave form indicate the conducting periods of triode 4. Wave form 27 applies similarly to the triode 10.

Wave forms 28 and 29 are those which would be observed at the anodes of the triodes 4 and 10 respectively when the flip-flop part of the circuit is operated at half the frequency of the tank circuit 1, 2. In this case it can be seen that tubes 4 and 10 are triggered on alternate cycles of the sine wave output from the tank circuit. The output for this type of operation remains the same as shown in line 25. This sub-harmonic operation is obtained by readjustment of the values of resistors 8 and 9.

It will be apparent to those skilled in the art that the relaxation oscillator of my invention is capable of modification in various ways to meet the particular requirements of associated circuits. The output from the oscillator may be taken off at various points. The circuits themselves are also capable of modification in various ways without departing from the spirit and scope of the invention.

I claim:

1. A frequency stable sine wave generator including an electron discharge network comprising a first electron discharge device having cathode, grid and anode electrodes, a second electron discharge device having cathode, grid and anode electrodes, load resistors connected to the anode electrodes of said electron discharge devices, a capacitor intercoupling the anode electrode of said first electron discharge device and the grid of said second electron discharge device, a grid resistor connecting the grid electrode of said second electron discharge device to the cathode electrodes of both of said electron discharge devices, a further resistor connected between said cathode electrodes and ground, and means to connect the positive pole of a source of direct potential to said load resistors and to connect the negative pole of said source to ground, said further resistor having a value normally at which said second discharge device is conducting and said first discharge device is blocked due to current flow of said conducting second discharge device, a switch and resistance element adapted to be connected across said further resistor effective to reduce the value of said further resistor to reduce the bias on the grid electrode of said first electron discharge device to render the same conducting and block said second electron discharge device after which said second electron discharge device becomes conducting effectively to restore said network to said normal condition, a resonant circuit comprising an inductor and a capacitor connected in parallel between the grid electrode of said first electron discharge device and ground, and a second resistor connecting the anode of said second electron discharge device to the grid of said resonant circuit connected to the grid electrode of said first electron discharge device to sustain oscillations at the resonant frequency of said resonant circuit.

2. A frequency stable sine wave generator including an electron discharge network compris-

ing a first electron discharge device having cathode, grid and anode electrodes, a second electron discharge device having cathode, grid and anode electrodes, load resistors connected to the anode electrodes of said electron discharge devices, a capacitor intercoupling the anode electrode of said first electron discharge device and the grid of said second electron discharge device, a grid resistor connecting the grid electrode of said second electron discharge device to the cathode electrodes of both of said electron discharge devices, a further resistor connected between said cathode electrodes and the grid electrode of said first electron discharge device, means connecting the grid electrode of said first electron discharge device to ground with respect to direct current, and means to connect the positive pole of a source of direct potential to said load resistors and to connect the negative pole of said source to ground, said further resistor having a value normally at which said second discharge device is conducting and said first discharge device is blocked due to current flow of said conducting second discharge device, means to reduce the value of said further resistor to reduce the bias on the grid electrode of said first electron discharge device to render the same conducting and block said second electron discharge device after which said second electron discharge device becomes conducting effectively to restore said electron discharge network to said normal state, a resonant circuit element interposed between the grid electrode of said first electron discharge device and ground, and a second resistor connecting the anode of said second electron discharge device to the grid electrode of said first electron discharge device to sustain oscillations at the resonant frequency of said resonant circuit element.

3. A frequency stable sine wave generator including an electron discharge network comprising a first electron discharge device having cathode, grid and anode electrodes, a second electron discharge device having cathode, grid and anode electrodes, load resistors connected to the anode electrodes of said electron discharge devices, a capacitor intercoupling the anode electrode of said first electron discharge device and the grid of said second electron discharge device, a grid resistor connecting the grid electrode of said second electron discharge device to the cathode electrodes of both of said electron discharge devices, a further resistor connected between said cathode electrodes and ground, a second grid resistor connected between the grid electrode of said first electron discharge device and ground, and means to connect the positive pole of a source of direct potential to load resistors, and to connect the negative pole of said source to ground, said further resistor having a value normally at which said second discharge device is conducting and said first discharge device is blocked due to current flow of said conducting second discharge device, means effective to reduce the value of said further resistor to reduce the bias on the grid electrode of said first electron discharge device to render the same conducting and block said second electron discharge device after which said second electron discharge device becomes conducting effectively to restore said electron discharge network to said normal state, a piezoelectric crystal connected between the grid electrode of said first electron discharge device and ground and a second resistor connecting the anode of said second electron discharge device to the grid electrode of said first electron discharge device

to sustain oscillations at the natural frequency of said piezoelectric crystal.

4. A frequency stable periodic wave generator including an electron discharge network comprising an electron discharge device having cathode, grid and anode electrodes, a load element coupled to the anode electrode of said electron discharge device, a resistor connected between the grid and cathode electrodes of said electron discharge device, a further resistor connected to the cathode electrode of said electron discharge device, means to apply direct potential to said load element and said further resistor to produce current flow therein and potential drops across said load and said further resistors, a further electron discharge device having a cathode connected to the cathode of the first said electron discharge device, an anode to which said potential is applied through the intermediary of an output element and a grid coupled to the terminal of said further resistor remote from the cathodes of said electron discharge devices, said further resistor having a value at which the potential drop thereat renders said further electron discharge device non-conducting, a capacitor coupling the anode of said further electron discharge device to the grid electrode of the first said electron discharge device, an impedance element coupled between the anode of the first said electron discharge device and the grid of said second electron discharge device, means to reduce the resistance of said further resistor to render said further electron discharge device conducting to charge said capacitor and thereby apply cut-off potential to the grid electrode of the first said electron discharge device, the first said electron discharge device again conducting upon dissipation of the charge on said capacitor through the first said resistor to block said further electron discharge device, and means periodically rendering said further electron discharge device conducting, said means comprising a resonant circuit interposed between the grid of said further electron discharge device and the cathodes of said electron discharge devices.

5. A frequency stable periodic wave generator including an electron discharge network comprising a first electron discharge device having cathode, grid and anode electrodes, a second electron discharge device having cathode, grid and anode electrodes, load elements connected to the anode electrodes of said electron discharge devices, a capacitor intercoupling the anode electrode of said first electron discharge device and the grid of said second electron discharge device, a resistor connecting the grid electrode of said second electron discharge device to the cathode electrodes of both of said electron discharge devices, a further resistor connected between said cathode electrodes and a point of fixed reference potential, an element coupling the grid electrode of said first electron discharge device to said point of fixed reference potential with respect to direct current, and means to apply positive direct potential to said electron discharge network between said point of fixed reference potential and load elements, said further resistor having a value normally at which said second discharge device is rendered conducting and said first discharge device is blocked due to current flow of said conducting second discharge device, means to remove the bias on the grid electrode of said first electron discharge device to render the same conducting and block said second electron discharge device after which said discharge network is re-

stored to said normal condition to complete one cycle of oscillation only, and a resonant circuit interposed in the grid electrode circuit of said first electron discharge device to reduce said bias periodically at the resonant frequency of said resonant circuit to sustain said oscillations.

WARREN H. BLISS.

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