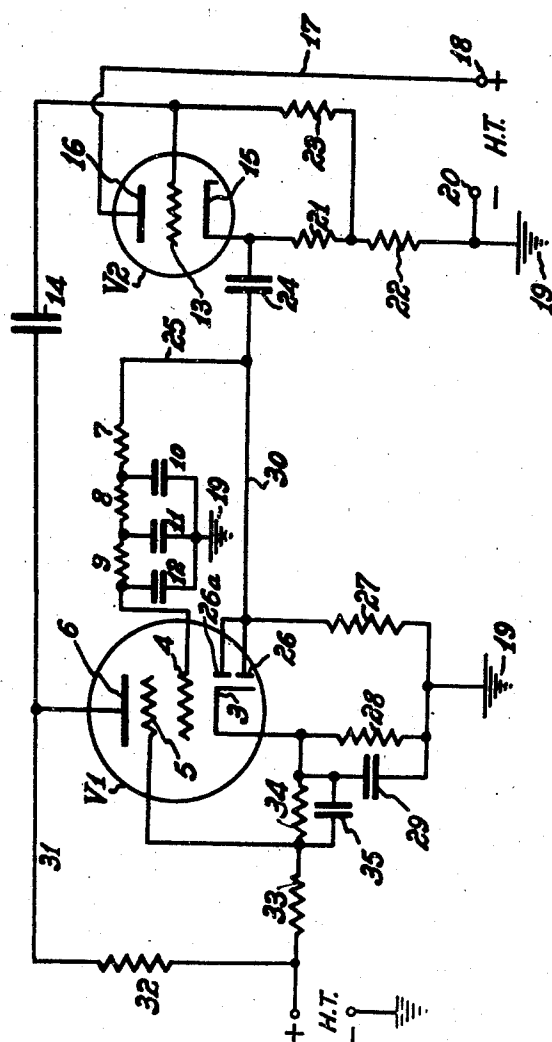


July 27, 1948.

D. S. ROBERTSON
PHASE SHIFT OSCILLATOR

2,446,106

Filed June 29, 1944



INVENTOR.
DAVID S. ROBERTSON
BY *H.S. Grover*
ATTORNEY

UNITED STATES PATENT OFFICE

2,446,106

PHASE SHIFT OSCILLATOR

David Stirling Robertson, Sydney, New South Wales, Australia, assignor to Amalgamated Wireless (Australasia) Limited, Sydney, New South Wales, Australia, a company of New South Wales, Australia

Application June 29, 1944, Serial No. 542,797
In Australia November 5, 1943

4 Claims. (Cl. 250—36)

1

This invention relates to phase shift oscillators and more particularly to an improved method of stabilizing the output frequency and voltage from such oscillators.

A phase shift oscillator consists of an amplifier with a delay or phase shift network connected in the feedback path between its output and input terminals. In order to produce self-sustained oscillations in the circuit, two conditions must be satisfied. Firstly, the voltage introduced from the output of the amplifier to its input must be in phase with the input voltage; secondly, the overall amplification of the amplifier must be such as to compensate for attenuation caused by the network.

The first requirement is fulfilled by the use of a non-resonant, multi-section, phase shifting network connected between the output and input of the amplifier valve or valves, each section of the phase shifting network comprising a series resistance and a shunt capacitor or vice versa. Since it is difficult to obtain the desired phase shift of 180 degrees, in two filter networks each composed of resistance and capacity, three or more sections are usually employed.

The second condition is met by the use of an amplifying valve having an amplification factor equal to, or greater than, the attenuation of the phase shifting network.

In the past, considerable difficulty has been experienced in obtaining satisfactory operation from oscillators of the type referred to. For example, variations in gain of the amplifier are liable to occur over a period of time brought about mainly by changes of the plate resistance of the amplifying valve as a result of fluctuations in the supply voltage. If the change in amplification is in a direction to cause the output to fall below the level necessary to compensate for the attenuation of the filter, oscillations will cease. Furthermore, as the plate resistance forms part of the phase shifting network, any variation of plate resistance will cause a change in the frequency of oscillation. This latter effect may be considerably reduced by coupling the anode of the amplifier to the input of the phase shifting network through an impedance transformer, such as a cathode follower stage.

Also, the amplitude of oscillation is only limited by the curvature of the valve characteristic so that, if the gain of the amplifier is increased, severe distortion occurs. This disadvantage may be avoided to a large extent by the use of automatic volume control (A. V. C.) as then the limitation of amplitude no longer depends on the curvature

2

of the valve characteristic, but on the delay bias applied to the A. V. C. rectifier.

By using both of the expedients outlined above, a fairly undistorted output can be achieved and the frequency stability of phase shift oscillators greatly improved.

It has been found, however, that the A. V. C. filter has a small effect on the frequency of oscillation, and also that the oscillator is liable to stop and start at a frequency determined by the time constant of the A. V. C. filter, (i. e., a low frequency, relaxation oscillation is liable to occur).

The object of the present invention is to provide a phase shift oscillator of simple construction and improved frequency stability in which all the desirable characteristics of prior art practice are retained and the attendant disadvantages avoided.

The above stated objective is achieved, in accordance with this invention, by providing an improved circuit arrangement which eliminates the customary A. V. C. filter and allows the A. V. C. bias to be fed into the input of the phase shifting network together with the feedback voltage.

Broadly, an oscillator arrangement according to the subject invention comprises a thermionic valve having cathode, anode and control grid electrodes, a feedback path connected between said anode and grid, an impedance transformer and a non-resonant multi-section phase shifting network serially connected in said feedback path, means for rectifying a portion of the output energy from the oscillator to derive an automatic biasing potential, and means for applying said potential to the control grid of said thermionic valve through the phase-changing sections of said network simultaneously with application to said valve of feedback energy.

For a more complete understanding of the invention, and the manner in which it is to be carried out, attention is now directed to the following description in connection with the accompanying drawing which illustrates one practical example of the invention.

Referring to the drawing, therein is illustrated an electron discharge device provided with a feedback circuit which includes an impedance transformer and a three section non-resonant phase shifting network made up of series connected resistances and parallel connected capacities. The phase shifting network functions to produce a voltage on the control electrode of the device which is substantially opposite in phase to the voltage in its anode.

In the example under consideration, the valve

V1 is shown as having a cathode 3, a control grid 4, a screen grid 5, and an anode 6. It is to be clearly understood, however, that any suitable type of valve, having a greater or lesser number of grids interposed in the electron stream, may be effectively employed, provided the amplification is equal to or greater than the attenuation of the phase shifting network.

Operating potentials are supplied to the anode 6 of the valve V1 from a source of D. C. supply (not shown) through an anode load resistor 32 and lead 31. Biasing potentials for the screen grid 5 are taken from a potential divider comprising the resistors 33, 34, 28 connected across the D. C. supply source (not shown). The screen grid is held at cathode A. C. potential by means of the bypass condenser 35.

More specifically the anode 6 of the valve V1 is coupled to the control grid 13 of a cathode follower valve V2 through the D. C. blocking condenser 14. The valve V2 is shown as a triode having a cathode 15 and an anode 16, and a control grid 13. Although the valve V2 is shown as a triode, a screen grid pentode or other suitable type of valve may be employed without affecting the scope of the invention.

The anode 16 of the valve V2 is connected to the high potential terminal 18 of a source of D. C. supply (not shown) through the lead 17, whilst the cathode 15 is connected to the earth 19 and low potential terminal 20 of the D. C. supply source through the series connected resistors 21, 22.

Biasing potentials, derived from the potential drop across the resistor 21, are applied to the grid 13 of valve V2 through the grid resistor 23.

The valve V2 thus connected functions in known manner to couple a high impedance input into a low impedance load.

The output of the valve V2 is developed across the serially connected cathode resistors 21, 22 and is applied to the input of the filter through the coupling condenser 24 and the lead 25. The phase changing network comprises the series connected resistors 7, 8, 9 and the parallel connected condensers 10, 11, 12 arranged in a three-section inverted L network.

The output from the cathode resistors 21, 22 is also applied through the condenser 24 to the anode 26 of a diode rectifier. In the present example the diode rectifier is shown as comprising a pair of anodes 26, 26a included in an envelope also common to the above mentioned electrodes of the valve V1, and cooperating with a portion of the cathode 3 thereof. Such valves are well known and provide a convenient method of obtaining the desired functions with a minimum of component parts. It is not desired to limit the invention to the precise arrangement shown, as equal results may be obtained by the use of a separate rectifier.

The anode 26 of the diode rectifier is connected to cathode 3 of the valve V1 through a D. C. path comprising resistors 27, 28 the junction point of said resistors being also connected to earth 19.

Resistor 28 and condenser 29 are employed to provide a negative biasing potential which is applied to the grid 4 of the valve V1 through resistor 27, leads 30, 25, and resistors 7, 8, 9.

As the biasing path for the control grid 4 is connected to the diode anode 26, the biasing potentials developed across the resistor 28 also serve as a delay bias for the diode rectifier.

When operating potentials are applied to the circuit thus described, a voltage impulse is developed across resistor 32 of the valve V1. This

voltage impulse is applied through condenser 14 to the grid 13 of valve V2. The valve V2, as already stated, functions in known manner as an impedance transformer. The voltage developed between the cathode and ground is almost equal to the grid-to-ground voltage and is of the same phase. So far as frequency of oscillation and attenuation in the feed-back path is concerned, this valve may be neglected. The use of an impedance transformer of this type, however, reduces to a negligible value the undesirable effects, of the valve V1, on the operating characteristic of the circuit.

The voltage impulse appearing across the cathode load resistor of the valve V2 is applied to the input of the phase shifting network through the condenser 24. This voltage impulse, when analyzed, is composed of a number of alternating current voltage trains, each train having a different frequency. It is well known that components of different frequencies travel through networks of the type illustrated at different velocities so that their relative arrival times at the end of the network differs from their relative starting times. The velocity of any one train through the filter is dependent upon the values of resistances and capacities chosen in constructing the network. The values of resistance and capacity are chosen so that a train of A. C. voltage, having a predetermined frequency, is so delayed in the network that the voltage appearing across the output and applied to the grid 4 is 180 degrees out of phase with the voltage of the same train when it enters the network through the coupling condenser 24.

This causes the valve V1 to sustain oscillations at the frequency whose network input and output voltages are 180 degrees out of phase.

Output potentials, from the valve 2, which are applied to the input of the phase changing filter network are also fed through the conductive connection 30 to the rectifier anode 26. The D. C. component of the rectified energy developed across the rectifier load resistor 27 is applied to the control grid 4 through the conductive path including the connection 30 and the network resistors 7, 8, 9.

It will thus be seen that in a circuit arrangement in accordance with this invention, the customary A. V. C. filter is dispensed with and the A. V. C. and feedback potentials are fed by a common path through the phase changing filter network to the control grid 4 of the valve V1. The elimination of the customary A. V. C. filter removes from the circuit the undesirable effects of the time constants of such filters and greatly improves the stability of the oscillator.

I claim:

1. A phase shift oscillator in combination with a system for stabilizing the amplitude and frequency of the oscillations generated, the components of said combination being constituted as a circuit arrangement having an oscillation generating discharge tube in which the electron emission from a cathode traverses a grid-controlled space path to a main anode and an uncontrolled space path to at least one rectifier anode, a capacitively shunted resistor connected between the cathode and ground, a resistive connection between ground and a grid which controls said controlled space path, said connection including a resistance element in series with a phase shifting network, a connection from said rectifier anode to the junction between said resistance element and said network, and a feedback circuit

5

coupled between the main anode and said junction.

2. The combination according to claim 1 wherein said feedback circuit includes electronic means for amplifying the feedback potentials.

3. The combination according to claim 1 wherein said resistive element in the connection between ground and a grid constitutes means for so biasing said rectifier anode that rectifier action takes place only when the output energy exceeds a predetermined value.

4. In apparatus for generating oscillatory energy of substantially constant frequency and amplitude, a first electron discharge device having input and output electrodes including an anode, cathode and control electrode and also having an additional electrode cooperating with said cathode to form a rectifier, a second electron discharge device having electrodes including an anode, a cathode and a control electrode, connections for applying electro-positive potentials to the anodes of said tubes and biasing potentials to the control electrode of said last tube, a coupling between the anode of said first named tube

6

and the control electrode of said second named tube, an impedance in the cathode return of said second named tube, a phase shifting network coupling the cathode of said second named tube to the control electrode of said first named tube, a rectifier circuit including an impedance connecting said additional electrode to the cathode of said first tube, and a connection between the input end of said phase shifting network and said rectifier circuit to control the bias on the control electrode of said first named device.

DAVID STIRLING ROBERTSON.

REFERENCES CITED

- 15 The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
20 2,343,539	Edson	Mar. 7, 1944

OTHER REFERENCES

Proceedings of the I. R. E., Feb. 1941, vol. 29, No. 2.