Feb. 5, 1946. C. A. SHANK ET AL 2,394,018

VACUUM TUBE OSCILLATOR

Filed April 24, 1943

Fig:1.

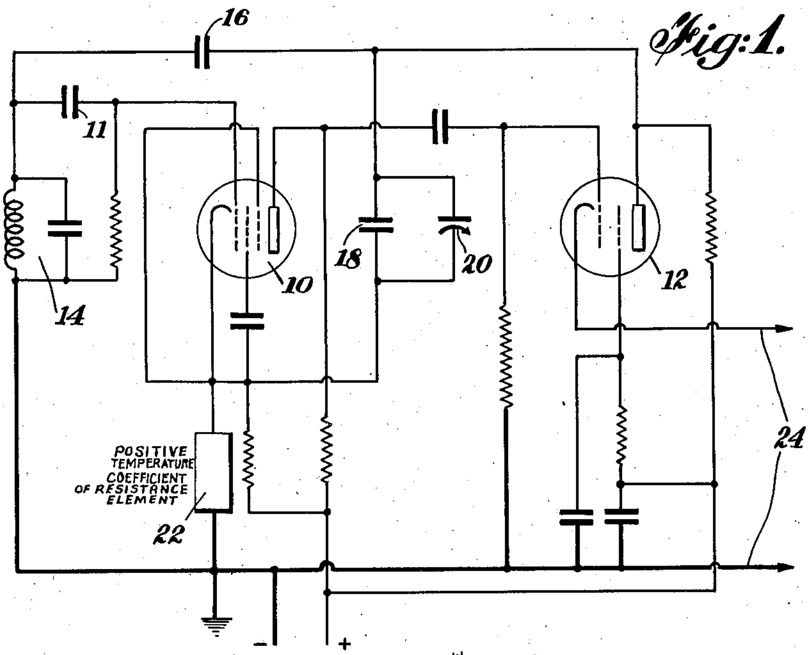


Fig:4.

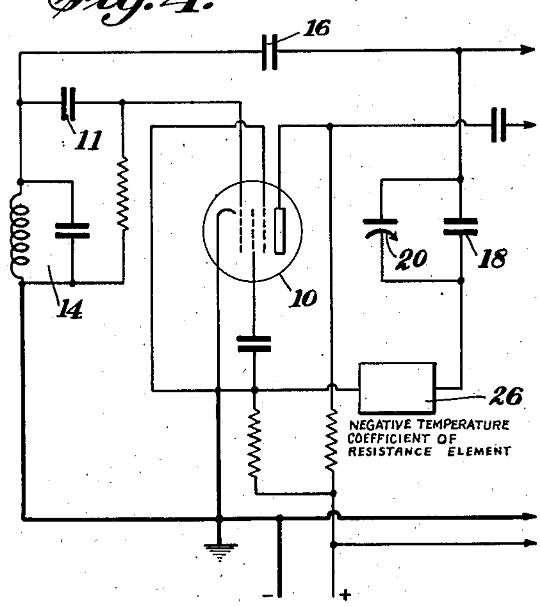


Fig:2.

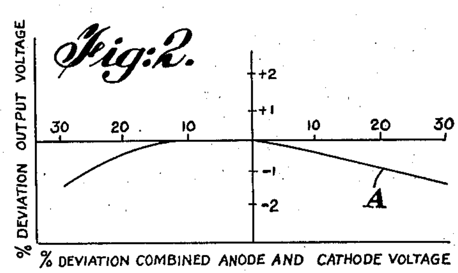
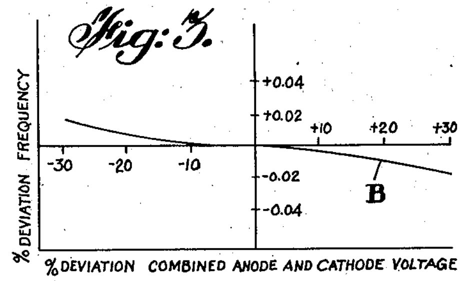


Fig:3.



INVENTORS
CLARE M. RIFENBERGH
CLIFFORD A. SHANK

BY

ATTORNEY

Patented Feb. 5, 1946

2,394,018

UNITED STATES PATENT OFFICE

2,394,018

VACUUM TUBE OSCILLATOR

Clifford A. Shank, Jackson Heights, and Clare M. Rifenbergh, Great Kills, Staten Island, N. Y., assignors to Federal Telephone and Radio Corporation, Newark, N. J., a corporation of Delaware

Application April 24, 1943, Serial No. 484,794

4 Claims. (Cl. 250—36)

This invention relates to improvements in vacuum tube oscillators, and more particularly to oscillators of the negative resistance type.

Vacuum tube oscillators of the negative resistance type have long been known for the generation of relatively low frequencies, for example, audio frequencies up to about 20,000 cycles. It is also known to use a two-stage resistance-capacitance coupled amplifier of this type with positive and negative feedback together with a ballast resistor in the negative feedback circuit for the purpose of stabilizing the amplitude of the oscillations despite changes in input voltage, variable circuit parameters, supply voltage and tube characteristics. Such an oscillator has been proposed, for example, by Terman et al., in the Proceedings of the I. R. E. (1939). However, none of these oscillators are adapted for operation at high frequencies and tests have shown that when it is attempted to produce high frequency oscillations with these known circuits they are extremely unstable.

It is an object of our invention to provide an improved vacuum tube oscillator of the negative resistance type which is adapted to operate at much higher frequencies than comparable oscillators, while at the same time having optimum frequency stability characteristics.

A further object of this invention is the provision of a high frequency vacuum tube oscillator which is characterized by a high frequency stability despite wide variations in circuit parameters including fluctuations in anode and cathode supply voltages.

We attain these objects for the arrangement shown by way of example in the annexed drawing, wherein:

Fig. 1 is a circuit diagram of a preferred form of high frequency vacuum tube oscillator according to the present invention;

Figs. 2 and 3 are graphs illustrating output voltage and frequency stability with respect to fluctuations in anode and cathode supply voltage according to our present invention; and

Fig. 4 is a partial circuit diagram illustrating a modified illustration of our invention.

In Fig. 1 we have illustrated a two-stage resistance coupled amplifier of generally known principles adapted, in accordance with the present invention to produce stable high frequency oscillations. The circuit includes a first vacuum tube 10 preferably of the pentode type coupled to a second amplifier tube 12, preferably of the tetrode type. The frequency at which the oscillator is adapted to work is determined by the constants of the tank circuit 14 feeding the control grid of the first tube 10 over the coupling condenser 11. Regeneration is obtained by a first positive feedback circuit leading from the anode of the tube 12 back to the grid of the tube 10 through a condenser 16, while a second negative feedback circuit independent of the first feedback is connected from the anode of the tube 12 to the cathode of the tube 10. This second negative feedback circuit includes a main condenser 18 shunted by a variable padding condenser 20 by which the phase shift in the negative feedback circuit can be properly adjusted and the circuit as a whole correlated with the constants of the tank circuit 14. The screen and suppressor grids of the pentode 10 and the screen grid of the tetrode 12 are connected in the usual manner. A device 22 such as a resistor having a positive temperature coefficient is connected in the cathode circuit of the tube 10 and works in conjunction with the negative feedback circuit through condensers 18 and 20 in such a manner that an increase in the amplitude of oscillations raises the current through the negative feedback circuit and through the device 22, resulting in an increase in resistance of the device 22 and thus increases the inverse feedback effect on the tube 12. Increase of feedback decreases the voltage amplification of the amplifier and thus tends to reduce the amplitude of oscillations. Thus, for example, if the cathode or anode voltage increases, tending to increase the amplitude of oscillations produced in the output circuit 24 of the tube 12, this undesired effect will be compensated for by a resultant decrease in amplification corresponding to the increase in feedback current and increase in the resistance of the device 22. Naturally, a decrease in cathode or anode voltages will have a reverse effect so that the final result is to produce an oscillator which is extremely stable. It will be noted, for example, that as compared with prior oscillators of a similar type, provision is made to correctly phase the feedback, an important consideration when operating at high frequency, while the positive and negative feedback circuits are independent of one another.

Actual tests of the oscillator illustrated in Fig. 1, indicate that the results desired are obtained. For example at a frequency of 400 k. c., the output voltage does not vary much more than 1.5% for combined anode and cathode voltage deviations up to plus or minus 30% as can be seen in Fig. 2. For negative voltage changes up to minus 10% no measurable change in output voltage results, while positive voltage changes of over 20% result in only a 1% reduction in the output voltage.

The frequency stability is also extremely high. For a combined anode and cathode voltage deviation of minus 30%, the frequency will only increase .02% while for a combined anode and cathode voltage deviation of plus 30%, the frequency deviation is only minus .02%. For smaller deviations of anode and cathode voltage, the frequency deviation is even less, as can be seen from the operating curve illustrated in Fig. 3.

Substantially the same results can be obtained by the arrangement illustrated in Fig. 4 where, in place of utilizing the increased voltage drop across a positive temperature coefficient resistor, a resistor or other device **26** having a negative temperature coefficient is serially inserted in the negative feedback circuit. The remaining elements of the circuit, including the tank circuit **14**, the condensers **16**, **18** and **20**, and the second amplifier, will remain the same as in the form of invention illustrated in Fig. 1.

While we have described above the principles of our invention in connection with certain specific circuits, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of our invention as set forth in the objects and the accompanying claims.

We claim:

1. An oscillator including, in combination, a tank circuit having a predetermined oscillating frequency, a first electron discharge device having an anode, a cathode and a grid, means for connecting one side of said tank circuit to the grid of said electron discharge device, an amplifier including a second electron discharge device having an anode, a cathode and a grid, an output circuit connected to said second amplifier, said output circuit including a lead common to the other side of said tank circuit and the cathode of said first electron discharge device, means coupling the anode of said first electron discharge device to the grid of the second electron discharge device, a first feedback circuit including a first condenser connected between the anode of said second electron discharge device and the grid of said first electron discharge device, a second feedback circuit independent of said first feedback circuit, including condenser means connected between the anode of said second electron discharge device and the cathode of said first electron discharge device, and resistor means having a predetermined temperature coefficient, connected to said cathode and responsive to changes in the amplitude of oscillations in said amplifier, for varying the amount of feedback through said second feedback circuit.

2. The combination according to claim 1, in which said last means comprises a resistor having a positive temperature coefficient, connected between the junction of the second feedback circuit with the cathode of said first electron discharge device and said common lead.

3. The combination according to claim 1, in which said last means comprises a resistor having a negative temperature coefficient, serially connected said second feedback circuit.

4. The combination according to claim 1, in which said condenser means includes a fixed condenser and a variable padder condenser connected in shunt therewith for correlating said second feedback circuit with said tank circuit.

CLIFFORD A. SHANK.
CLARE M. RIFENBERGH.