

March 1, 1938.

W. J. POCH ET AL

2,109,752

OSCILLATOR

Filed Aug. 29, 1935

FIG. 1.

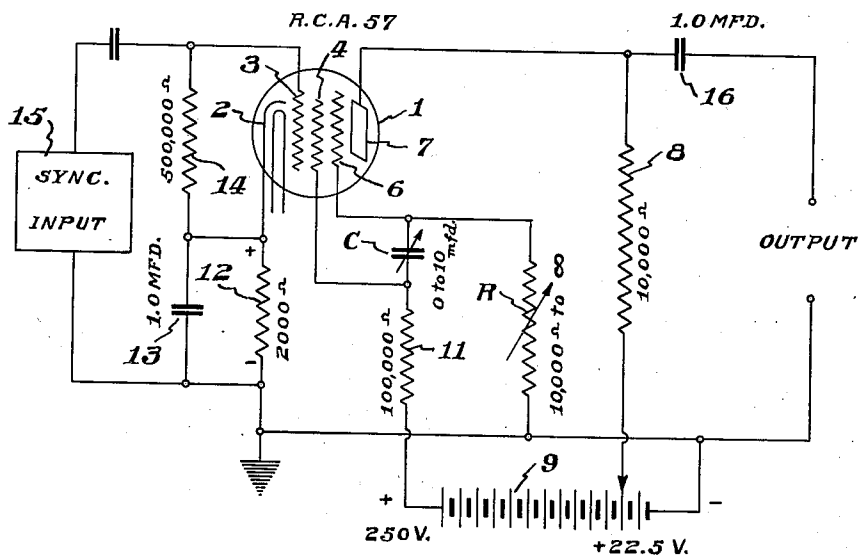
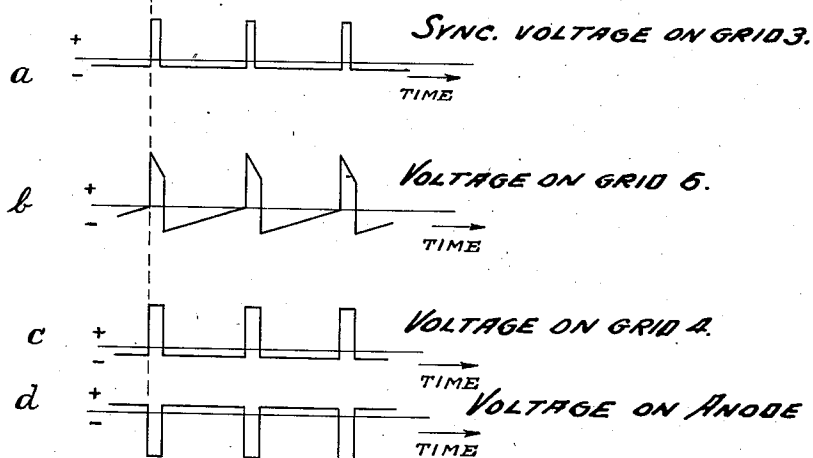


FIG. 2.



Witness

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OSCILLATOR

2,109,752

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Application August 29, 1935, Serial No. 38,426

3 Claims. (Cl. 250—36)

Our invention relates to oscillators and particularly to oscillators of the relaxation type.

One form of relaxation oscillator is described by Balh. van der Pol in the "Phil. Mag. and Jour. of Science" for November, 1926. This oscillator comprises a double-grid vacuum tube connected in a circuit including only resistance and capacity, the frequency of oscillation being determined largely by the time constant of a portion of the circuit.

An object of our invention is to provide an improved oscillator of the general type described in the above-mentioned article.

A further object of our invention is to provide an improved relaxation oscillator which may be readily synchronized.

In a preferred embodiment of our invention we employ a vacuum tube of the pentode type such as an RCA—57. The inner grid, which will be referred to as the control grid, is utilized as a synchronizing electrode. The remaining electrodes correspond to those in the tube employed by van der Pol.

Other objects, features and advantages of our invention will appear from the following description taken in connection with the accompanying drawing in which

Fig. 1 is a circuit diagram of one embodiment of our invention, and

Fig. 2 is a group of curves which are referred to in explaining the operation of the circuit shown in Fig. 1.

Referring to Fig. 1, the oscillator comprises a vacuum tube 1 of the pentode type having a cathode 2, a control grid 3, a screen grid 4, a suppressor grid 6, and an anode 7. In a tube of this type the control grid 3 is the inner grid and is positioned next to the cathode 2. The suppressor grid 6 is positioned next to the anode 7 while the screen grid is positioned between the other two grids.

The anode 7 is supplied through a resistor 8 with a low positive voltage from any suitable source such as a battery 9. The screen grid 4 is supplied through a resistor 11 with a comparatively high positive voltage from a suitable source such as the battery 9.

The cathode 2 is connected to ground through a self-biasing resistor 12 which is preferably shunted by a condenser 13. Usually, however, satisfactory operation of the oscillator may be obtained with the condenser 13 omitted.

The suppressor grid 6 is connected to the grounded end of the self-bias resistor 12 through a variable resistor R whereby the suppressor grid

is biased negatively with respect to the cathode. A variable condenser C is connected between the suppressor grid 6 and the screen grid 4, this condenser and the variable resistor R being the two elements which largely determine the frequency of oscillation. By varying either R or C, the frequency at which the oscillator oscillates in the absence of a synchronizing signal may be varied.

The control grid 3 may be maintained at substantially zero bias by means of a connection to the cathode 2 through a grid resistor 14. If desired, the amplitude of oscillation may be decreased by applying a negative bias to the control grid. Synchronizing impulses may be applied either directly across the grid resistor 14 or across both the grid resistor 14 and self-biasing resistor 12 from any suitable source 15 as indicated in the drawing.

The synchronizing impulses may be of the character indicated by the curve (a) in Fig. 2, this curve representing the synchronizing voltage on the control grid 3. Curves (b), (c) and (d) in Fig. 2 represent the voltages appearing on the suppressor grid 6, the screen grid 4 and the anode 7, respectively, at the time the synchronizing impulses (a) are impressed upon the control grid 3. The curves in Fig. 2 are for the condition of 10,000 impulses per second with C=25 micro-microfarads and R=3 megohms.

The plate resistor 8 and output coupling condenser 16 serve only to utilize the impulses in the plate circuit and are not necessary for the generation of oscillations.

The circuit constants indicated on the drawing in ohms and microfarads and volts are given merely by way of example. With the elements C and R variable through the ranges indicated, the oscillator can be made to produce impulses occurring anywhere from 1 impulse in several seconds to 200,000 impulses per second. The smaller the capacity of C is made, the less charge it will take and the narrower the plate negative impulse will become.

One characteristic of our oscillator which should be mentioned is that, in general, the suppressor grid must be biased negatively, and the positive screen grid voltage should be higher than the plate voltage in order to obtain oscillations. Of course, this suppressor grid bias may be obtained from a biasing source such as a battery instead of from the self-biasing resistor 12 shown in the drawing.

It is believed that the operation of the oscillator may be explained as follows: Consider elec-

trode 4 as a positive electrode of grid-like structure, electrode 6 as a control grid, and electrode 2 as the cathode. The effect of the first or inner grid 3 may be neglected for the moment. Most of the electrons emitted at the cathode 2 will pass to the positive electrode or inner plate 4 but, since it has a grid-like structure, some of the electrons will pass through it and start toward the outermost plate or electrode 7 which is at a lower positive voltage than the electrode 4. The grid 6 with its negative charge, will repel some of the electrons which will be turned and attracted to the more positive electrode 4. As the grid 6 is made less negative, it will repel less electrons to the electrode 4, and permit more to pass to the outer plate electrode 7. That is, plate 7 takes more current away from electrode 4.

Thus, we have a circuit with a negative resistance characteristic in which increased positive or less negative charges on the control grid 6 cause decreased current in the circuit of electrode 4 since the total number of electrons supplied by the cathode remains substantially constant. Decreased current flowing through the resistor 11 will increase the positive potential on inner plate 4. The instantaneous increased positive potentials, if fed back to the control grid 6, will be in phase to sustain oscillations. The capacity C connected between the inner plate 4 and outer control grid 6 is all that is required to feed back properly phased potentials. The positive potential of the outer electrode 7 must not be made so high that the outer control grid 6 will have little effect on the electronic currents flowing to the outer plate 7. The outer control grid 6 must turn back a substantial quantity of electrons to use efficiently the negative resistance characteristic just described.

One benefit derived from the use of a third grid electrode is that the frequency stability of the oscillator is improved. The main advantage, however, in using a third grid as described is that it serves as a very sensitive synchronizing electrode. As an example of the ease with which the oscillator may be synchronized, if a 1000 cycle per second sine wave having a voltage of 0.1 volt R. M. S. is applied to the control grid 3 when the idle impulse frequency is 500 impulses per second, the oscillator frequency is raised to synchronism. Furthermore, the idle impulse frequency can be "dragged downward" to synchronism with nearly as much ease.

Since our improved oscillator readily synchronizes on harmonics and subharmonics of a weak exciting or synchronizing voltage, it is valuable for use in frequency multiplication and division.

It will be understood that various modifications may be made in our invention without departing from the spirit and scope thereof, and we desire, therefore, that only such limitations shall be

imposed thereon as are necessitated by the prior art and are set forth in the appended claims.

We claim as our invention:

1. A relaxation oscillator comprising a vacuum tube having a cathode, a control grid, a screen grid, a suppressor grid and an anode, a circuit between said cathode and said anode consisting of a resistor and a source of voltage in series, said source being so poled as to apply a positive voltage to said anode, a circuit between said cathode and said screen grid consisting of a resistor and a source of potential in series, said second source being so poled as to apply a positive voltage to said screen grid, a circuit between said cathode and said suppressor grid consisting of a resistor and a third source of potential, said third source being so poled as to apply a negative potential to said suppressor grid, a condenser connected between said screen grid and said suppressor grid, and a grid resistor connected between said control grid and said cathode, the voltage of said second source being substantially greater than the voltage of said first source.

2. In combination, a relaxation oscillator comprising a vacuum tube having a cathode, a first grid, a second grid, a third grid and an anode located in the order named, a non-reactive anode circuit including means for applying a positive potential to said anode, a circuit between said cathode and said second grid consisting of a resistor and a source of potential in series, said source being so poled and its potential being such as to apply a positive potential to said second grid which has a greater magnitude than the potential applied to said anode, a substantially purely resistive circuit connected between said cathode and said third grid, a condenser connected between said second grid and said third grid, a source of periodic synchronizing voltage, and means for applying said synchronizing voltage to said first grid.

3. In combination, a relaxation oscillator comprising a vacuum tube having a cathode, a first grid, a second grid, a third grid and an anode located in the order named, a non-reactive anode circuit including means for applying a positive potential to said anode, a circuit between said cathode and said second grid consisting of a resistor and a source of potential in series, said source being so poled and its potential being such as to apply a positive potential to said second grid which has a greater magnitude than the potential applied to said anode, a substantially purely resistive circuit connected between said cathode and said third grid, a condenser connected between said second grid and said third grid, and a grid resistor connecting said first grid to said cathode.

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DISCLAIMER

2,109,752.—*Waldemar J. Poch*, Collingswood, *Ciro C. Martinelli*, West Collingswood, and *Alfred H. Turner*, Collingswood, N. J. OSCILLATOR. Patent dated March 1, 1938. Disclaimer filed March 23, 1940, by the assignee, *Radio Corporation of America*.

Hereby enters this disclaimer to claim 1 in said specification.
[*Official Gazette April 16, 1940.*]