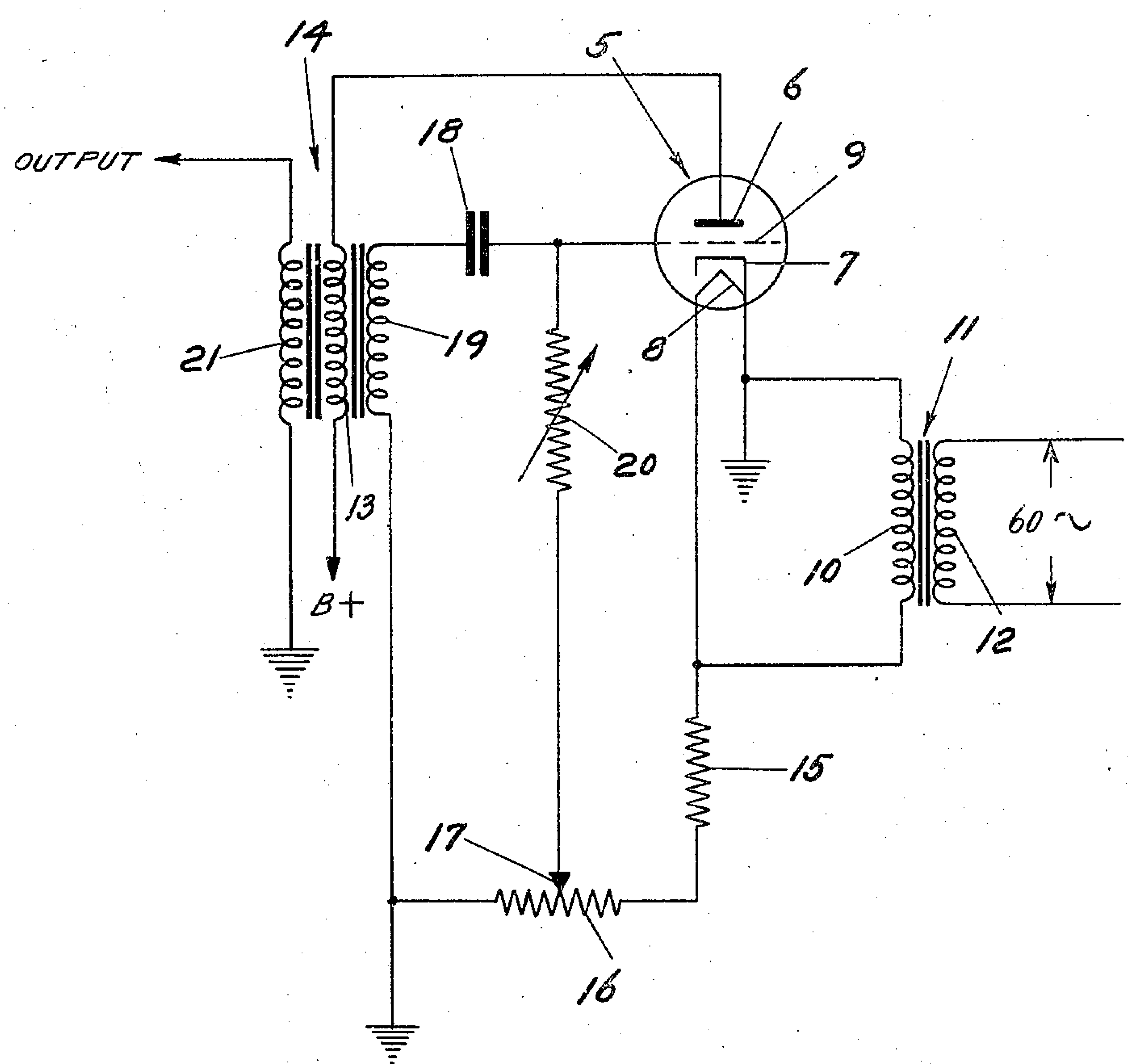
Oct. 25, 1949. T. A. O. GROSS 2,486,021

OSCILLATOR

Filed Feb. 28, 1945



INVENTOR.
THOMAS A. O. GROSS,
BY Elmer J. Gorn
ATTY.

Patented Oct. 25, 1949

2,486,021

UNITED STATES PATENT OFFICE

2,486,021

OSCILLATOR

Thomas A. O. Gross, Waltham, Mass., assignor to Raytheon Manufacturing Company, Newton, Mass., a corporation of Delaware

Application February 28, 1945, Serial No. 580,213

5 Claims. (Cl. 250—36)

1

My present invention relates to relaxation oscillators, and more particularly to means for frequency modulating such oscillators.

By the term "relaxation oscillators," I mean to include any circuit for generating a periodic wave which, for fixed values of applied voltage and circuit parameters, has two stable conditions of equilibrium, abruptly changing from one to the other at a repetition frequency which is an inverse function of the time-constant of a resistance-capacitance network constituting a component of the circuit. Blocking oscillators, multivibrators, flip-flop circuits, transitrons, and gas-tube relaxation circuits are examples of the type of oscillators to which I have reference.

Various of these circuits, or modifications thereof, are utilized, for example, to generate the audio-frequency keying pulses in radar systems of the so-called pulse-echo type. In such systems, there is a critical maximum pulse rate above which, depending upon the range limits within which it is desired to detect targets, the system will not function. On the other hand, a loss of average power is suffered if the pulse rate is low, and it is, therefore, desirable to utilize as high a pulse rate as is consistent with the detecting range of the system. Furthermore, where a number of radar installations, employing the same repetition frequency, are located in the same general vicinity, interference with each other is difficult to avoid.

For both of these reasons, it is desirable to frequency modulate the repetition rates of such systems; but, in so doing, care must be taken that over-modulation does not occur, for if it does, the above referred to critical maximum pulse rate may be exceeded. In addition, it is desirable that the modulating system be such that, when it is disconnected from the oscillator, the unmodulated or free-running pulse rate of such oscillator be the maximum possible for the installation.

It is, therefore, an object of my present invention to provide a simple frequency-modulating system for relaxation oscillators which is so designed that, after the oscillator, in its free-running condition, has been adjusted to operate at a selected maximum frequency, the introduction of the frequency modulation will not result in over-modulation, in other words, not result in exceeding said maximum frequency.

It is a further object of my present invention to provide a frequency-modulating system for relaxation oscillators which, when disconnected, permits the free-running oscillator to return to its selected maximum frequency without further adjustment.

2

These and other objects of my present invention, which will become more apparent as the detailed description progresses, are attained, broadly, in the following manner:

As above indicated, the frequency of the type of oscillator which I desire to frequency modulate is determined by the time-constant of an R.-C. network. Said time-constant is initially adjusted so that the free-running frequency of said oscillator is, let us say, a certain maximum. Now, in introducing the modulating energy, I employ means, preferably, in the form of a variable voltage divider connected across the source of said modulating energy, which, as the magnitude of the injected energy is varied, alters the time-constant of said R.-C. network in direct proportion. As a result, the tendency of the frequency, for example, to increase as the magnitude of the injected modulation is increased, is counteracted by the simultaneous increase in said time-constant, and vice versa. By such means, over-modulation is prevented, and when the source of modulating energy is disconnected from the circuit, the oscillator returns to its pre-selected, free-running frequency without further adjustment by the operator.

In the accompanying specification I shall describe, and in the annexed drawing show, an illustrative embodiment of the frequency-modulated relaxation oscillators of my present invention. It is, however, to be clearly understood that I do not wish to be limited to the details thereof herein shown and described for purposes of illustration only, inasmuch as changes therein may be made without exercise of invention and within the true spirit and scope of the claims hereto appended.

In said drawing, the single figure is a schematic diagram of a relaxation oscillator, incorporating means for frequency modulating the repetition rate thereof, assembled in accordance with the principles of my present invention.

Referring now more in detail to the aforesaid illustrative embodiment of my present invention, and with particular reference to the drawing, the numeral **5** generally designates a vacuum tube which, in the specific embodiment to be described, is a triode having an anode **6**, a cathode **7**, a heating filament **8**, and a control grid **9**.

The filament **8** may be supplied with heating current from the secondary **10** of a filament transformer **11** whose primary **12** may be connected across, for example, a source of 60-cycle alternating current. One end of the secondary 10 is grounded, as shown.

The anode 6 of the tube 5 is connected, through the winding 13 of a coupling transformer 14, to the positive terminal of a source of B voltage, the other terminal of said source (not shown) being conventionally grounded.

Connected in series, across the secondary 10 of the transformer 11, are two resistors 15 and 16, the former having for its purpose, current-limiting, and the latter constituting a voltage divider, and having a variable tap 17 by means of which the magnitude of the drop taken across the same may be varied at will.

The grid 9 of the tube 5 is connected, through a capacitor 18 and another winding 19 on the transformer 14, to the ground end of the resistor 16, and the junction between said grid 9 and said capacitor 18 is connected to one end of a variable resistor 20. The other end of said variable resistor 20 is connected to the variable tap 17 on the resistor 16.

The circuit is completed by an output winding 21 on the transformer 14.

It will be noted that the circuit shown and described is, essentially, a blocking oscillator whose repetition frequency is an inverse function of the time-constant of the network including, primarily, the resistor 20 and capacitor 18. Now, in a standard blocking oscillator, the current-limiting resistor 15 and voltage divider, comprised of the resistor 16 and its associated variable tap 17, are not present, the variable resistor 20 being returned to the cathode 7 via ground. However, in the present circuit, I utilize said voltage divider to introduce therein the modulating energy, and control the time-constant thereof.

While the modulating energy can be obtained from any desired source, I prefer to utilize the 60-cycle A. C. employed to heat the filament 8 of the tube 5. It will be noted that the voltage divider 16, 17 is across the transformer secondary 10 and, therefore, is fed from said 60-cycle A. C. Hence, by adjusting the tap 17, a selected portion of the modulating energy may be applied between the grid 9 and cathode 7 of the tube 5, altering the bias on said tube, and, therefore, the repetition rate of the oscillating circuit including the same.

It will also be noted that the selected portion of the resistor 16, across which the modulating energy being fed to the circuit is developed, is a part of the R.-C. network between the grid 9 and cathode 7. Therefore, as said selected portion is enlarged to apply greater modulating energy, the resistance in the R.-C. network is increased in direct proportion, thereby increasing the time-constant of said R.-C. network and counteracting the frequency-increasing effect of the greater modulating energy.

In operation, the tap 17 is initially grounded, and the resistor 20 adjusted to obtain a desired maximum repetition rate. The tap 17 is then moved away from ground to simultaneously introduce modulating energy and increase the time-constant of the R.-C. network.

It will thus be seen that I have provided a means for frequency modulating a relaxation oscillator without danger of over-modulation, and it will also be seen that, upon disconnecting the modulating energy from the circuit, as by returning the tap 17 to ground, the oscillator automatically returns to the free-running repetition rate to which it was initially adjusted by means of the variable resistor 20.

Other advantages of the circuit of my present invention will readily occur to those skilled in the art to which the same relates.

What is claimed is:

1. In combination with a relaxation oscillator whose repetition frequency is an inverse function of the time-constant of a resistance-capacitance network, means for frequency modulating said oscillator comprising: a source of modulating voltage; and means for applying a selected portion of said modulating voltage to the input circuit of said oscillator and to said resistance-capacitance network; said means being adjustable whereby the magnitude of the selected portion of the modulating voltage so applied, and the time-constant of said resistance-capacitance network are simultaneously variable in direct proportion to each other.

2. In combination with a relaxation oscillator whose repetition frequency is an inverse function of the time-constant of a resistance-capacitance network, means for frequency modulating said oscillator comprising: a source of modulating voltage; and a variable voltage divider, connected across said source of modulating voltage, for applying a selected portion thereof to the input circuit of said oscillator, in series with said resistance-capacitance network; the adjustment of said voltage divider simultaneously varying, in direct proportion to each other, the magnitude of the modulating voltage applied to said oscillator, and the time-constant of said resistance-capacitance network.

3. In combination with an oscillator circuit including an electron-discharge device having an anode, an electron-emitting cathode, and a control grid, a source of voltage connected between said anode and cathode, a resistance-capacitance network connected between said grid and said cathode, and a coupling device between said anode-cathode circuit and said grid-cathode circuit, whereby relaxation oscillations are obtained whose repetition frequency is an inverse function of the time-constant of said resistance-capacitance network, means for frequency modulating said oscillator circuit comprising: a source of modulating voltage; and means for applying a selected portion of said modulating voltage between said grid and said cathode, in series with said resistance-capacitance network; said means being adjustable whereby the magnitude of the selected portion of the modulating voltage so applied, and the time-constant of said resistance-capacitance network, are simultaneously variable in direction proportion to each other.

4. In combination with an oscillator circuit including an electron-discharge device having an anode, an electron-emitting cathode, and a control grid, a source of voltage connected between said anode and cathode, a resistance-capacitance network connected between said grid and said cathode, and a coupling device between said anode-cathode circuit and said grid-cathode circuit, whereby relaxation oscillations are obtained whose repetition frequency is an inverse function of the time-constant of said resistance-capacitance network, means for frequency modulating said oscillator circuit comprising: a source of modulating voltage; and a variable voltage divider, connected across said source of modulating voltage, for applying a selected portion thereof between said grid and

said cathode, in series with said resistance-capacitance network; the adjustment of said voltage divider simultaneously varying, in direct proportion to each others, the magnitude of the modulating voltage applied between said grid and said cathode, and the time-constant of said resistance-capacitance network.

5. A frequency-modulated relaxation oscillator comprising: an electron-discharge device having an anode, an electron-emitting cathode, and a control grid; a source of unidirectional voltage connected between said anode and said cathode; a source of alternating voltage; a resistor connected across said source of alternating voltage; a resistance-capacitance network connected, in series with a selected portion of said resistor, between said grid and said cathode; and a coupling device connected between said anode-cathode circuit and said grid-cathode circuit; variation of the selected portion of said resistor simultaneously altering, in direct proportion to each other, the magnitude of the alternating voltage applied between said grid and said cathode, and the time-constant of said resistance-capacitance network.

THOMAS A. O. GROSS.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
Re. 20,338	Tolson	Apr. 20, 1937
2,292,835	Hepp	Aug. 11, 1942
2,323,596	Hansell	July 6, 1943
2,358,297	Bedford	Sept. 19, 1944
2,424,274	Hansell	July 22, 1947

Certificate of Correction

Patent No. 2,486,021

THOMAS A. O. GROSS

October 25, 1949

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 4, line 58, for the word "direction" read *direct*; column 5, line 4, for "others" read *other*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of February, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.