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2,623,954

ELECTRON DISCHARGE TUBE AMPLIFIER FOR SIGNAL VOLTAGES

Filed March 16, 1948

Fig. 1.

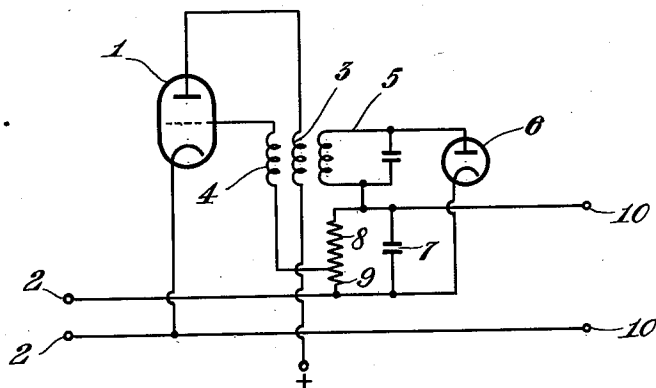


Fig. 2.

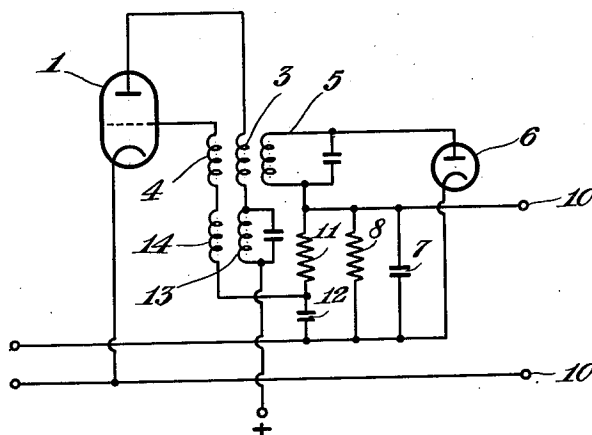
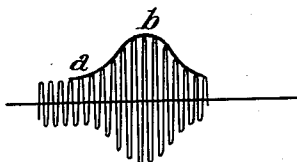


Fig. 3a.



Fig. 3b.



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UNITED STATES PATENT OFFICE

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ELECTRON DISCHARGE TUBE AMPLIFIER
FOR SIGNAL VOLTAGES

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4 Claims. (Cl. 179—171)

1

The invention relates to an improvement in or modification of the invention described and claimed in copending application Serial No. 684,071, filed July 16, 1946. In the said application, now issued as Patent No. 2,554,132, on May 22, 1951, there is described a circuit arrangement for amplifying electrical oscillations with the aid of electric discharge tubes, the ratio between the output and the input voltages of the amplifier (amplification factor) having a constant or substantially constant value.

In the above referred to application there is described a circuit arrangement for amplifying electrical oscillations with the aid of discharge tubes, the circuit self-oscillating at a frequency which is outside the frequency range of the oscillations to be amplified. From these oscillations there is derived, by detection, a control voltage, by means of which the amplification factor is kept substantially constant.

The invention relates to a variant of the circuit arrangement of the type above described and which exhibits favourable characteristics with respect to the amplification factor.

According to the invention, the amplified voltage is derived from the said auxiliary-frequency oscillations. The value of at least one of the alternating control-grid voltages of one of the oscillator discharge tubes, a value which varies in accordance with the oscillation to be amplified, is determined on the one hand by the input signal voltage and on the other hand by the said control-voltage.

In order that the invention may be more clearly understood and readily carried into effect, it will now be described more fully with reference to the accompanying drawing, in which:

Fig. 1 shows one embodiment of a circuit arrangement according to the invention,

Fig. 2 shows another embodiment of a circuit arrangement according to the invention,

Fig. 3a shows the input signal, and

Fig. 3b shows the modulated oscillations developed in the circuits of Figs. 1 and 2.

Referring to Fig. 1, 1 designates an electric discharge tube, with the aid of which the voltage fed to input terminals 2 is amplified with a substantially constant amplification factor. The anode circuit of the tube 1 includes a primary 3 of a transformer, a secondary 4 of which is connected to the grid of the discharge tube 1. The coupling between windings 3 and 4 provides regenerative feedback so that the circuit will tend to self-oscillate at a frequency which is determined by a tuned circuit 5 coupled to the inductance 3. The oscillations set up across the cir-

2

cuit 5 are detected with the aid of a detector 6, the output circuit of which comprises a smoothing filter 7, 8 constituted by a capacity 7 and a resistance 8. The grid of the discharge tube 1 has a bias voltage which is determined, on the one hand, by the signal voltage which is fed to terminals 2 and, on the other hand, by the voltage set up across a portion 9 of the resistance 8. The amplified voltage is developed across the resistance 8 and obtained from output terminals 10.

The circuit-arrangement operates as follows:

If, on the basis of a definite setting at which an alternating voltage of given frequency is developed across the circuit 5, the voltage fed to the input terminals 2 increases slightly, the equilibrium required for self-oscillation is upset. This is due to the fact that the tube shifts to another operating point associated with a steeper slope. This results in an increase in amplitude of the generated oscillation, so that the voltage developed across the smoothing filter 7, 8 of the detector 6 is also increased. For self-oscillation the effective mutual conductance of tube 1 should have a constant value determined by the coupling of feedback windings 3, 4. The amplitude of the oscillations produced will thus be increased to such an extent that there is developed across the portion 9 of resistance 8 an increased voltage. This increase in voltage is substantially equal and opposite to the increase of the input signal voltage. Since the voltage set up across the portion 9 of resistance 8 is a small part of the voltage set up across the entire resistance 8, an amplified voltage will thus be obtained from the terminals 10, the value of the amplification factor being equal to the ratio between the entire resistance 8 and the portion 9.

An amplifier of this kind provides a constant, approximately 300 fold amplification, the amplification being limited by the parameters of the tube. It is found that the variation of mutual conductance of the tube as a function of the control-grid voltage should be high, and a higher amplification is realized as the frequency of the auxiliary oscillation is increased with respect to the frequency of the oscillations to be amplified.

Fig. 2 shows a circuit arrangement, in which the amplification factor can be increased to a materially higher extent and in which the degree of constancy is slightly less satisfactory.

In this circuit arrangement, in which the same reference numerals are used as in the circuit arrangement shown in Fig. 1, the detected oscillation is developed across the smoothing filter 7, 8 of detector 6. The output voltage is derived from the detected oscillation and is applied to a low-

pass network 11, 12, which comprises a large resistance 11 and a condenser 12 by which the frequencies of the oscillation to be amplified are decoupled.

Owing to a small variation of the voltage fed to the terminals 2, this voltage variation will be fed through the decoupling condenser 12 directly to the grid of the tube 1. Hence, starting with a definite state of equilibrium, a small increase in input voltage will lead to a constant increase in amplitude of the self-oscillating auxiliary oscillation. If the input voltage then retains its old value, the oscillation produced will continue to self-oscillate with an amplitude corresponding to the value thus attained.

This procedure is illustrated in Fig. 3a, which shows the input oscillation, and in Fig. 3b, which shows the oscillation produced across the circuit 5. At the instant *a*, at which the input voltage increases from its equilibrium value, the oscillation produced will increase more and more in such manner that the amplitude of this oscillation is, to a first approximation, proportional to the period of time and to the increase in input voltage. This increase in amplitude continues up to the instant *b* at which the input voltage regains its value associated with the state of equilibrium. Due to the decrease in input voltage below this value, the generated oscillation will then be damped, and so forth. The voltage set up across the output terminals 10 is thus proportional to the integral of the input voltage fed to the terminals 2.

The amplification is increased to a high extent and may even attain a value of, for example, 10,000 by providing a feedback circuit 13, 14 for the signal oscillations which, if desired, is tuned to the central frequency of these oscillations. Although in this case the amplification factor is not as constant as that achieved with the circuit-arrangement shown in Fig. 1, it is reasonably satisfactory, since the direct voltage set up across the condenser 12 acts to control the grid voltage of the tube 1 so that this tube is always adjusted so as to be in a region of constant slope determined by the feedback 3, 4.

This circuit arrangement is found to yield an amplification factor which increases as the percentage slope variation is greater and, as pointed out hereinbefore, it is found to exhibit a characteristic curve which is inversely proportional to the frequency of the low-frequency signal.

It is obvious that the triode 1 shown in the figures may be replaced, for example, by a pentode or by a multi-tube circuit, the signal voltage being fed to the same or to different grids respectively. The voltage set up across the resistance 9 or the condenser 12 respectively is also fed to the same or to one of the other grids of these tubes respectively. The network 11, 12 may furthermore, be proportioned so as to ensure particularly favourable properties with respect to given frequencies to be amplified.

What I claim is:

1. A circuit arrangement for amplifying an input signal voltage in a given range of frequencies, comprising an electron discharge tube having cathode, grid and anode electrodes, feedback means intercoupling said anode and grid electrodes in regenerative relationship to produce an oscillation having a frequency outside of said range of frequencies, means to apply said input signal voltage to the grid electrode of said discharge tube to vary the gain of said discharge tube thereby to vary the amplitude of said oscillation

as a function of the amplitudes of said signal voltage, rectifying means coupled to said anode electrode to derive from said variable amplitude oscillation a potential varying in amplitude depending on the amplitude of said variable amplitude oscillation, and means to apply a portion of said potential to the grid electrode of said discharge tube to vary the gain of said tube in a sense opposite to the variations thereof produced by said input signal voltage.

2. A circuit arrangement for amplifying an input signal voltage in a given range of frequencies, comprising an electron discharge tube having cathode, grid and anode electrodes, feedback means intercoupling said anode and grid electrodes in regenerative relationship to produce an oscillation having a frequency outside of said range of frequencies, means to apply said input signal voltage to the grid electrode of said discharge tube to vary the gain of said discharge tube thereby to vary the amplitude of said oscillation as a function of the amplitude of said signal voltage, rectifying means to derive from said variable amplitude oscillation a potential varying in amplitude depending on the amplitude of said variable amplitude oscillation comprising a detector for said oscillation coupled to the anode electrode of said discharge tube and a load impedance coupled to said detector, and means to apply a portion of the potential across said load impedance to the grid electrode of said discharge tube to vary the gain of said tube in a sense opposite to the variations thereof produced by said input signal voltage.

3. A circuit arrangement for amplifying an input signal voltage in a given range of frequencies, comprising an electron discharge tube having cathode, grid and anode electrodes, transformer means intercoupling said grid and anode electrodes in regenerative relationship to produce an oscillation having a frequency outside of said range of frequencies, means to apply said input signal voltage to the grid of said discharge tube to vary the gain of said discharge tube thereby to vary the amplitude of said oscillation as a function of the amplitude of said signal voltage, rectifying means to derive from said variable amplitude oscillation a potential varying in amplitude depending on the amplitude of said variable amplitude oscillation comprising a rectifier for said oscillation and a load impedance element coupled to said rectifier, a low-pass network coupled to said load impedance, and means coupled to said low-pass network to apply a portion of the potential across said load impedance to the grid of said discharge tube to vary the gain of said tube in a sense opposite to the variations thereof produced by said input signal voltage.

4. A circuit arrangement for amplifying an input signal voltage in a given range of frequencies, comprising an electron discharge tube having cathode, grid and anode electrodes, first transformer means intercoupling said grid and anode electrodes in regenerative relationship to produce an oscillation having a frequency outside of said range of frequencies, second transformer means tuned to the frequency of said input signal voltage intercoupling said grid and anode electrodes in regenerative relationship, means to apply said input signal voltage to the grid electrode of said discharge tube to vary the gain of said discharge tube thereby to vary the amplitude of said oscillation as a function of the amplitude of said signal voltage, rectifying means coupled to said anode electrode to derive from said variable am-

plitude oscillation a potential varying in amplitude depending on the amplitude of said variable amplitude oscillation, and means to apply a portion of said potential to the grid electrode of said discharge tube to vary the gain of said tube in a sense opposite to the variations thereof produced by said input signal voltage.

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