July 7, 1942. J. B. MAGGIO 2,288,817

OSCILLATION MODULATOR

Filed July 18, 1939

FIG. 1

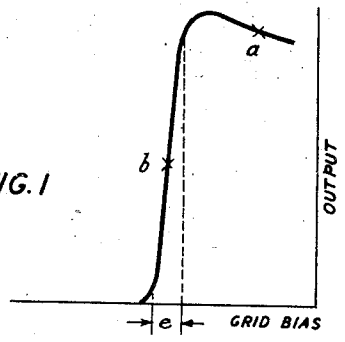


FIG. 2

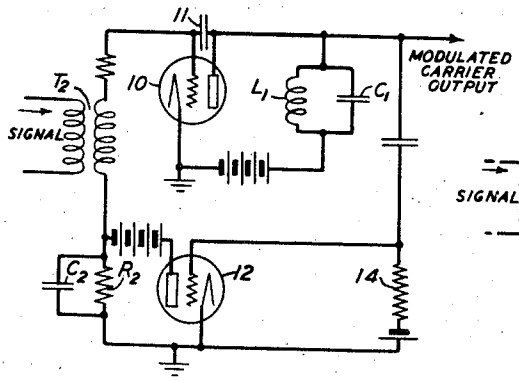


FIG. 3

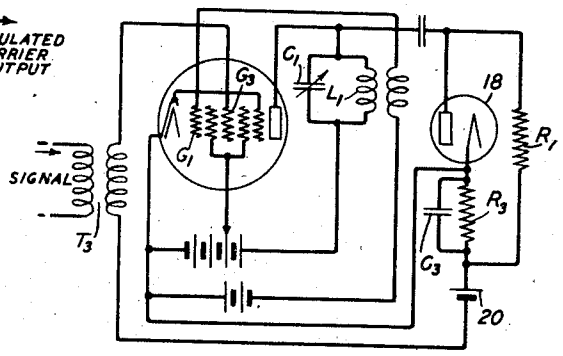


FIG. 4

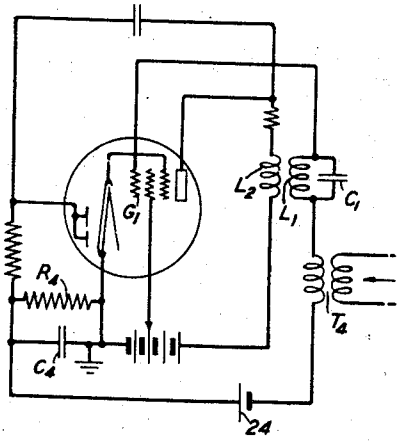
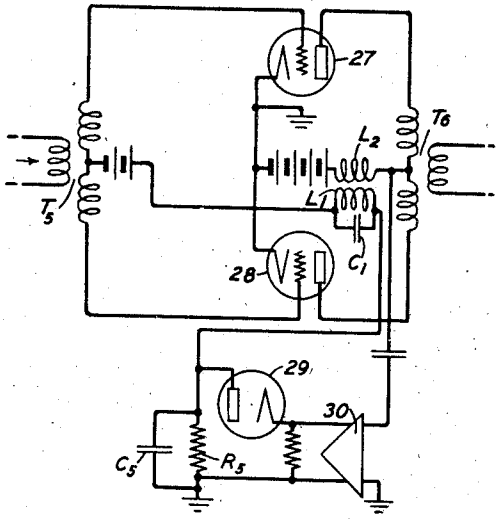


FIG. 5



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OSCILLATION MODULATOR

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1 Claim. (Cl. 179—171.5)

This invention relates to oscillation modulating systems and particularly to means for controlling the transmission characteristics of such systems.

The purpose of the invention is to improve the over-all efficiency of the system without sacrificing the quality and fidelity of the transmitted signal. A particular object is to obtain effective modulation of a carrier frequency with a minimum of apparatus and a minimum of expended power. More specifically, the invention consists in stabilizing an oscillation generator at a point on its operating characteristic where a relatively small impressed signal frequency voltage will cause large changes in oscillation amplitude in such manner as to yield a well and highly modulated oscillation wave. The invention will be better understood by reference to the following specification and the accompanying drawing in which:

Fig. 1 shows a typical output characteristic of a simple oscillator circuit;

Fig. 2 is a circuit showing one specific form of the invention; and

Figs. 3, 4 and 5 are modifications thereof.

Referring more particularly to Fig. 1 there is shown a curve of alternating current output versus control grid bias for a simple oscillator circuit. Normally the output of an oscillator will be that output at which overloading causes the gain to be so reduced that a stable condition has been reached where the amplitude of oscillations is fairly constant. This would be represented ordinarily in Fig. 1 by such a point as *a* on the curve and under these conditions the oscillator is operating over a portion of its characteristic involving large curvature. Modulation under these conditions is not only inefficient but involves a very considerable amount of distortion and change in oscillation frequency. It is possible, however, by the introduction of automatic oscillation control to stabilize the output at some point such as *b* on the steep and nearly linear portion of the curve of Fig. 1, where the amplitude is sensitive to small changes in grid bias. It is evident, however, that stable operation at such a point as *b* could not be secured without some form of automatic control.

If now a varying voltage, such as a signal varying at too high a rate for such an automatic control circuit to follow, is introduced in the oscillator circuit at some suitable point, either in series with a control grid or with a screen grid or in the plate circuit itself, its effect would be to alter the amplitude up and down on the curve about the point *b* at the rate and by a magnitude determined by the amplitude and frequency of the external signal voltage. If the signal frequencies are too high for the control circuit to follow, the oscillator amplitude will vary widely, yielding a modulated wave. Thus in connection with Fig. 1 it is evident that 100 per cent modulation will be obtained for a change in equivalent grid voltage equal to *c*. For a suitably chosen tube the voltage *e* may be only a fraction of a volt and since no grid current is flowing, no appreciable power is required from the signal source. Even the output of a microphone or similar device will be sufficient to control a relatively large amount of high frequency output power.

Fig. 2 shows a circuit illustrating one specific form of the invention. In this figure a simple triode tube **10** is connected as an oscillator, the formal circuit being one which comprises the tuned circuit L_1C_1 in the plate circuit and a coupling condenser **11** from the output to the input. In order to stabilize the circuit a bias is maintained by a charge on the condenser C_2, the magnitude of this bias being determined by a rectified voltage which in turn is obtained from the output circuit of the oscillator. In this figure such rectified output is obtained by connecting across the output of the oscillator the input of a vacuum tube rectifier circuit. This rectifier may take on a large variety of forms but is here shown as consisting of the vacuum tube **12**, the input of which is connected over the large resistance **14**. The output of the tube **12** includes the resistance R_2 with the by-pass condenser C_2, as a result of which there is a direct current voltage across the resistance R_2 and the condenser C_2, the magnitude of which increases as the amplitude of oscillations impressed on the grid of tube **12** is increased. This direct current voltage is then used as a grid bias for the tube **10**, the connection being such that if the amplitude of the oscillations increases, the voltage drop across R_2 increases and the negative bias of the oscillator increases, thus tending to keep the oscillations independent of slow fluctuations in any portion of the oscillator circuit and permitting stable operation about such a point as *b*.

The signal with which the oscillations are to be modulated may be impressed at a number of points in the oscillator circuit but I find that one of the most advantageous points is to introduce it in the grid circuit of the oscillator, as shown at the transformer T_2.

In general, any voltage changes impressed on the grid from the signal circuit will vary the

amplitude of oscillations but a stabilizing circuit will tend to wipe out such variations. However, by making the time constant of the circuit R_2C_2 quite large, this portion of the circuit will not follow the signal frequency and thus, while it serves to stabilize the oscillator at such a point as *b* of Fig. 1, at least so far as slow variations are concerned, the presence of the signal frequency at the transformer T_2 will nevertheless show itself by altering the amplitude of the oscillations in accordance with the signal voltage, so yielding a modulated high frequency wave in the output circuit. Furthermore, since, as shown by Fig. 2, the steep portion of the curve is substantially linear, the circuit itself yields substantially linear modulation.

While the invention has been described in connection with a simple triode oscillator circuit, it is to be understood that it may be applied with other types of tubes and other types of circuit connections. This is illustrated in Fig. 3 in which the so-called 6L7 tube is used. This tube is characterized by the presence of a special grid G_3 and has the property that the gain of the tube can be modified over a wide range by control of the potential of grid G_3. In Fig. 3 the output circuit comprises the tuned circuit L_1C_1 with an inductive coupling to the grid G_1. Such a circuit will oscillate in essentially the same manner as the circuit of Fig. 2 but the amplitude of the oscillations is controlled by the potential on grid G_3. Shunted around the output circuit is a rectifier circuit comprising the resistance R_7 in parallel with the series combination of the diode **18** and resistance R_3. A by-pass condenser C_3 is shunted around the resistance R_3 and there is then available across R_3 a biasing voltage which is impressed on the grid G_3, the direction of connection being such that as the amplitude of the oscillations increases, a larger negative bias is impressed on G_3. Supplementing this variable bias may be a fixed bias **20** of such value as to bring the circuit to the desired operating point. If now signal voltage through a transformer T_3 is also impressed on grid G_3, the amplitude of the oscillations will vary in accordance with the signal voltage. However, it is important to point out that the time constant of the circuit R_3C_3 shall be large so that its response is sluggish as compared with the frequency of the modulating signal.

Fig. 4 illustrates the application of the invention to a double diode pentode tube in which the double diode serves as a single rectifier. Here again the input circuit includes the tuned circuit L_1C_1, which is coupled to the output circuit to set up oscillations. In response to the oscillations the diode portion of the tube, serving as a rectifier, will give a direct current voltage across the resistance R_4, which resistance is by-passed by the condenser C_4. The magnitude of this resistance is such that the rectified voltage generated, taken with supplemental biasing such as that due to battery **24**, will stabilize the oscillator in the manner described above. Signal coming in at the transformer T_4 in the control grid circuit will then serve to modulate the oscillations as indicated above. It is again important to note that the time constant of the R_4C_4 circuit shall be large compared with the signal frequencies.

In some cases it is desirable to have balanced modulation, that is, modulation with elimination of carrier frequency as illustrated in the patent to Carson, 1,463,796, August 7, 1923. The principle of my invention may be applied in such a circuit also as shown in Fig. 5. In this circuit two tubes **27** and **28** are connected for self-oscillation by means of the coupling from the output circuit to the input circuit through the winding L_2 and the tuned circuit L_1C_1. Signal coming in at the transformer T_5 is then effective in giving rise to a modulated wave through the transformer T_6 with elimination of carrier frequency, all in a manner well understood in the art. In this simple circuit, however, the oscillations will ordinarily build up to overload conditions. Here again the oscillations may be stabilized by the principles given above. Specifically this is shown by the generation of a biasing voltage across the resistance R_5 in the circuit comprising the diode **29** supplied from the amplifier **30**. Thus, bias introduced in the portion of the grid circuit common to both tubes will serve to stabilize the oscillations. Since the time constant of the R_5C_5 circuit is again made large, the amplitude of oscillations will be subject to the amplitude of incoming signals.

While a number of modifications have been shown to illustrate my invention, it is to be understood that still other modifications may be produced without departing from the spirit thereof.

What is claimed is:

In combination, an oscillator comprising a space discharge device having at least one control electrode and circuit means fixing the frequency of oscillation, means for voltage biasing said control electrode in fixed proportion to the output intensity of said oscillations, said biasing means being so proportioned that said oscillations tend to be stabilized at a fixed operating point on a steep portion of the oscillation output intensity versus biasing voltage characterisic of said oscillator, and means for concurrently applying modulating signal potential to said oscillator tending to effect corresponding changes in the amplitude of said oscillations, said biasing means being so sluggish in its response to said changes in the said output intensity that the said operating point fluctuates along said characteristic substantially in conformity with the instantaneous amplitude of said modulating signal potential, whereby said output oscillations are signal modulated.

JOHN B. MAGGIO.