Dec. 23, 1941. O. HENKLER 2,267,703

MODULATION

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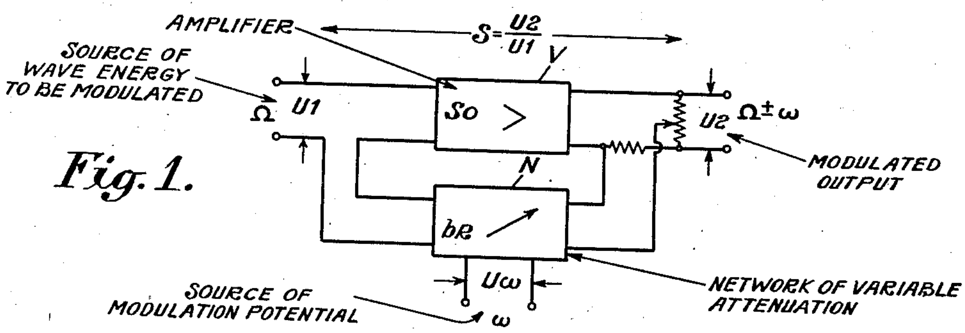

Fig. 1.

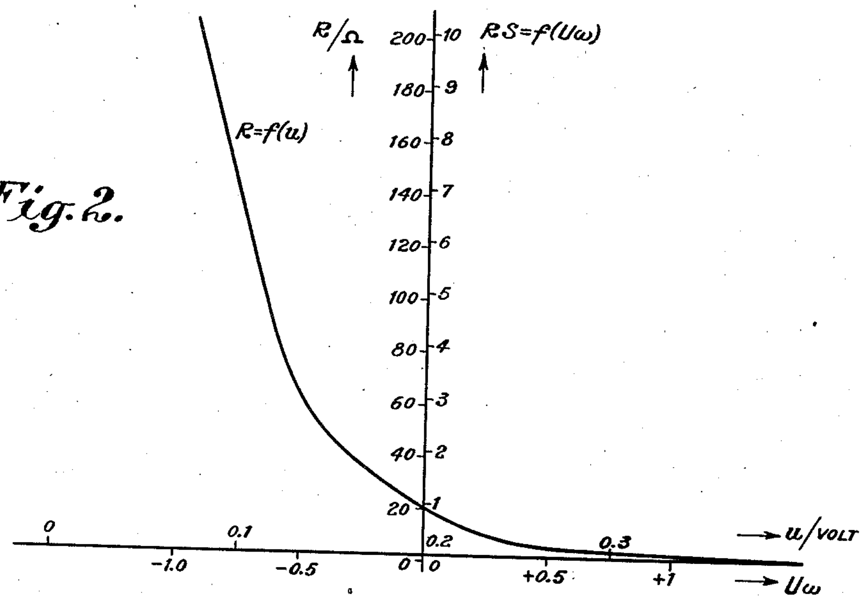

Fig. 2.

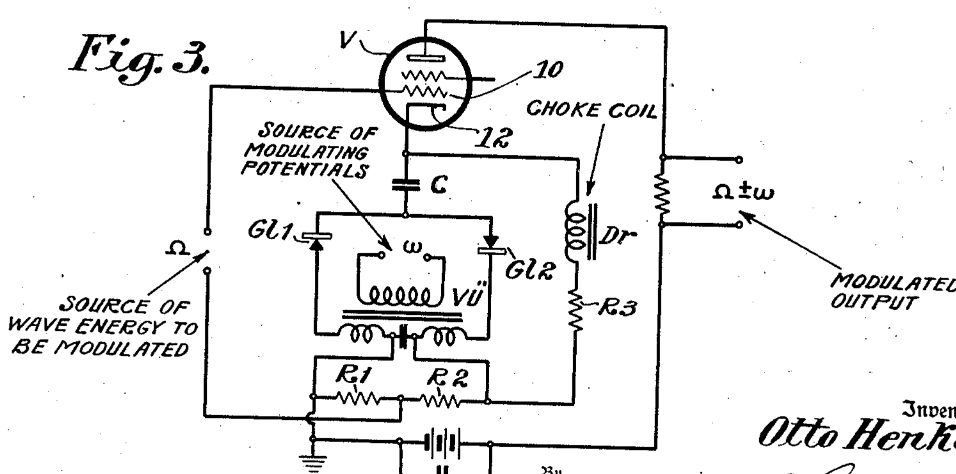

Fig. 3.

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Fig. 4.

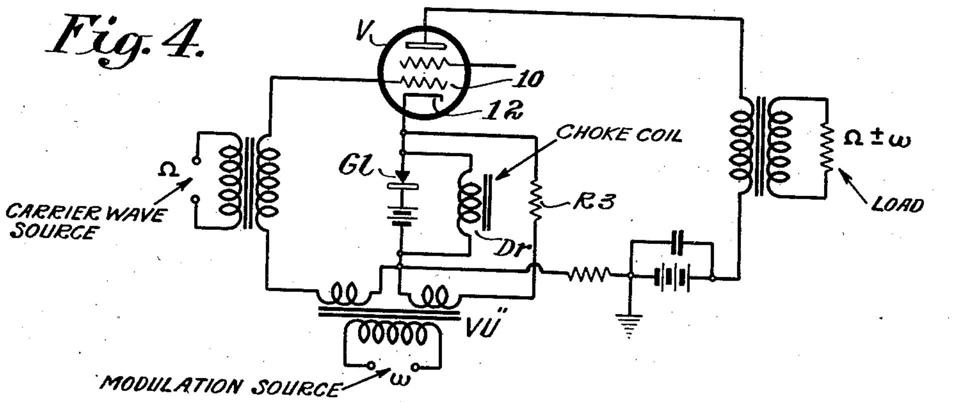


Fig. 5.

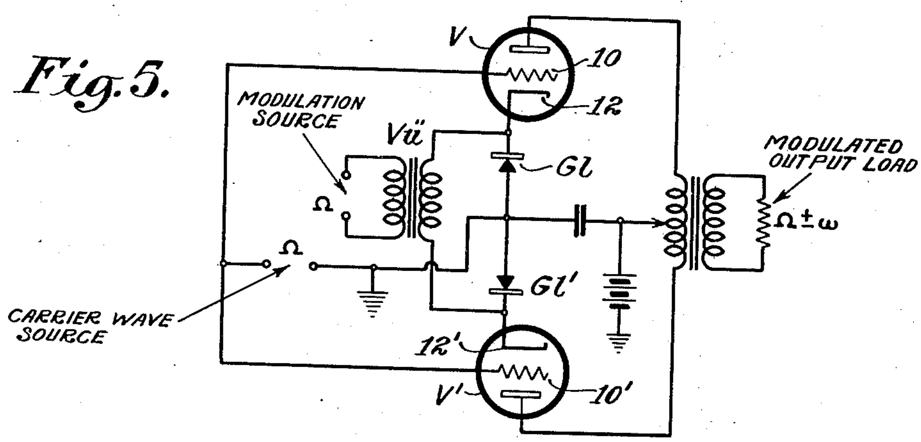
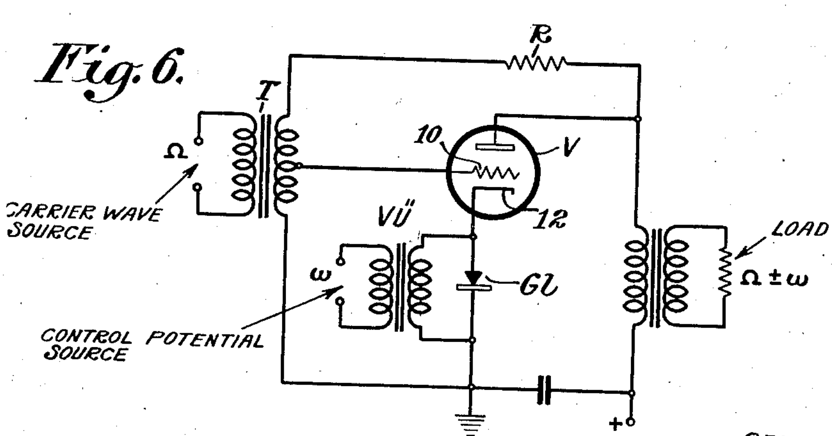


Fig. 6.



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MODULATION

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5 Claims. (Cl. 179—171.5)

For modulation purposes the invention utilizes an amplifier which has been linearized (that is to say, in which non-linear distortions are corrected) by means of a negative feedback between the input and the output circuit. This amplifier may be regarded as amplifying one of the frequencies to be modulated with each other. The amplifier itself may consist of a cascade of amplifiers. According to the invention, the damping occurring in the feedback path is controlled by the other one of the frequencies to be modulated with one another.

The basic principle of the invention shall now be described more fully by reference to the appended drawings, wherein:

Fig. 1 illustrates diagrammatically an embodiment of my modulation system.

Fig. 2 is a curve showing the characteristic of a rectifier used in the system; while

Figs. 3, 4, 5 and 6 are each modifications of my controlled degenerative feedback amplifier of waves to be modulated.

In the feedback path of amplifier V for carrier frequency Ω, having a gain So, is a network or mesh N of variable attenuation bR. The negative feedback, as shown in the prior art, may be predicated upon a current or a voltage feedback, or else a combination of both. Attenuation bR and thus the gain

$$s=\frac{U2}{U1}$$

of the arrangement is subject to control or modulator action occurring at the rhythm of voltage Uω. U2 is the output voltage, U1 is the carrier voltage and Uω is the modulation voltage. According to the amplitude of the signal frequency ω, the attenuation of the network or mesh will be either raised or diminished. The carrier frequency voltage U2 arising in the output end of the amplifier, as will thus be seen, varies at the rate or rhythm of the signal and contains the desired sideband frequencies $\Omega\pm\omega$.

The control of the amplifier V is insured in the input circuit. Both for the carrier frequency Ω as well as for the controlling signal frequency ω only very small energies are thus required. This is of importance and value, for instance, in connection with the central supply of carrier current for several systems, especially where multiple generators are employed.

While the negative feedback varies it is always present, and as a result the properties of the amplifier tube are improved as well known in the art. More particularly, additional modulation in the tube as a result of its curvature is lessened.

It is known in the earlier art to utilize a plate current or amplifying detector for modulation purposes in which by negative feedback and the use of tubes having a very low grid penetration factor a nearly ideally bent characteristic is obtained. However, because of the peculiarity inherent in this known arrangement, the gain is extremely low. The invention contradistinct therefrom discloses how to use the negative feedback network or mesh in a linearized amplifier for modulation purposes, that is to say, the combination of a negative feedback amplifier with a modulator. In this way a high gain is securable, while yet the necessary circuit means are not elaborate.

In the modulator arrangement of this invention the negative feedback network comprises the use of non-linear resistances which is known in the prior art. The characteristic of the non-linear resistance structure, by expedient choice of the non-linear resistances and/or the biasing voltages thereof, is made so that a straight-line inter-relationship is obtained between the output potential of the modulator arrangement and the controlling modulator potential.

Resistance R of the negative feedback network must satisfy more particularly the following condition:

$$R=\frac{1}{S}\cdot\left(\frac{e^{s_0-s'}}{1+k.U\omega}-1\right) \quad (1)$$

where S is the mutual conductance or slope of the amplifier tube, s_0 is the gain of the amplifier V in the absence of negative feedback, s' is the gain of the amplifier tube with negative feedback. Uω is the amplitude of the controlling frequency ω and k the ratio between the output amplitude U2 and the control amplitude Uω. To satisfy the said condition it would seem that the dry-type (oxide) rectifier, more especially copper-oxide rectifiers or combinations comprising the same is most suitable.

Fig. 2 shows the dependence of the resistance of a copper-oxide rectifier upon the controlling alternating amplitude $U\omega$. The operating point is defined, for example, by expedient choice of the biasing potential u. It will be seen that the curve satisfies very closely the condition:

$$R.S=\frac{1-U\omega}{1+U\omega} \quad (2)$$

This condition has been derived from Equation 1, that is to say, there was introduced in Equation 1

$$e^{s_0-s'}=2$$

and $k=1$, which is an important special instance.

Particular exemplified embodiments of the modulator arrangement of this invention are illustrated in Figs. 3 to 6. The circuit organizations are more particularly so designed that the carrier and/or the signal frequencies are absent in the amplifier output. Exemplified embodiments Figs. 3 and 4, for instance, illustrate circuit organizations where the signal frequency is absent in the output.

A preferred exemplified embodiment adapted to suppress the signal frequency is shown in Fig. 3. Included in the cathode circuit of the amplifier tube V for carrier frequency are the non-linear negative feedback resistances G11 and G12; these may consist more particularly of dry rectifiers. The resistances R1 and R2 serve for furnishing a biasing voltage, required under certain circumstances for the rectifiers. The resistances R1 and R2 are included in the amplifier direct-current circuit. The drop of potential caused by the plate current across the resistances R2 and R3 may also serve for biasing the tube V. Alternating current is precluded from this circuit by means of the choke-coil Dr known in the art, while condenser C prevents the flow of the plate direct current across the non-linear resistances G11 and G12. Owing to the differential winding of the signal transformer VÜ the signal ω is suppressed in the grid and thus in the plate circuit. The amplifier tube V should preferably be of the screen-grid type.

In Fig. 3, the drop in the alternating-current path comprising condenser C and the network between C and ground is in the circuit between the grid 10 and cathode 12 so that degenerative potentials are fed to the grid 10. The amplitude of the potentials fed back is controlled by controlling the conductivity of the non-linear resistances G11 and G12 and is done by the modulating potential ω impressed on the transformer VÜ. R1 is included in the grid circuit to supply a desired bias for the grid.

Also, in exemplified embodiment Fig. 4 the signal frequency is suppressed in the output of the arrangement by using the differential transformer VÜ as shown. This embodiment contains only one non-linear resistance G1 in the feedback path. In this circuit a single non-linear resistance G1 is in the modulation potential degenerative feedback circuit.

By using a push-pull circuit organization as shown in Fig. 5, it is also possible to suppress the carrier frequency as known in the prior art. The push-pull arrangement consists of the two amplifier tubes V and V′. These also are preferably of the screen-grid type. Signal frequency, for example, is fed through transformer VÜ to the rectifiers G1 and G1′ so that it is also absent in the output. The carrier frequency, however, as shown in Fig. 6, could also be compensated by the use of a differential transformer T for the carrier frequency Ω and by introducing the resistance R in the output circuit. In the arrangement of Fig. 6 a point on the secondary winding of transformer T is connected to the grid 10 and a terminal is connected to the cathode return circuit and a second terminal to the anode 14 by way of resistance R.

What is claimed is:

1. In a modulation system, an electron discharge device having input and output electrodes including a control grid, an anode and a cathode, means for impressing wave energy to be modulated on said control grid, a modulated wave energy output circuit connected with said anode, a rectifier connected between said cathode and anode, a connection between said grid and cathode including said rectifier to provide in said tube a degenerative effect and means for modulating the degenerative effect including a source of modulating potentials coupled with said rectifier.

2. In a modulation system, an electron discharge device having input and output electrodes including a control grid, an anode and a cathode, means for impressing wave energy to be modulated on said control grid and cathode, a modulated wave energy output circuit connected with said anode and cathode, a non-linear resistance connected in an alternating current circuit between said cathode and anode, a circuit between said grid and cathode including said non-linear resistance to provide a degenerative effect in said tube and means for modulating the degenerative effect including a source of modulating potentials coupled with said non-linear resistance.

3. In a modulation system, an electron discharge device having an anode, a cathode and a control grid, a source of modulating potentials, a source of wave energy to be modulated, opposed non-linear impedances in a loop circuit common to connections between the cathode and the anode and between the cathode and the control grid to provide degeneration in said tube, an output circuit coupled to said anode and cathode, means for impressing the wave energy to be modulated on said control grid and cathode, and a differential transformer coupling said source of modulating potentials to said non-linear impedances by a circuit such that the provided degeneration is modulated and the modulating potentials are suppressed in said output circuit.

4. In a modulation system, an electron discharge device having an anode, a cathode and a control grid, a source of modulating potentials, a source of wave energy to be modulated, a pair of rectifiers connected in opposed relation by similar impedances, a connection between adjacent terminals of said rectifiers and the cathode of said tube, connections between adjacent terminals of said impedances and the grid and the anode of said tube to provide degeneration in said tube, an output circuit coupled to the anode of said tube, means for impressing the wave energy to be modulated on said control grid and cathode, and means for applying modulating potentials differentially to said impedances to modulate the provided degeneration and to suppress said modulating potentials in said output circuit.

5. In a modulation system, a pair of electron discharge devices each having an anode, a cathode and a control grid, a pair of rectifiers connected in opposed relation between the cathodes of said tubes, means connecting one of said rectifiers in a common portion of an alternating current circuit between the anode and cathode and

grid and cathode of one of said tubes, means connecting the other of said rectifiers in a common portion of an alternating current circuit between the anode and cathode and grid and cathode of the other of said tubes, an output circuit coupling the anodes of said tubes in push-pull relation, means for impressing wave energy of carrier wave frequency in phase between the control grids and cathodes of said tubes, whereby said carrier wave energy is suppressed in said output circuit, and means for impressing modulating potentials in push-pull relation on said rectifiers whereby the carrier wave is modulated and said modulating potentials are suppressed in said output circuit.

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