

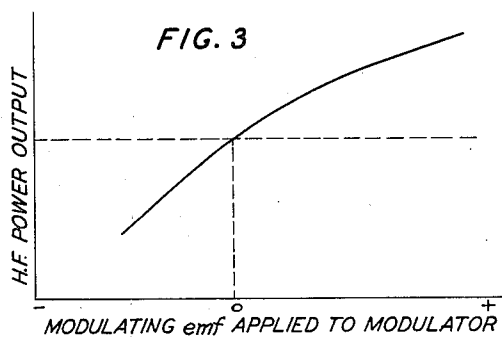
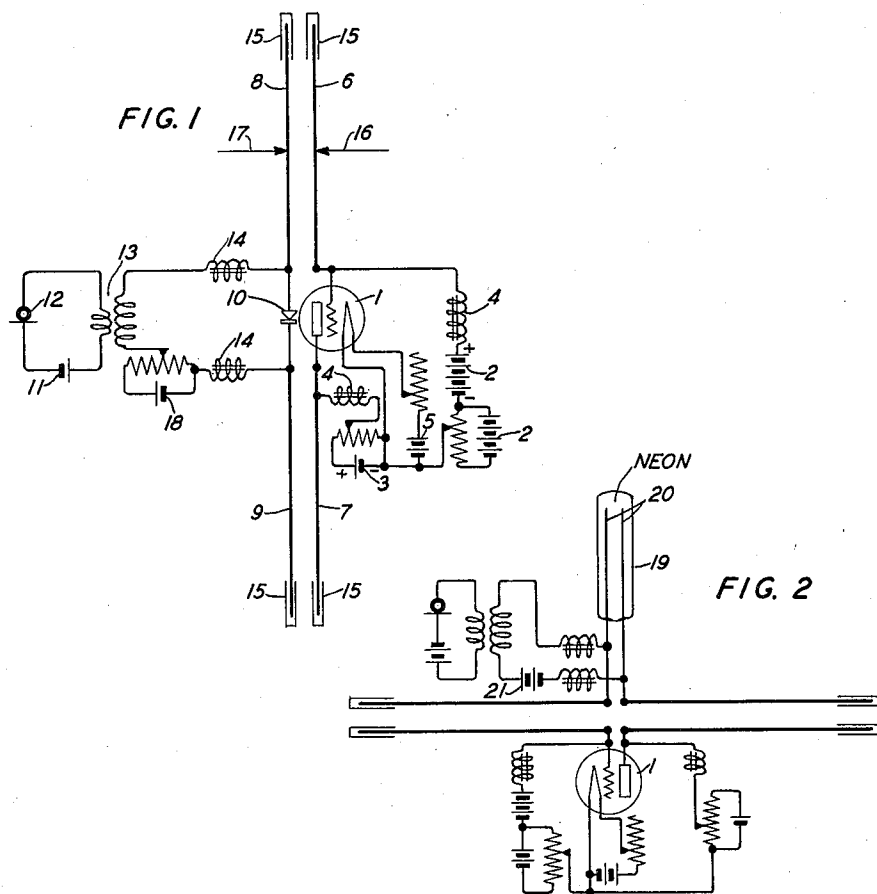
Sept. 13, 1938.

A. J. RACK

2,129,870

AMPLITUDE MODULATION SYSTEM

Filed Dec. 30, 1936



INVENTOR
A. J. RACK
BY
E. V. Griggs
ATTORNEY

UNITED STATES PATENT OFFICE

2,129,870

AMPLITUDE MODULATION SYSTEM

Alois J. Rack, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York.

Application December 30, 1936, Serial No. 118,281

6 Claims. (Cl. 179-171)

This invention relates to amplitude modulation systems for ultra-high frequency waves.

It is customary in modulating systems employing electron discharge oscillators to vary the potential of the grid or the anode of the electron discharge device comprising an element of the oscillator by an electromotive force corresponding to the desired modulating wave. However, with oscillators producing waves of a length of a few centimeters and particularly with oscillators of the Barkhausen type, the frequency of the oscillations produced depends to a very large extent upon the operating voltages. It is accordingly difficult where amplitude modulation of such oscillators is desired to avoid excessive frequency modulation.

The principal object of the invention is to modulate the amplitude of very short waves without modulating their frequency to an undesirable extent.

In accordance with the invention a Lecher system is associated with an electron discharge tube in such a manner as to constitute the frequency determining and load circuit of an oscillator. The polarizing electromotive forces of the electron discharge tube are adjusted to such a point that the impedance of the vacuum tube does not match that of the Lecher system load circuit. A variable resistance or modulating device connected in the Lecher circuit and controlled by signal electromotive forces varies the impedance of the Lecher circuit so that the mismatch in impedance is changed. As the power transferred to the load circuit is a maximum when the impedances are matched it follows that if the alternating current resistance of the modulating device is varied, thus varying the impedance of the Lecher system into which the vacuum tube works, the load power will vary. Moreover, if the variable resistance is located at a nodal point in the Lecher system, variation in its resistance will not change the reactance into which the tube works, so that the frequency of the oscillations will remain constant. Accordingly, if the resistance of the modulating device is varied at an audio frequency about a magnitude where the impedance of the Lecher system and the electron discharge device are mismatched by imposing an audio frequency electromotive force across the modulating device, the load power delivered by the oscillator will be modulated at an audio frequency.

The invention will be more clearly understood by reference to the accompanying drawing in which:

Fig. 1 is a circuit diagram of an electric discharge oscillator embodying the invention;

Fig. 2 illustrates a modification of the circuit of Fig. 1; and

Fig. 3 is a graph to assist in explaining the adjustment of the circuit for best operation.

Referring to Fig. 1, an electron discharge device 1 which may be of conventional type except that its interelectrode capacitances and its lead resistances and reactances are preferably reduced to a minimum, has its grid and anode respectively polarized by sources 2 and 3 over paths each of which include a choke coil 4. One portion of source 2 is associated with a potentiometer, as indicated, to permit variation of the grid voltage. With the grid polarized highly positively, as indicated, the device with its associated circuits operates to produce oscillations as a Barkhausen oscillator. The cathode is heated by current from source 5. The cathode heating current may be varied by means of a resistance in the heating circuit. The anode potential may be varied by means of a potentiometer associated with source 3.

A Lecher system 6, 7, 8, 9 comprises conductors interrupted near the center. The conductors 6 and 7 which form one side of the Lecher system are connected respectively to the grid and plate of the oscillator tube 1. The conductors 8 and 9 which form the other side of the Lecher system are connected to the terminals of a variable resistance device 10 which may comprise a rectifying crystal, or a non-linear resistance element of any desired type, the high frequency alternating current resistance of which is controllable by impressed electromotive forces or impulses of a signal or control wave. In order to control the resistance of the device 10, a source 11 of unidirectional current associated with a microphone or other signaling transmitter 12 is included in a circuit coupled to the terminals of the device 10 by a transformer 13 and leads extending through high frequency choke coils 14.

In operation the Lecher circuit is tuned to resonance at the desired oscillation frequency by manipulating the telescoping extensions 15 of well-known type.

The adjustment of the resistance of the modulating element 10 and of the electromotive forces applied to the electron discharge device may best be effected by use of a graph such as that of Fig. 3 relating the high frequency output power of the Lecher system to the unidirectional electromotive force applied to the modulating element 10 for fixed values of all other electromotive

forces. The unidirectional biasing or polarizing electromotive force applied to the modulator 10 is derived from a source 18 connected in series with the choke coils 14 and the secondary winding of transformer 13 by means of a potentiometer of conventional type. The operating electromotive forces are changed to different values and graphs similar to that of Fig. 3 plotted for each set of values. From several such curves, each for a different set of electromotive forces, it is possible to select one which, over a desirable range of applied modulating electromotive forces, is most nearly symmetrical about an intermediate point in that range and which, at the same time, is sufficiently linear to produce faithful modulation. The intermediate point may be made the origin by proper adjustment of the electromotive force applied by source 18. The other operating electromotive forces are then fixed at the values indicated for this symmetrical condition and the circuit is ready for operation.

The adjustment should be such that the value of the impedance of the Lecher system including the modulating device is sufficiently removed from that of the electron discharge device to which it is connected so that throughout the entire range of values which the Lecher system impedance undergoes during the modulation that impedance will not become equal to the impedance of the electron discharge device. Consequently, with increasing modulating potentials of one polarity the impedance of the Lecher system will approach the impedance of the electron discharge device, with increasing modulating potentials of the opposite polarity the impedance of the Lecher system will diverge farther from the impedance of the electron discharge device. In this manner the power delivered to the Lecher circuit is varied as the relationship between the mismatched impedance varies.

As the modulating device 10 is located at substantially a nodal point of the conductor 8, 9 it has little or no effect upon the resonance frequency of the Lecher system and thus does not substantially affect the frequency of the oscillations produced. The modulated oscillations so produced may be transmitted to a work circuit of any kind of which the dipole antenna 16, 17 connected to conductors 6 and 8 is one example.

The circuit of Fig. 2 is similar to that of Fig. 1, but utilizes as a modulating device a gaseous electric discharge tube 19 containing two linear electrodes 20 enclosed in an atmosphere of neon or a mixture of gases. Such a device has a non-linear characteristic and may serve like the apparatus 10 to control the resistance of the load circuit for ultra-high frequency waves. A source of current 21 may be employed to impress a suitable biasing electromotive force upon the electrodes 20. The vacuum tube 1 in this circuit is constructed with plate and grid leads at the same end of the tube and the Lecher circuit is arranged perpendicular to these leads. Not only does this shorten the leads and improve the coupling of the Lecher circuit to the tube, but it also minimizes the effects of the parallel leads inside the tube upon the Lecher circuit. The operation of the circuit is similar to that of the circuit of Fig. 1 and will be readily understood without further explanation.

Although the invention has been disclosed in connection with the modulation of Barkhausen type oscillators it should be understood that it is applicable to other types of oscillators as well and in particular to vacuum tube oscillators of

the negative grid type. It is also to be understood that the invention is not to be limited to the circuit embodiments disclosed, but only by the scope of the appended claims.

What is claimed is:

1. In combination, an electron discharge amplifier having input and output electrodes, polarizing means electrically connected to said electrodes whereby oscillations are produced by the amplifier operating as an oscillation source of the braking field type, a load circuit coupling the output electrode to the input electrode, means to mismatch the impedance presented by the amplifier with respect to that of the load circuit at its connections to the load circuit for electromotive forces of the frequency of the oscillations produced, modulating means to vary the impedance of the load circuit for the oscillation frequency currents, presented at the points to which the amplifier is connected, in accordance with signals to correspondingly vary the amplitude of the oscillations supplied thereto by the amplifier, and means electrically connecting the impedance varying means to the load circuit at substantially a nodal point therein so as not to introduce a substantial reactance in the load circuit whereby the oscillation frequency is substantially unaffected by the modulating operation.

2. A Lecher system comprising two parallel conductors resonant at a desired oscillation frequency, an electric discharge amplifier having a cathode, an anode, and an impedance control element, means for polarizing the anode and impedance control element with respect to the cathode, one of the Lecher conductors comprising two separate portions, means for connecting the anode to one portion of the Lecher conductor and the impedance control element to the other to cause the amplifier to generate oscillations of the frequency of the Lecher circuit, means to mismatch the impedance of the amplifier with respect to the impedance of the Lecher circuit, and means to vary the impedance of the Lecher circuit to modulate the amplitude of the oscillations produced.

3. In combination, a Lecher circuit, a vacuum tube amplifier having input terminals and output terminals connected thereto to produce oscillations therein of a frequency corresponding substantially to the natural frequency of the Lecher circuit, and means connected in series in one of the Lecher circuit conductors at a central point to vary the impedance of the Lecher circuit in accordance with a variable modulating electromotive force to modulate the amplitude of the oscillations produced.

4. A tuned circuit comprising two parallel conductors, an electron discharge amplifier having two electrodes connected to separated points in one of the conductors to couple it to the tuned circuit, the other conductor having an interruption in its continuity, a variable impedance gas-filled electric discharge device bridging the discontinuity to vary the impedance of the tuned circuit, and means for controlling the impedance of the device in accordance with signals.

5. An electrical system comprising two closely adjacent parallel conductors constituting a resonant circuit at a desired oscillation frequency, an amplifier having input and output electrodes connected to the resonant circuit to constitute therewith an oscillation generator, one of the conductors having an interruption intermediate its ends, and a signal controlled variable impedance device bridging the interruption.

6. An oscillator comprising a Lecher circuit open at each end, an electric discharge device having a cathode, an anode and an impedance control element, a polarizing circuit including a source of current and connecting the impedance control element to the cathode, a second polarizing circuit including a source of current and connecting the anode to the cathode, the Lecher circuit comprising parallel conductors, one of which is interrupted at a nodal point, and means connecting the anode and the impedance control elements respectively to the two portions of the interrupted conductor adjacent the point of interruption. 5

ALOIS J. RACK.