

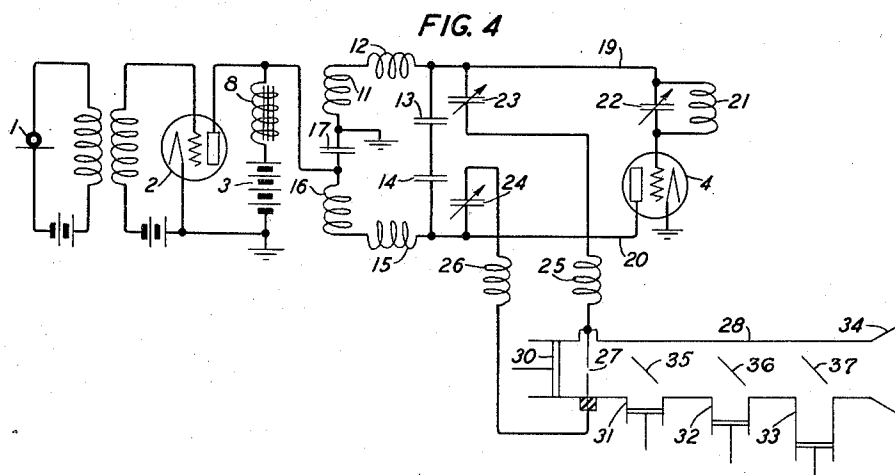
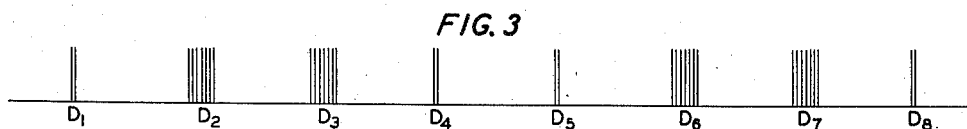
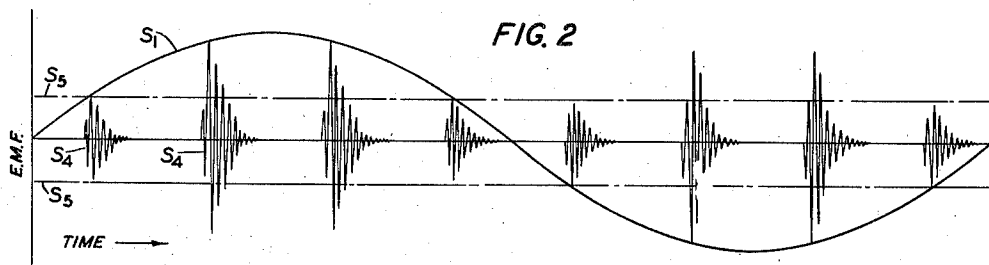
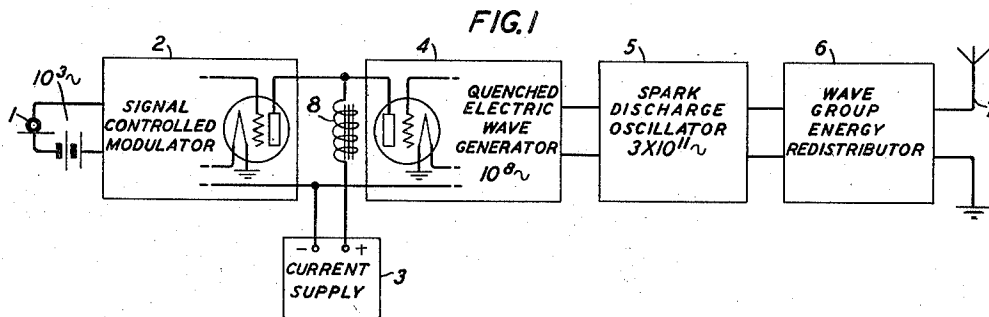
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MODULATION SYSTEM

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MODULATION SYSTEM

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This invention relates to modulation of high frequency oscillations and, more particularly, to modulation systems for controlling spark discharge oscillation systems in accordance with signal or control waves or impulses.

An object of the invention is to modulate oscillations of frequencies for which the usual triode electron discharge device is relatively inefficient.

Another object of the invention is to enable effective modulation of the output energy of a spark discharge oscillator.

In accordance with this invention, a spark discharge gap is subjected to an alternating electromotive force produced by a power supply source of high frequency waves of, for example, 100 megacycles frequency. The spark gap breaks down during any half cycle of the impressed power supply waves in which the impressed electromotive force rises to a magnitude in excess of the breakdown voltage of the gap. At each discharge of the gap there is produced a train of waves of the order of millimeter wave-lengths as determined by a resonance system associated with the gap. The source of power supply may preferably comprise a vacuum tube wave generator controlled by signal wave electromotive forces so that some half cycles attain a magnitude exceeding the breakdown voltage of the gap and others do not. Consequently, the number of discharges and of corresponding trains of millimeter wave-length oscillations varies with the amplitude of the modulating signal wave. The energy of the millimeter wave trains produced is proportional to the number of trains and, hence, to the magnitude of the modulated signal wave.

In the drawing, Fig. 1 is a block diagram which illustrates the novel method of the invention and a modulating system embodying features of the invention;

Figs. 2 and 3 are graphs to assist in the explanation of Fig. 1; and

Fig. 4 is a schematic circuit diagram of a short wave transmission system utilizing a modulator for a spark gap discharge oscillator.

Referring to Fig. 1, a source of signal currents or control waves is represented by the microphone 1 electrically connected to the input circuit of a signal controlled modulator 2, preferably of the well-known electron discharge type. A source 3 of unidirectional current serves as a supply for space current for the modulator 2 and an electric wave generator 4. The well-known Heising constant current circuit disclosed in U. S. Patent 1,442,147, January 16, 1923,

may be employed with a speech frequency choke coil 8 in the common portion of the external space current paths of devices 2 and 4.

The wave generator 4 is preferably of the type in which the alternating waves generated are quenched in the general manner of the super-regenerative amplifier so as to break the generated waves up into periodically recurring trains of waves. The purpose of this feature is to afford the spark gap, which the wave generator excites, periodic inactive or rest periods in which incipient ionization at the gap may be dispelled. The quenched wave generator 4 is preferably of the type disclosed and claimed in U. S. Patent No. 2,240,941, May 6, 1941, to R. S. Ohl.

The operation of the system as so far described may be understood by reference to Fig. 2. Assume that the source 1 produces a signal wave having as a representative component a tone of 1000 cycles, the amplified electromotive force of which is indicated by the curve S_1 of Fig. 2. The signal wave represented by the 1000 cycle tone is impressed upon the input of the modulator 2 which operates effectively as an audio frequency amplifier to produce amplified 1000 cycle current in its output circuit. Since the constant current choke 5 maintains the total space current of the devices 2 and 4 constant, audio frequency variations in the space current of modulator 2 are attended with supplementary variations of the same frequency in the space current of the wave generator 4. Consequently, the waves produced by generator 4 are modulated by the 1000 cycle tone or whatever speech or other signal is impressed on microphone 1 and the envelope of the modulated waves will correspond to curve S_1 which represents the amplified audio frequency output electromotive force of modulator 2. The principal frequency of the waves generated by source 4 may be, for example, of 100 megacycles self-interrupted or quenched to break them up into trains of waves as indicated at S_2 . The trains of waves S_2 are of different peak amplitudes, the trains periodically waxing and waning with the S_1 envelope wave in accordance with which they are modulated.

The output terminals of the quenched wave generator 4 are connected to a spark discharge oscillator 5 in the manner disclosed in U. S. Patent No. 2,240,941, to which reference has been made. The spark discharge oscillator comprises a spark gap having a breakdown voltage represented by the broken lines S_3 of Fig. 2. The discharge gap will be subjected to a potential dif-

ference sufficient to cause successive breakdowns during each period that the applied electromotive force is in excess of the breakdown potential, and a number of discharges may occur in each such period. This condition will recur each time a half-cycle of an S_4 wave train is intercepted by either of the lines S_3 . The discharges occasioned by the successive wave trains S_4 will, therefore, be roughly as indicated by the vertical lines D_1, D_2, D_3 of Fig. 3, in which the fact that there are normally several discharges for each half-cycle of the oscillator is roughly indicated by the fact that there are more vertical lines shown than there are half-cycles of damped trains of Fig. 2 which exceed the breakdown potential. Each discharge sets up a train of oscillations of a frequency determined by the resonance system associated with the spark gap of the discharge oscillator 5. The wave-length of these oscillations may be in the millimeter range as disclosed in U. S. Patent No. 2,240,941. It will be apparent, therefore, that at the first train of oscillations S_4 only two discharges occur, as indicated at D_1 and two trains of the millimeter wave-length oscillations are produced. At D_2 and D_3 the number of trains is much greater with a decrease at D_4 and D_5 . Since the gap breaks down at the same potential each time, the energies of the trains are substantially equal so that the millimeter oscillation energy produced is substantially proportional to the number of discharges as indicated in Fig. 3. Accordingly, the output of the spark discharge oscillator 5 consists of trains of millimeter length oscillations which occur in groupings such that the energy transmitted varies in accordance with a modulating signal or control wave. Thus five different frequencies are involved in the process. They are, in order, the signal frequency, the quenching frequency, the principal oscillation frequency, the frequency of the spark discharges and the ultra-high frequency of the millimeter length oscillations.

The modulated millimeter length oscillations may be supplied to a wave group energy redistributor 6, preferably of the type disclosed and claimed in U. S. Patent 2,250,934, issued July 29, 1941. The function of this device is to redistribute the energy of the oscillation trains with respect to time to make them more nearly simulate continuous oscillations. The oscillations may then be impressed upon a transmission line or antenna 7 for transmission of their energy to a remote point.

In Fig. 4 the circuits of the individual apparatus of Fig. 1 are schematically presented. For simplicity, the modulator 2 and wave generator 4 are shown as simple triodes and the source 3, which may be a rectified current supply, is illustrated as a battery. Associated with device 4 is a closed tuned circuit 11, 12, 13, 14, 15, 16, 17 which is resonant at the quenching frequency and a selective or tuned system 19, 20, 14, 13, which, for the principal wave frequency of the damped oscillations S_4 , may constitute a quarter wave-length Lecher circuit terminated by the large capacity elements 13, 14 which are of negligible impedance at the principal wave frequency. The principal wave frequency, which is that of the individual waves of the trains S_4 of Fig. 2, may be of the order of 100 megacycles and the quenching frequency may be from 20 to 100 kilocycles. In the interests of simplifying the drawing, no attempt has been made to retain these

frequency ratios in the diagram of Fig. 2 and there would actually be a very much larger number of trains S_4 per cycle of S_1 and a very much larger number of waves per train than is indicated. It should also be borne in mind that the millimeter oscillation trains have not been represented but that there is one for each spark discharge of the graph of Fig. 3.

An inductor 21 which freely passes the quenching electromotive force but excludes the principal waves and a variable capacitor 22 having the converse function enables the relative magnitudes of these electromotive forces to be varied as desired. This enables a proper quenching action to be had and also provides means for adjusting the intensity of the oscillations of the device 4, a very desirable feature, since it is found that the discharge gap does not perform nearly as well if driven by excessive electromotive forces. The capacitor 17 freely passes oscillations of the quenching frequency but interposes a relatively high impedance to modulating frequency electromotive forces imposed by modulator 2.

Across the Lecher circuit 19, 20 is connected a shunt path comprising capacitances 23, 24, millimeter wave chokes 25 and 26 and the spark gap 27. The chokes 25 and 26 are so dimensioned that in the absence of a gap discharge they will be tuned to the principal frequency by the capacitance of the gap electrodes. Upon the initiation of a discharge, however, this gap capacitance is instantaneously short-circuited by the electron stream and the chokes 25 and 26 thereupon offer high impedances, both to confine the millimeter oscillations to the gap resonant system and to prevent the energy of the principal frequency oscillations from influencing them. The frequency of oscillations generated at the gap may be determined by characteristics of a local resonance system as, for example, by the diameter of the tubular housing 28 surrounding the gap. A reflector 30 may be positioned to constitute a unidirectional propagation system and also to assist in redistributing the oscillation train energy, as more fully explained in U. S. Patent 2,250,934. A series of delay paths 31, 32, 33, each associated with a partial reflector 35, 36, 37 and represented as a whole by block 6 of Fig. 1, may retard a portion of the oscillation train energy to additionally redistribute it with respect to time, as disclosed more fully and claimed in U. S. Patent 2,250,934. Finally, the speech-modulated millimeter wave-length oscillations may be impressed upon a radiator 34, such as the flaring horn 19 of G. C. Southworth U. S. Patent 2,106,768, issued February 1, 1938.

What is claimed is:

1. A short wave transmission system comprising an electric wave generator, means for periodically quenching the waves produced thereby at a supra-audible frequency, means for modulating the waves in accordance with control energy, a discharge gap, and means for impressing the modulated waves across the gap, the breakdown voltage of the gap lying intermediate the maximum and minimum peak voltages of the impressed modulated waves whereby the number of discharges across the gap varies in accordance with the modulation of the modulated waves.

2. In combination, a source of electric waves of high frequency, means for periodically quenching the waves at a supra-audible frequency, means for varying the amplitude of the waves in accordance with control energy of audi-

ble frequency, a spark discharge gap oscillator, and means for impressing the modulated waves upon the gap to produce discharges which vary in number with the modulation of the modulated waves.

3. A spark gap, a resonance system connected electrically thereto to determine the frequency of oscillations produced when electrical discharges occur across the gap, and means for applying to the gap an electromotive force modulated in accordance with control waves, to initiate breakdown of the gap, and means for confining said oscillations to the gap and the resonance system.

4. The combination in accordance with claim 3, characterized in this, that means are provided for periodically quenching the modulated control wave to provide inactive periods in which incipient ionization across the discharge gap may be checked.

5. In combination, a generator of high frequency oscillations periodically quenched at a lower but supra audible frequency, means for modulating the quenched oscillations in accordance with a control signal, a discharge gap, and means for impressing a voltage of the modulated quenched oscillations across the gap, the breakdown voltage of the gap lying intermediate the maximum and minimum peak voltages of the impressed oscillations, whereby the number of discharges across the gap varies in accordance with the control signal.

6. A short wave transmission system comprising, in combination, a generator of high frequency oscillations periodically quenched at a lower but supra-audible frequency, means for modulating the quenched oscillations in accordance with a control signal of audible frequency, a discharge gap, a resonance system associated with the gap and tuned to a frequency substantially higher than said oscillation frequency, and means for impressing a voltage of the modulated quenched oscillations across the gap, the breakdown voltage of the gap lying intermediate the maximum and minimum peak voltages of the impressed oscillations, whereby the number of damped wave trains, initiated by discharges across the gap, is proportional to the control signal.

7. In combination, a source of oscillations, means for periodically quenching the oscillations at a supra audible frequency, means for modulating the quenched oscillations in accordance

with signal waves, a spark discharge gap, means for applying an electromotive force derived from the modulated quenched oscillations to the gap to produce discharges thereacross, and an electrically resonant system connected with the gap to cooperate therewith in the production of oscillations of wave-lengths of the order of millimeters.

8. In combination, a space current oscillator comprising means for producing oscillations and for periodically self-quenching the oscillations at a supra audible frequency, a space current device, means for controlling the device in accordance with signals, and a constant current space current source connected to the oscillator and the device in parallel to supply a substantially constant total space current to the oscillator and the device whereby the quenched oscillations are modulated in accordance with the signals.

9. In combination, an electronic oscillator comprising means for producing oscillations and for periodically self-quenching the oscillations at a supra audible frequency, an electronic device, means for controlling the device in accordance with signals, a discharge gap and an electrically resonant system connected therewith, and means for causing the modulated quenched oscillations to impress an alternating electromotive force across the gap to set up modulated oscillations of still higher frequency in the electrically resonant system.

10. In combination, an electronic repeater having an input circuit and an output circuit, a signal wave source connected to the input circuit, a space current oscillator having a space current path connected with said output circuit in constant current relation whereby the total space current of the repeater and of the oscillator is maintained substantially constant, a supra audible frequency tuned circuit connected to the oscillator and including a portion of the space current circuit thereof, a Lecher circuit having its most effective response at a frequency materially higher than said supra audible frequency, the Lecher circuit forming a part of the space current oscillator and serving to determine its principal frequency whereby oscillations of the principal frequency varied at the supra audible frequency and controlled by the signal wave are produced.

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