

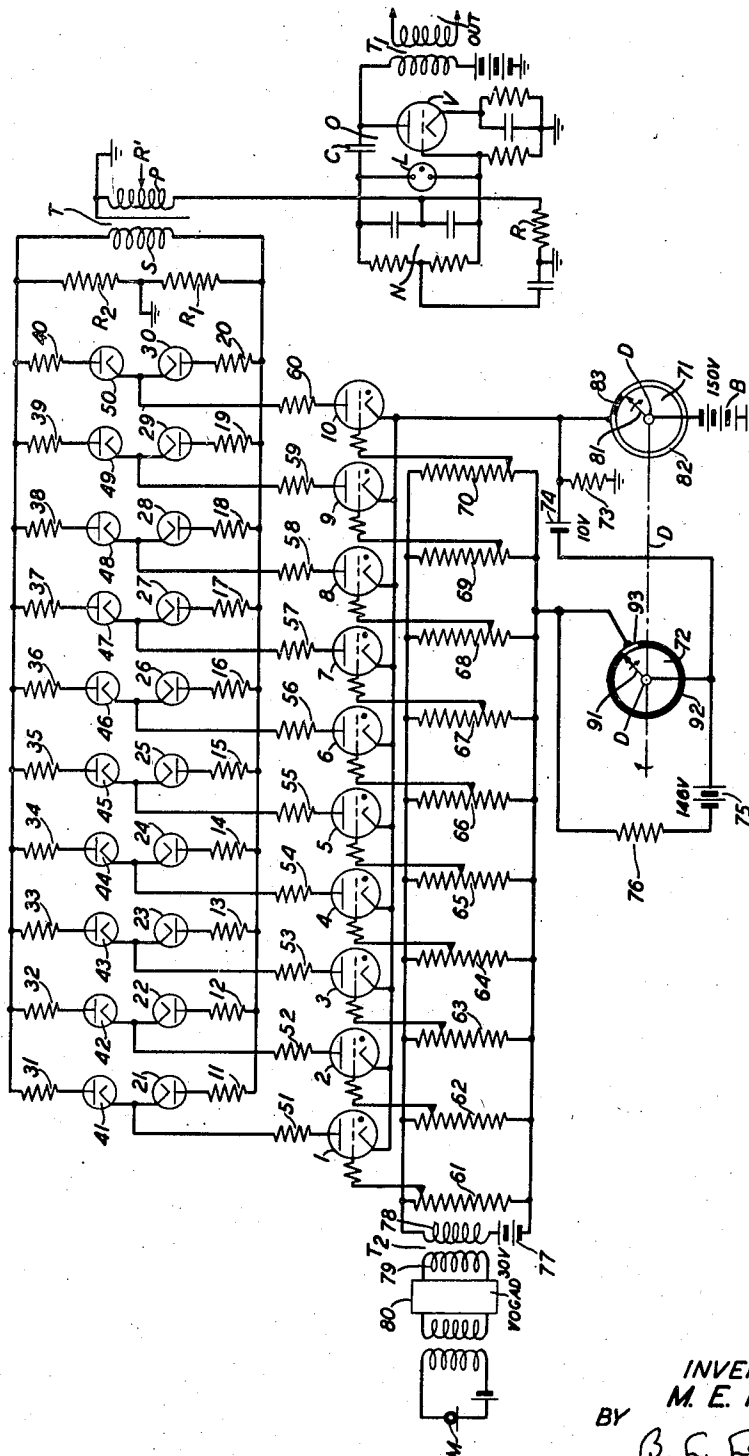
May 10, 1949.

M. E. MOHR

2,469,837

WAVE TRANSLATING SYSTEM

Filed Sept. 26, 1946



INVENTOR
M. E. MOHR
BY
B. C. Eger
ATTORNEY

UNITED STATES PATENT OFFICE

2,469,837

WAVE TRANSLATING SYSTEM

Milton E. Mohr, New Providence, N. J., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application September 26, 1946, Serial No. 699,555

5 Claims. (Cl. 332-29)

1

This invention relates to circuit switching and to wave modulation.

Objects of the invention include impedance control, modulation, frequency control and frequency modulation.

In a specific aspect the invention is a frequency modulator comprising an oscillator circuit with signal responsive electric space discharge tubes, for example gas tubes, controlling rectifiers for switching discrete resistances into and out of the oscillator circuit to vary the oscillator frequency abruptly in steps.

Also, in a specific aspect the invention is a frequency modulator responsive to a modulating signal which may be a signal of gradually varying instantaneous magnitude, to produce a frequency modulated wave whose frequency variations occur abruptly in steps. When a signal, in its transmission either directly or as a modulation on a carrier wave, is subject to noise, the signal quality, for example, articulation in the case of speech, is degraded by the noise. In the case of a continuously or gradually varying signal (for example a speech wave or a speech modulated carrier wave) this degradation increases with the ratio of noise energy to signal energy at the receiver output (after demodulation or detection of the signal in the case of carrier transmission), or in other words the graph plotted with articulation or quality as ordinates and noise-to-signal ratios as abscissae, has a negative slope. However, when the signal is transmitted in stepped wave form, (i. e., with the signal variations occurring in abrupt steps of substantial magnitude), then for noise-to-signal ratios up to a considerable magnitude the quality degradation (due to the noise), though greater than in the case of the gradually varying signal, is substantially uniform, and for higher noise-to-signal ratios it is not materially different from the degradation in the case of gradually varying signal. It is found that, due apparently to this closer approach to uniform quality over a considerable range of noise-to-signal ratio, the signal is received, for example, by a listener when the receiving apparatus is an electro-acoustic reproducer, with greater ease, accuracy and intelligibility when transmitted in stepped wave form than when transmitted as a continuous or gradual variation.

It is also an object of the invention to improve ease, accuracy and intelligibility of reception of signals subject to disturbance by noise where the noise-to-signal ratio varies widely.

Other objects, aspects and features of the in-

2

vention will be apparent from the following description and claims.

The single figure of the drawing shows a frequency modulator embodying a form of the invention.

Oscillator O is shown as a variable frequency RC oscillator of the bridge type disclosed for example in Fig. 5 of R. O. Wise Patent 2,319,965, May 25, 1943, the amplitude control resistance L in oscillator O being shown, however, as a gas-filled tube, as in my Patent 2,345,712, April 4, 1944. The oscillator comprises a vacuum tube V with feedback from the plate to the grid through a direct current stopping condenser C and a frequency determining parallel-T feedback network N of the general type shown in Fig. 23 (d) on page 918 of "Radio Engineer's Handbook," by F. E. Terman, published by McGraw-Hill Book Co., Inc., N. Y., 1943. T₁ is an output transformer for the oscillator. Network N comprises, as one shunt arm, two resistances R and R' in parallel. The resistance R' comprises transformer T and its load. T comprises a primary winding P and a secondary winding S. Its load comprises equal resistances R₁ and R₂ in series, and comprises a variable portion of resistances 11 to 20 and respectively equal resistances 31 to 40. Resistances 11 to 20 and 31 to 40 can be effectively connected across S by diodes 21 to 40 under control of gas-filled discharge tubes 1 to 10 shown by way of example as triodes, which are controlled by signals from signal source M and by switching means, for example of electronic or mechanical type, represented for simplicity by mechanical rotary switches 71 and 72.

Plate current limiting resistances 51 to 60, which may have values of the order of 20,000 ohms, for example, connect the plates of tubes 1 to 10 with cathodes of the diodes as shown.

Discharge currents of the triodes pass from their cathodes through switch 71, plate current supply source B, resistances R₁ and R₂ in parallel, the resistances 11 to 20 and 31 to 40 and the associated diodes, and from the diode cathodes through the limiting resistances to the triode plates. If desired, switch 71 and battery B may be shunted by a high resistance 73, of the order of a megohm, for example. This resistance serves to prevent ionization of the tubes 1 through 9 by possible small leakage across the insulating section 83.

The grids of tubes 1 to 10 are connected to adjustable contacts of potential dividing resistances or potentiometers 61 to 70, preferably through resistors as shown, which serve to prevent inter-

action between ionized and unionized tubes through the mutual output impedance of the vogad 80. This occurs because the grid of a tube which has ionized is held at a positive potential which must be kept from ionizing the following tubes. These latter resistors may have values of the order of one megohm, for example. If desired, the potentiometer resistances may be equal. They may have values of the order of 50,000 ohms, for example. The grid circuits extend through the potentiometers, a high resistance 76, of the order of a megohm, for example, and negative grid biasing sources 75 and 74, to the triode cathodes. The path through resistance 76 and source 75 is shunted by switch 72. The voltages of sources 74 and 75 may respectively have values of 10 volts and 146 volts, for example. Across the potentiometers are connected a positive grid biasing source 77 in series with secondary winding 78 of signal input transformer T_2 for the triodes. The primary winding 79 of the transformer is fed from signal source M. The signal source may be, for example, a microphone or telephone transmitter delivering speech currents. A vogad 80 may be connected between the microphone and the winding 79, so constant volume signals are supplied to the winding 79. The vogad may be a system such, for instance, as that disclosed in H. L. Barney Patent 2,285,794, June 9, 1942, or the paper entitled "A Vogad for radio telephone circuits," by S. B. Wright, S. Doba and A. C. Dickieson, Proceedings of the Institute of Radio Engineers, April 1939, page 254.

The voltage of source 77 may be substantially half the value of the maximum range (negative to positive) of the voltage induced in winding 78, so that, when signals are being delivered by transmitter M, the voltage input to potentiometers 61 to 70, is a direct current or unidirectional voltage varying between the limits zero and a positive value equal to the maximum range of the voltage induced in winding 78. For instance, with this maximum range or swing (negative maximum to positive maximum) adjusted to 60 volts (by means of the vogad) the voltage of battery 77 may be 30 volts.

Te switches 71 and 72 are shown by way of example as mechanical switches, respectively comprising radial contact arms 81 and 91 rotated by the same shaft D in the direction indicated by the arrow headed arcs at a speed of the order of 4,000 revolutions per second, for example. The shaft is driven by any suitable means (not shown). Arm 81 cooperates with stationary contact 82 which, with a short arc of insulation 83, forms a ring or circle. Arm 91 cooperates with stationary contact 93 which, with a long arc of insulation 92 forms a ring. If desired, the arcs 83 and 93 may be approximately equal (in degrees or in radians). Each may be of the order of ten or more per cent of 360 degrees. However, the switch 72 is arranged to close a short time after the switch 71 has closed, as indicated in the drawing, wherein the arm 81 is shown as having just left the insulation 83 and the arm 91 is shown as just arriving at the contact 93. The time interval between the departure of 81 from 83 and the arrival of 91 at 93 may be of the order of one or two percent of the time required for one revolution of shaft D, for example.

Resistances R_1 and R_2 may each be of the order of 5,000 ohms, for example. The resistances 11 to 20 and 31 to 40 may each be of the order of 200,000 ohms, for example; but they will be given values appropriate to yield linear or any

other desired modulation law, and this will not in general result in equal resistances.

The potentiometer contacts are adjusted to respectively supply successively lower potentiometer voltages to the grids of the associated tubes, as indicated in the drawing. If desired, these decrements may be equal to each other and to the potentiometer voltage applied to the grid of tube 10.

In operation of the system, when switch 71 opens, it removes the plate voltage supplied by battery B from the plates of tubes 1 to 10, whereupon all ten of the tubes are non-conducting. After switch 71 again closes, they are maintained non-conducting by grid bias batteries 75 and 74 for an instant until switch 72 closes and thereby short-circuits battery 75 and resistance 76, thus effectively removing battery 75 from the grid circuits. This removal of battery 75 conditions the tubes 1 to 10 to be controlled, throughout the short period in which switch 72 remains closed, by the signal voltage across winding 78, the voltage of battery 77 and the voltage of battery 74.

If that signal voltage is zero, battery 77 will fire tubes 1 to 5. If, on the other hand, that signal voltage is equal and opposite to the voltage of battery 77, all of the tubes 1 to 10 remain unfired, with a negative bias of 10 volts from battery 74. If that signal voltage is positive and equal to the voltage of battery 77, all of the tubes 1 to 10 fire. Whatever that signal voltage, the tubes 1 to 10 are controlled in accordance with the magnitude of such voltage. Thus, in accordance with such magnitude, any of the tubes may fire, the number of tubes that fire being dependent on such magnitude, and the magnitude required to fire any given tube exceeding that required to fire the lower numbered tubes.

After switch 72 again opens, the tubes that fired during the time switch 72 was closed remain fired until switch 71 again opens to complete a cycle of operation; but during this interval between the opening of switch 72 and the opening of switch 71, battery 75 prevents firing of any other tube.

During a cycle of operation such as that just considered, whenever tube 1 is in the conducting condition diodes 21 and 41 effectively connect resistances 11 and 31 in series across winding S, because of the flow of plate current of tube 1 from battery B through the branched circuit comprising R_1 , 11 and 21 in parallel with R_2 , 31 and 41 and thence through resistance 51, tube 1, and switch 71 to battery B. Whenever tube 1 is not in the conducting condition, the circuit across winding S through 11 and 31 in series is effectively open at 21 during those half-cycles of the oscillator wave induced in S that have a given sign and is effectively open at 41 during the alternate half cycles. The oscillator then returns to minimum frequency, a value determined by network N with only R_1 and R_2 across S.

In the same way that tube 1 controls the switching of an associated pair of oscillation frequency control resistors through an associated pair of diodes, so does each of the tubes 2 to 10. Thus, the resistance R' , and consequently the oscillation frequency of the oscillator O, is varied in discrete steps in accordance with the continuous changes in intensity of the signal wave induced in winding 78. That is, the oscillations generated by oscillator O are frequency modulated at the signal frequency in abrupt steps, by the gradually or continuously varying signal;

5

and the stepped envelope of the frequency modulated wave conforms to the modulating signal wave (except during the interval, which from a practical standpoint may be neglected, during which 81 is on segment 83 so the oscillator returns to the reference condition). In the case, for example, in which the modulation law for which the resistances 11 to 20 and 31 to 40 are proportioned is that of linear modulation, a smooth curve drawn as nearly as possible through the centers of the tops of the steps of the envelope of the curve of oscillator frequency versus time would have substantially the same form as the modulating signal wave or the curve of signal intensity versus time. Any desired width, i. e., time duration, of the steps may be provided by appropriate choice of the angular velocity of contacts 81 and 91. Any desired number of different values of oscillator frequency adjustment may be provided by appropriate choice of the number of gas tubes and their associated diodes and resistances.

When any of the triodes 1 to 10 are in the conducting condition, the conducting triodes are conjugate to winding S. Therefore, the currents through these tubes do not flow through winding S. Consequently the starting or stopping of the direct current through tubes 1 to 10 does not produce transient currents in S which, acting through winding P, could apply to the oscillator grid a transient voltage that would be transferred by the oscillator tube to the output through transformer T1. In the system shown, the oscillator frequency is controlled by resistance R', which in turn is controlled by the resistance shunts placed across winding S. The diodes act as switches activated by the gas tubes passing current through them. As one gas tube after another fires, more and more shunt resistances are placed across the coil secondary and the oscillation frequency increases, yet no disturbing pulses are transmitted to the oscillator.

The receiving end of the radio or carrier signalling system in which the frequency modulator of the drawing may be used is not shown, as it may be of customary form, for example, with frequency detecting or frequency demodulating means and telephone receiver or signal reproducer of usual type, for instance.

What is claimed is:

1. Frequency modulating apparatus comprising an oscillator circuit having discrete frequency controlling impedances for connection in varying number in said circuit to vary the oscillator frequency abruptly in steps in accordance with the number of said impedances simultaneously in said circuit, a source of modulating signals, means responsive to said signals for varying the number of said impedances simultaneously in said circuit in accordance with the magnitudes assumed by said signals at prescribed instants, and control apparatus rendering said means responsive to said signals at only said instants regardless of magnitude changes in said signals at other times.

2. In a frequency modulation system, an oscillator circuit comprising discrete resistances for connection in varying number in said circuit to correspondingly vary in steps the oscillator frequency, a source of modulating voltage of continuously varying instantaneous magnitude, means responsive to said voltage at moments separated by prescribed relatively long time intervals of length independent of magnitude changes in said voltage for changing the number

6

of said resistances connected in said circuit in accordance with the instantaneous magnitude of said voltage, and timing circuits for determining the lengths of said intervals.

3. A wave translating system comprising a wave generator having a frequency controlling circuit, discrete impedances for connection in said circuit to vary the frequency of the generated waves, means comprising grid controlled gas tubes respectively associated with said impedances for switching each impedance into said circuit when the gas tube associated with the impedance becomes conductive, means for supplying periodically reduced potential to the plates of said gas tubes, a source of modulating voltage, means operative momentarily after each period of reduced plate potential for rendering said gas tubes subject to triggering by said voltage, and means for rendering the magnitude of said voltage required to trigger said tubes different for each of said tubes.

4. A frequency modulator comprising an oscillator having two terminals, discrete impedances for connection in varying number between said terminals to modulate the frequency of said oscillator, a pair of rectifiers individual to each of said impedances for switching the impedance into and out of circuit, a grid controlled gas tube individual to each pair of rectifiers for controlling the switching operation of the pair, each of said gas tubes having its plate circuit conjugate to said terminals, means for supplying plate potential to said gas tubes, means for supplying a modulating signal to the grids of said gas tubes, with a different magnitude for each grid, and means for periodically interrupting the supply of plate potentials momentarily and after each restoration of the plate potentials conditioning momentarily the grid circuits of said gas tubes for controlling the ionization of said gas tubes in accordance with the modulating signal.

5. A modulating system comprising a plurality of Wheatstone bridges having one diagonal in common and having a pair of adjacent ratio arms in common, each of the two remaining arms of each bridge comprising a resistance and a rectifier in series, said rectifiers in each bridge being oppositely poled with respect to said one diagonal, gas tubes having control grids, means connecting the internal plate-cathode paths of said tubes in the other diagonals of the respective bridges, means for supplying periodically interrupted plate potential to said tubes, a source of modulating voltage, means for connecting said source in the grid-cathode circuits of said tubes, means for causing the magnitude of said voltage required to render said tubes operative different for each of said tubes, means normally preventing said voltage from rendering said tubes operative, means for disabling said preventing means momentarily after each period of plate potential interruption, and an oscillator having a resistance-capacity frequency determining circuit including said one diagonal.

MILTON E. MOHR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,262,468	Percival	Nov. 11, 1941
2,278,658	Kroger	Apr. 7, 1942
2,321,269	Artzt	June 8, 1943