July 2, 1935.

G. L. USSELMAN

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MODULATION

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Fig. 1

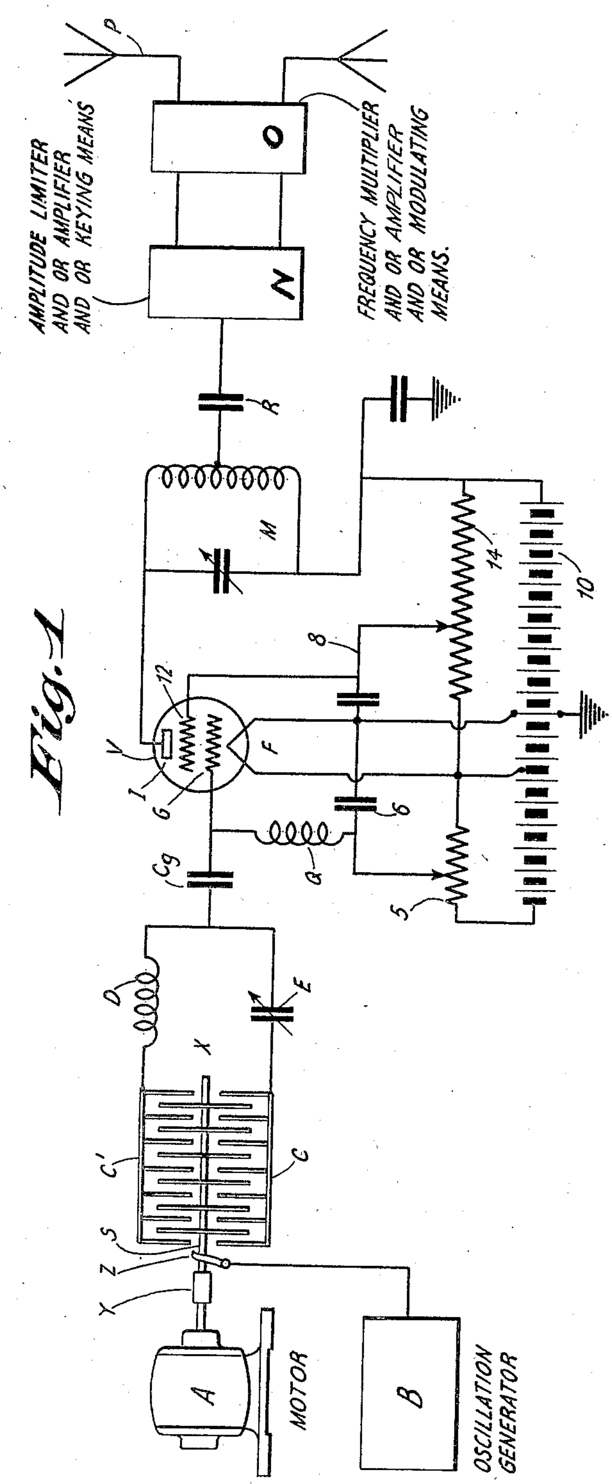


Fig. 3

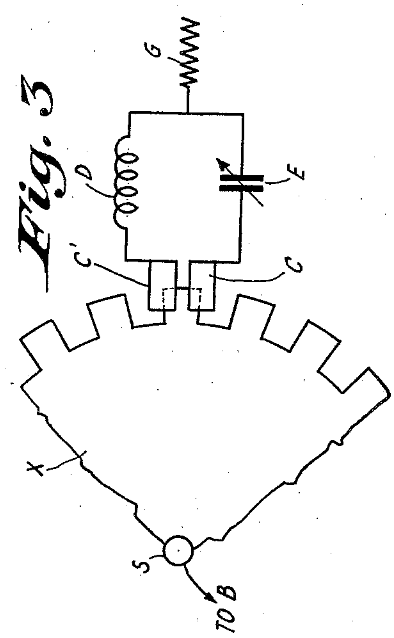
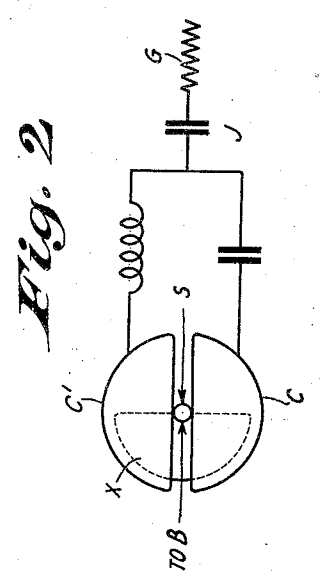


Fig. 2



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MODULATION

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Application September 16, 1932, Serial No. 633,431

22 Claims. (Cl. 179—171)

This invention relates to signalling means and in particular to means whereby the characteristics of high frequency oscillations other than amplitude are varied in accordance with signals to be transmitted.

It has been found that ordinary amplitude modulated high frequency oscillations in transmission from the sending station to the receiving station are subject to what is known as fading effects. In particular, the transmission of telegraph signals in the past was attendant by detrimental fading at the receiver where the diversity receiving system was not in use. This is a decided disadvantage since it introduces drop-outs and errors in the signal. It was later found that if the frequency band of the transmitted signal were spread out or made wider the effect of this fading was reduced.

In the prior art the carrier frequency band was made wider by modulating the amplitude of the carrier energy at some desirable rate, usually in the neighborhood of 500 cycles per second. This produced side bands at, say, 500 cycles above and 500 cycles below the carrier frequency. The signal band was in this case 1000 cycles wide. Amplitude modulation of a telegraph transmitter makes it necessary to reduce the power output to a great extent.

It has been found that the carrier can be modulated in phase to spread the frequency band of the transmitted signal. This produces side bands on each side of the carrier frequency, which also reduces the effects of fading at the receiver.

I have found that if the high frequency oscillations are modulated in phase or in frequency in accordance with the telegraph signal to be transmitted they are less subject to the effect of fading than amplitude modulated waves, assuming like amounts of power are utilized in the transmission. Also the reason why phase or frequency modulated oscillations in telegraph transmission are subject to a less extent to fading effects than oscillations modulated otherwise is that a greater amount of the transmitter power is available for transmission. In other words, a transmitter can operate at full power with phase or frequency modulated telegraph signals, while it is necessary to reduce the power output to about one quarter for amplitude modulation of the same signals If we assume equal power output, reduction of fading should be slightly greater where the oscillations are modulated in phase or frequency than when they are modulated otherwise.

When a high frequency carrier is modulated in phase or frequency in accordance with telegraph signals, such modulation of the carrier is usually accomplished in a stage following the carrier frequency generator, which is usually a crystal control oscillator, or a long line crystal control oscillator, or any other kind of oscillation generator. Furthermore, the keying of the transmitter in accordance with the telegraphy signals, is usually accomplished in a stage subsequent to the modulator stage. Any standard method of keying may be used.

In each of my United States applications, Serial No. 623,558, filed July 20, 1932, serial No. 616,026, filed June 8, 1932, Serial No. 602,487, filed April 1, 1932, and Serial No. 607,932, filed April 28, 1932, I have shown means for varying at signal frequency the characteristics other than the amplitude of a carrier frequency. In each of these arrangements the carrier frequency is impressed through phase shifting means on the control grids of a pair of thermionic tubes which have their anodes connected in parallel to a common tank circuit and their internal impedances varied in phase opposition by the signal wave. In each of these arrangements the phase modulator stage comprises two tubes having their input electrodes symmetrically connected and energized as indicated above, and a common tank circuit connected in parallel to the anodes of said pair of tubes.

In my United States applications Ser. No. 633,955, filed September 20, 1932, and Ser. No. 637,923, filed October 15, 1932, I have shown improved transmitters of the type referred to above. In each of these transmitters one or more thermionic tubes are used to accomplish phase modulation of the carrier frequency.

The present invention relates to an improved and simplified modulating means by which the characteristics of a carrier wave other than amplitude may be varied at any desirable frequency to be transmitted by the use of a single thermionic tube.

More in detail, this invention relates to an improved modulating means to reduce fading in a signal wherein the modulator stage comprises a single tube having a control grid coupled alternately to a source of high frequency oscillations of constant frequency by way of two branch circuits each including phase shifting means of different characteristics. The coupling between said branch circuits and said high frequency oscillations varies at a certain frequency whereby the high frequency oscillations are modulated in phase at this frequency.

The present invention is applicable either to new installations or to transmitters now in use. In the latter case any single tube stage in a transmitter may be readily adapted to phase modulation in accordance with the present invention. This changeover may be made easily at a small cost.

An apparent advantage to be gained by the use of the present invention results from the fact that the carrier frequency and modulating waves are applied to the thermionic modulator through a purely mechanical means of simple and durable nature. This results in low first cost and economic upkeep.

The novel features of my invention have been pointed out with particularity in the claims appended hereto.

The nature of my invention and the operation thereof will be best understood from the following detailed description thereof and therefrom when read in connection with the drawing, throughout which like reference numerals indicate like parts, and in which:

Figure 1 illustrates a specific embodiment of the invention; while

Figures 2 and 3 illustrate a detail and a modification of the arrangement of Figure 1.

The practice in prior art has been to use vacuum tubes to shift the phase in a phase modulator stage to phase modulate a telegraph transmitter. To reduce fading in telegraph signals by phase modulation it is only necessary to modulate the phase of the carrier frequency of the transmitter at some desirable but uniform frequency, usually between 300 and 1000 cycles per second. The present invention does this simply with a phase splitting circuit and a motor driven rotary condenser. The way in which this is accomplished is described below in connection with the drawing.

A specific embodiment of my invention is shown schematically in Figures 1, 2 and 3. Referring to Figure 1, the motor A drives the shaft S of rotary condenser C—X—C′ through the insulated shaft coupling Y. The upper part C′ of the rotary condenser is connected to the grid G of tube V through the phase shifting inductance coil D while the lower part of the rotary condenser is connected to grid G of tube V through the phase shifting capacity or condenser E. Tube V is shown as the screen grid or four element type, but by using a neutralized circuit a three element tube may be used. Direct current biasing potential for the grid G of tube V is supplied by way of choking inductance Q (a resistor may be used if preferred) from a potentiometer 5 connected as shown in parallel with a portion of source 10. A low impedance path for alternating currents passing through Q is provided by condenser 6 connected as shown between Q and the grounded lead of the heating circuit for cathode F. Alternating current in tank circuit M is shunted around source 10 by means of a by-pass condenser 8 connected as shown. Charging potential for the screen electrode 12 of tube V is provided by a filter circuit comprising a lead 8 tapped to a point on potentiometer resistance 14 and a condenser connected as shown.

The output of tube V and tank circuit M is connected by a line R to stage N, which may be a limiter, a frequency multiplier, an amplifier, or all three combined. Stage N is coupled to stage O by lines S—S. Stage O may be a frequency multiplier, an amplifier, or both. The output of stage O is connected to a load circuit, which is the transmission line and antenna P in this case. The oscillator B is connected to the rotatable element X of the rotary condenser by the sliding contact Z which rests on the element which rotates the plates X.

Figure 2 shows an end view of the rotary condenser used in the modulator of Figure 1. As shown here, the movable plates X, which are connected with the high frequency oscillator, are driven by an element S relative to the fixed plates C′ and C. The plates C′ and C are conductively connected as shown to the phase shifting elements D and E respectively.

The transmitter keying means has not been shown but it may be keyed or modulated by any of the well known methods. The modulating or keying of the energy may be accomplished in any stage following the phase modulator, as indicated in the drawing.

The operation of the phase modulator will now be set forth. In the following statement of the operation assume that the motor A is driving the shaft S and the rotating element X of the rotary condenser X—C—C′ at a speed to give the desired rate or frequency of phase shift or modulation. We may assume this speed gives, say, 500 cycles per second modulation. If the oscillator B is delivering constant high frequency energy, say 2,000,000 cycles per second to X by way of contact Z and the shaft S of the rotary condenser, the two stationary halves C′ and C will become excited with high frequency energy alternatingly at a rate of 500 cycles per second (assumed). The insulator Y prevents this excitation from B from escaping to ground through the motor A. The excitation from C′ passes to the grid G through the phase retarding inductance D. The excitation from C passes to the grid G through the phase advancing capacity E. Since C′ and C are alternately excited at a 500 cycle rate, the phase of the high frequency excitation reaching the grid G will be retarded and advanced in phase at a 500 cycle rate. Consequently the phase of the carrier frequency transmitted or radiated by the antenna will be phase modulated at a 500 cycle rate or at a rate determined by the speed of the rotary condenser C′—X—C. Amplitude limiters or frequency multipliers may be used in the transmitter before the signal is finally amplified and radiated by the antenna. Consequently the signal characters radiated from the transmitter will be modulated in phase at the assumed 500 cycle rate.

The operation of the rotary condenser is simply to capacitively couple the oscillator B alternately to the excitation phase retarding element D and the excitation phase advancing element E, from which elements the excitation energy is conducted to the grid G of tube V. The anode current of tube V causes the oscillations in tank circuit M to be phase modulated and from this circuit the radio frequency in the following stages of the transmitter is phase modulated at a regular rate. The carrier energy of the transmitter may be keyed or modulated by the signal with any suitable means before it is radiated by the antenna. This keying or interrupting of the phase modulated carrier energy may be accomplished in any stage of the transmitter. Preferably, keying, modulating, or interrupting of the phase modulated carrier is accomplished in any stage subsequent to the modulator stage. For example, this operation may be accomplished as indicated either in stage N or O.

When it is desired to obtain a higher modulating frequency without increasing the speed of the motor A an arrangement as shown in Figure 3 may be used. In this compound rotary condenser of Figure 3 the rotatable element X takes the form of a disk with teeth fastened to the periphery of the rotating disk which is mounted on a shaft S for rotation by the motor A. The plates C, C' are mounted adjacent the path of rotation of the teeth of X so that the capacity between the disk X and the plates C', C alternately increase and decrease. This alternate increase and decrease of coupling is transferred by way of phase shifting means D and C to the control electrode G of tube V, the same as in Figure 1. Due to the fact that there are a plurality of teeth X on the disk 14, a single rotation of the shaft S alternately increases and decreases the coupling between the rotatable disk 14 and the fixed plates C', C a number of times. The capacity X—C—C' may comprise a single disk X and single plates C', C or a plurality of disks X and a pair of fixed plates C', C located adjacent the periphery of each of the disks X so that the coupling between the disk X and the plates C', C will alternately increase and decrease as the teeth of the disk X move toward the plates C', C.

Having thus described my invention and the operation thereof, what I claim is:

1. Phase modulating means comprising a source of high frequency oscillations, a thermionic tube, a rotatable condenser, a connection between one armature of said condenser and the control electrode of said tube, a connection between the other armature of said condenser and said source of high frequency oscillations, and a motor for rotating said condenser at a modulating frequency rate.

2. Phase modulating means comprising a source of high frequency oscillations, a thermionic tube, parallel variable capacities connected in series between the control electrode of said tube and said high frequency oscillation source, and means for varying said capacities in opposite sense at a modulating frequency rate.

3. Modulating means comprising a source of high frequency oscillations, a thermionic tube, parallel variable condensers connected in series between the control electrode of said tube and said high frequency oscillation source, and means for alternately increasing and decreasing the capacity of said condensers at a modulating frequency note.

4. Signalling means comprising a source of high frequency oscillations, a thermionic tube, a pair of paths of different electrical characteristics connected to the control electrode of said tube, reactances for coupling said paths to said source of oscillations, and means for varying the values of said reactances in opposite sense at a frequency, low in comparison to the carrier frequency.

5. Signalling means comprising a source of high frequency oscillations of constant amplitude, a thermionic tube, a pair of conductors of different electrical impedances connected to the control electrode of said tube, and mechanical means for coupling said conductors to said source of oscillations and for changing the value of the coupling between the respective conductors and said source between predetermined maximum and minimum values in a complementary sense.

6. Modulating means comprising a thermionic tube, a work circuit connected between the output electrodes of said tube, a pair of paths of different electrical characteristics connected to the control electrode of said tube, the other terminals of said paths being connected to the stator plates of a condenser, a source of high frequency oscillations connected to the rotor plates of said condenser, and means for rotating the rotatable plates of said condenser at a rate of the order of an audible frequency.

7. Signal modulating means comprising a source of high frequency oscillations, a thermionic relay tube, a tuned circuit connected between the output electrodes of said tube, a pair of paths of different electrical characteristics connected to the control electrode of said tube, the other terminals of said paths being connected to the stator plates of a condenser having two stators and a rotor, means for connecting said source of high frequency oscillations to the rotor plates of said condenser, and means for rotating the rotatable plates of said condenser.

8. Signal modulating means comprising a source of high frequency oscillations of constant frequency, a thermionic tube, a tuned tank circuit connected between the output electrodes of said tube, a pair of paths connected to the control electrode of said tube, one of said paths including a phase retarding element, the other of said paths including a phase advancing element, means for connecting the other terminal of each of said paths to a stator of a condenser having two stators and a rotor, means for connecting said source of high frequency oscillations to the rotor of said condenser, and means for rotating the rotor of said condenser at a desired modulating frequency rate.

9. Signal modulating means comprising a thermionic tube having input and output electrodes, a work circuit connected to the output electrodes of said tube, a pair of transmission channels of different electrical characteristics connected to the input electrode of said thermionic tube, a compound condenser comprising a pair of fixed plates and a set of rotatable plates, a connection between each of said transmission channels and one of said fixed plates, a source of high frequency oscillations connected to said rotatable plates, and means for rotating said rotatable plates at a desired frequency rate.

10. The combination of a frequency multiplier, a thermionic relay tube having its output electrodes connected thereto, a compound condenser comprising a movable plate, a pair of fixed plates, reactances of different character connecting said fixed plates to the input electrodes of said thermionic relay tube, said movable plate being adapted to be rotated at a rate equal to an audible frequency, and a high frequency oscillator connected to said movable plate.

11. Phase modulating means comprising in combination a thermionic tube, a variable capacity having a pair of fixed elements and a rotatable element, said fixed elements each being connected through series reactances to the input electrodes of said tube, a source of high frequency oscillations connected to said rotatable element, and means for driving said rotatable element.

12. The combination of a frequency multiplier, an amplitude limiter connected thereto, a thermionic tube having its output electrodes connected to said limiter, a condenser comprising a pair of fixed plates connected to the input electrodes of said thermionic relay tube said condenser also comprising a rotatable plate of mechanical means for rotating said rotatable plate, and a high frequency oscillator connected to said rotatable plate.

13. Signal modulating means comprising a thermionic tube having input and output elec-

trodes, a tank circuit connected to the output electrodes of said tube, a pair of transmission channels connected to the input electrode of said thermionic tube, one of said channels being capacitive in character, the other of said channels being inductive in character, a condenser comprising a pair of fixed plates and a movable plate, a connection between each of said transmission channels and one of said fixed plates, a source of high frequency oscillations connected to said rotatable plate, means for rotating said rotatable plate at a low frequency rate, means for tuning said tank circuit to a frequency which is a multiple of the frequency of said source, and means for keying or modulating the resulting phase modulated high frequency energy at signal frequency.

14. Signal modulating means comprising a thermionic tube having input and output electrodes, a tank circuit connected to the output electrodes of said tube, a pair of transmission channels connected to the input electrode of said thermionic tube, one of said channels being capacitive in character, the other of said channels being conductive in character, a pair of fixed plates and a movable plate, a connection between each of said transmission channels and one of said fixed plates, a source of high frequency oscillations connected to said rotatable plate, means for rotating said rotatable plate at a low frequency rate, means for tuning said tank circuit to a frequency which is a multiple of the frequency of said source of oscillations, means for keying or modulating the resultant phase modulated high frequency energy at signal frequency, and radiating means coupled to said tank circuit.

15. Wireless telegraphy means comprising a source of high frequency oscillations, means for wobbling the phase of said oscillations comprising a thermionic tube, said tube having input and output electrodes, capacities connecting the input electrode of said tube to said source of high frequency oscillations by way of reactances of unlike character, means for varying said capacities at a rate equivalent to an audible frequency and keying means connected with the output of said tube.

16. Telegraphy signalling means comprising, a thermionic tube having input and output electrodes, a pair of conductors of different electrical characteristics connected to the input electrode of said tube, means for applying high frequency oscillations to said conductors, said oscillations being alternately applied at a rate equivalent to an audible frequency, a work circuit coupled to the output electrodes of said tube, and keying means interposed between said work circuit and the output electrodes of said tube.

17. Telegraphy means comprising a thermionic tube having input and output electrodes, a pair of conductors of different electrical characteristics connected to the input electrode of said tube, means for alternately applying high frequency oscillations to said conductors, said oscillations being alternately applied at low frequency rate, a tank circuit connected between the output electrodes of said tube, said tank circuit being tuned to a multiple of the frequency of the applied high frequency oscillations, a utilization circuit, and relaying means includin keying means connecting said tank circuit to said utilization circuit.

18. In a telegraph transmitter the combination of, phase modulating means, frequency multiplying means and amplifying means coupled thereto, said phase modulating means comprising a thermionic tube having input and output electrodes, a pair of conductors of different electrical characteristics connected to the input electrode, means for alternately applying high frequency oscillations to said conductors, said oscillations being applied at a low frequency rate, and means coupled to the output electrodes of said tube for keying or modulating the phase modulated carrier energy in accordance with the signals to be transmitted.

19. Signal modulating means comprising, a thermionic tube having an output circuit connected between its output electrodes and a direct current circuit including an impedance and a source of potential connected between its input electrodes, a condenser comprising a pair of fixed plates and a stator plate mounted adjacent said fixed plates, a motor and a source of high frequency oscillations connected to said stator plate, a capacity having one terminal connected to the control grid of said tube and an inductance connecting the other terminal of said capacity to one of said fixed plates, and a capacity connecting said other terminal of said condenser to the other fixed plate of said condenser.

20. Signal modulating means comprising, a thermionic tube having an input electrode, a pair of high frequency conductors of different electrical characteristics connected to the input electrode of said thermionic tube, a compound condenser comprising a pair of fixed plates and a movable plate, a connection between each of said transmission lines and one of said fixed plates, a source of high frequency oscillations connected to said movable plate, and means for moving said movable plate relative to said fixed plates at a modulating frequency rate.

21. A transmitting system comprising a source of high-frequency oscillations, an inductive circuit for said oscillations, a capacitive circuit for said oscillations, means to continuously cause, alternately, maximum energy to flow from said source through said circuits, means combining the energy flowing through said circuits, said combined energy being in the form of oscillations continuously varied in phase, means to impress a signal to be transmitted upon said phase-varied oscillations, and means for transmitting said oscillations bearing said phase variations and said signal.

22. In a transmitter for reducing fading effects, a source of high-frequency oscillations, an inductive circuit, a capacitive circuit, each of said circuits being connected to said source, means for increasing the flow of oscillations from said source through said inductive circuit while decreasing the flow of oscillations from said source through said capacitive circuit, and for decreasing the flow of oscillations from said source through said inductive circuit while increasing the flow of oscillations from said source through said capacitive circuit, means for combining the oscillations flowing through said circuits whereby said combined oscillations form oscillations continuously varying in phase, means for amplifying said oscillations varying in phase, means for impressing a signal on the amplified oscillations, and means for transmitting said oscillations bearing said signal.

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