Oct. 27, 1936. G. L. USSELMAN 2,058,928

MODULATION

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Fig. 1

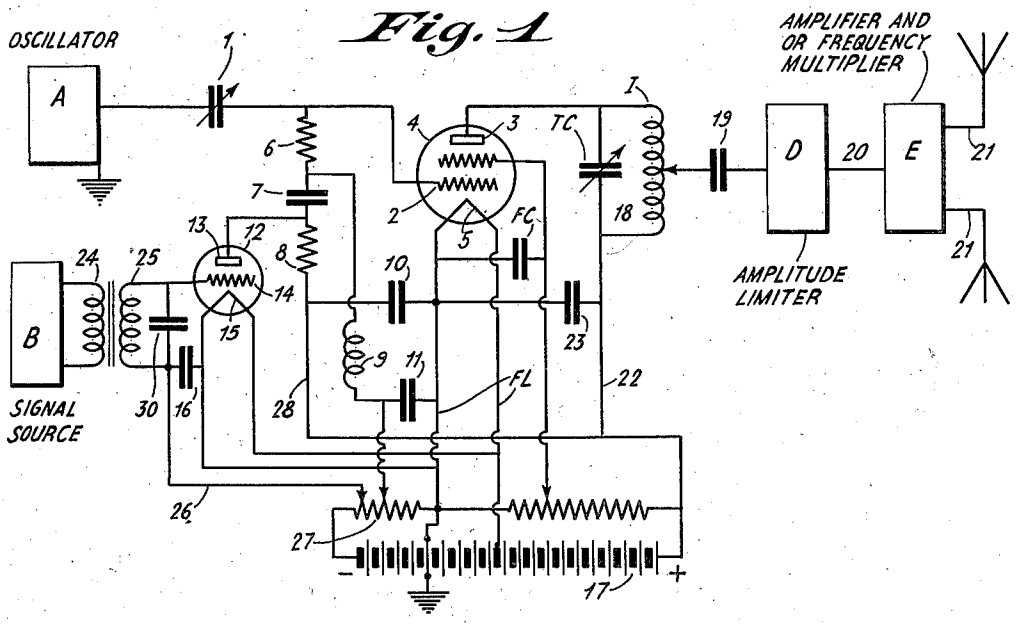
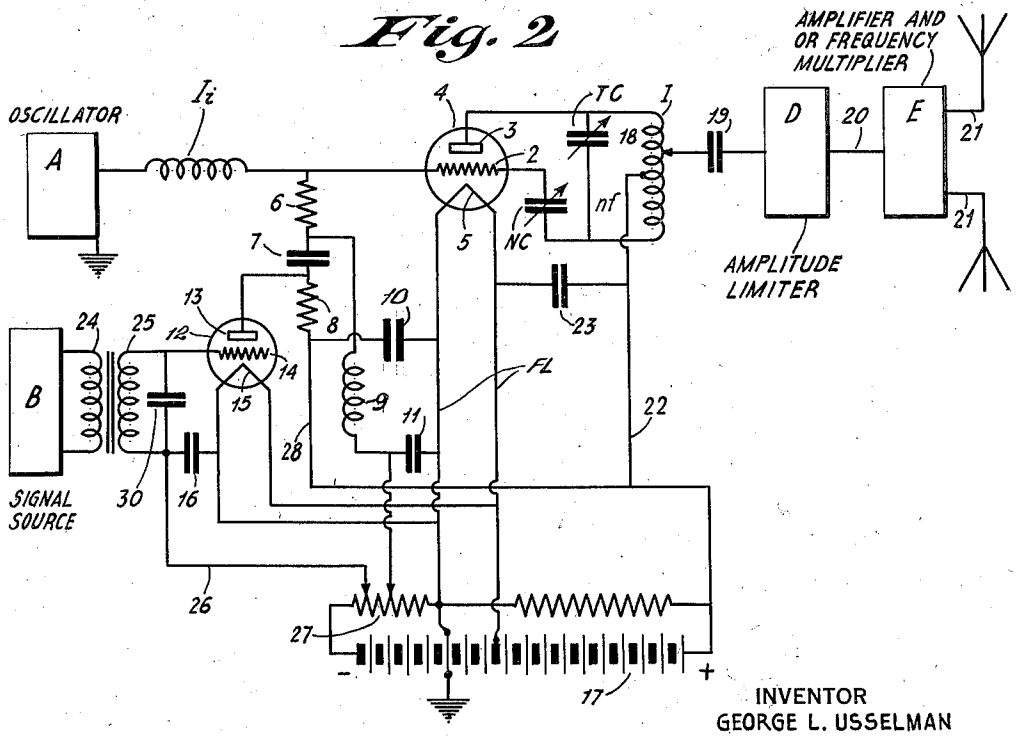


Fig. 2



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MODULATION

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13 Claims. (Cl. 179—171)

This invention relates to signaling 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. This is a decided disadvantage since it introduces drop-outs and errors in the signal. Even where diversity receivers are used to receive the amplitude modulated signals the effect of fading is of serious disadvantage.

I have found that if the high frequency oscillations are modulated in phase or in frequency in accordance with the 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. The reason why phase or frequency modulated oscillations in transmission are subject to a less extent to fading effects than oscillations modulated otherwise is that a greater amount of the transmitted power is available for transmission. In other words, a transmitter can operate at full power in phase or frequency modulation, while it is necessary to reduce the power output to about one quarter for amplitude modulation. Assuming equal power output, reduction of fading may be slightly greater in phase or frequency modulation than in other kinds of modulation.

In each of my United States applications, Serial No. 623,558, filed July 20, 1932, Serial No. 616,026, filed June 8, 1932, Patent No. 2,036,165, March 31, 1936, Serial No. 602,487, filed April 1, 1932, Patent No. 2,036,164, March 31, 1936, 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 to 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.

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 in accordance with the signal to be transmitted.

More in detail, this invention relates to an improved modulating means wherein the modulator stage comprises a single tube having a control grid connected to a source of oscillations of constant frequency, through phase shifting means, by way of a compound circuit which includes a radio frequency path, the resistance of which may be varied at signal frequency, thereby varying the resistance of the grid circuit of the tube and consequently the phase of the oscillations repeated therein at signal 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 the transmitter may be readily adapted to phase modulation in accordance with the present invention. This changeover may be made easily at a small cost.

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

Figure 2 illustrates a modification of the arrangement of Figure 1.

In describing my invention reference will be first made to the arrangement shown in Figure 1. A constant frequency oscillator A of any known type, as, for example, a crystal or long line frequency control type oscillator, is connected through impedance 1 to the grid 2 of tube 4. Constant or steady direct current bias is supplied to grid 2 from the source 17 through choke coil 9 and resistor 6. The lower end of choking inductance 9 is grounded for radio frequency through condenser 11 connected between 9 and one side of the filament heating circuit FL. The radio frequency output circuit of oscillator A is completed by way of ground since A is grounded and one of the leads FL is connected to the grounded terminal of source 17. The anode 3 of tube 4 is connected to the tank circuit 18 as shown in Figure 1. The tank circuit 18 comprises an inductance I and a tuning capacity TC. The lower end of inductance I of tank circuit 18 is connected by lead 22 to the positive end of

source 17. The tank circuit 18 is also grounded for radio frequency by condenser 23 connected between lead 22 and the filament circuit FL. The cathode 5 of tube 4 is connected to the power source, as shown, by the cathode heating circuit FL. The tube 4 in the modulator stage is shown as a screen grid type of tube, but a three element tube may be used by using a grid to plate capacity neutralizing circuit. When a screen grid tube is used the screen grid electrode thereof may be charged, as shown, through a filter circuit FC connected to 17.

The output of the stage including tube 4 is connected through line 19 to the amplitude limiter stage D. Stage D is connected through line 20 to stage E, which may consist of several stages of frequency multipliers or amplifiers or one or more of such devices. The output of stage E is connected through lines 21—21 to the antenna.

The signal source B is connected to the primary winding 24 of transformer having a secondary winding 25. One end of the secondary winding 25 of transformer is connected to the grid 14 of thermionic tube 12 and the other end of the secondary winding 25 is connected by lead 26 to a point on the resistance 27 connected in parallel to the source of direct current 17, as shown in Figure 1. This end of the secondary winding is also connected to the cathode 15 of tube 12 through by-pass condenser 16. In order to prevent radio frequency potentials appearing in the winding 25 and being transferred to source B, the winding 25 is shunted by a by-pass condenser 30. This by-pass condenser should be large enough to shunt the radio frequency potentials around 25, but small enough not to affect the audio frequency potentials applied to the grid electrode of 12.

The anode 13 of tube 12 is connected by lead 28 to the positive end of source 17 through resistor 8 as shown. The lower end of resistor 8 is grounded for radio frequency through a by-pass condenser 10 connecting said resistance to the cathode heating circuit FL. The upper end of resistor 8, besides being connected to anode 13, is also connected through the radio frequency by-pass condenser 7 to a point between resistor 6 and choke 9.

Tube 4 is the phase modulator and tube 12 is the modulating potential amplifier. Impedance 1 and resistors 6 and 8 comprise the phase shifting circuits. If oscillator A is supplying carrier energy, the excitation voltage on the grid 2 of tube 4 will have a certain phase shift or angle as compared with that delivered by oscillator A, due to the action of impedance 1 and resistors 6 and 8. The tube 12, the anode to cathode impedance of which is in effect connected in parallel with resistor 8 for radio frequency, has a steady anode current when there is no signal. Consequently, the phase angle of the excitation voltage on grid 2 of tube 4 is steady or constant. Now if signal frequency is started from source B, the bias voltage on grid 14 of tube 12 will change. This will cause a change in the anode to cathode impedance of tube 12 and in the anode current of tube 12. The radio frequency impedance of this tube is thus changed so that the effective radio frequency impedance of the parallel combination of tube 12 and resistor 8 is changed. As the bias voltage of grid 14 is driven positively, the anode current in tube 12 increases and the radio frequency impedance of the tube decreases and, as the grid bias voltage is driven negatively, the tube impedance increases.

Any change in the resistance connected to the grid 2 of tube 4 will cause a change in the phase angle of the excitation voltage reaching this grid. This change in phase shift will follow the signal from source B and may be used for phase modulating the transmitter. Amplitude modulation will also be produced but this can be limited out by stage D.

It will be understood that the variable capacity 1, which serves to shift the phase of the high frequency oscillations reaching the grid 2 of tube 4, may be replaced by any known phase shifting means. For example, this capacitive impedance may be replaced by an inductive impedance I_1, as shown in Figure 2. Moreover, this phase shifting means may comprise the combination of an inductance and capacity. The tube 4 of Figure 1 may be replaced by a three-electrode tube, as indicated in Figure 2. Where a three-electrode tube is utilized, in order to prevent feed-back between the input and output circuits due to the capacity between the electrodes in tubes, a neutralizing circuit, as shown in Figure 2, may be provided. The arrangement of Figure 2 is otherwise the same as the arrangement of Figure 1 and a further description thereof is thought unnecessary at this point.

The arrangement of Figure 2 operates the same as the arrangement of Figure 1 and the operation thereof need not be set forth at this point. It might be said, however, that the tank circuit of Figures 1 or 2 may be tuned to the fundamental or to any harmonic thereof, as indicated in Figure 2.

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

1. A signaling system including, a source of carrier frequency oscillations, a thermionic tube having input and output electrodes, a work circuit connected with the output electrodes of said tube, a compound carrier frequency input circuit connected with the input electrodes of said tube, said compound circuit including two parallel carrier frequency paths connected by a resistance between the input electrodes of said tube, one of said paths including a fixed impedance and the other a variable impedance including the anode to cathode impedance of an additional tube, means for impressing high frequency oscillations from said carrier frequency source on said input circuit, and means for varying said variable impedance at signal frequency including a source of signal potential connected with the control grid of said additional tube whereby the character of the high frequency oscillations applied by said first named impedance to the input electrodes of said tube is varied at signal frequency.

2. A device for impressing phase modulations at signal frequency on high frequency oscillations comprising, a thermionic tube having input and output electrodes, a tuned tank circuit connected between the output electrodes of said tube, an alternating current circuit connected between the input electrodes of said tube, said alternating current circuit including fixed impedances in series, means for impressing high frequency oscillations on said input electrodes, and means for varying the phase of the oscillations impressed on said input electrodes at signal frequency including, a thermionic tube having its output electrodes connected in parallel with an impedance in said input circuit to form a high frequency alternating current path in shunt to said impedance, means for applying signal potentials to the input electrodes of said last tube, and a frequency multi-

plier connected to said tank circuit to increase the degree of phase modulation.

3. The combination of a source of high frequency oscillations, a source of signal potentials, of means for modulating the phase of the oscillations at the rate of the signal potentials to an extent proportional to the amplitude of the signal potentials including, a thermionic tube having input and output electrodes, a compound circuit connecting the input electrodes of said thermionic tube to said source of high frequency oscillations, a thermionic tube for impressing signal potentials on one branch of said compound circuit, and an amplitude limiter coupled to the output electrodes of said tube for suppressing any amplitude modulation inherently produced during said phase modulation.

4. The combination, with a source of high frequency oscillations, of means for modulating the phase of said oscillations in accordance with signal potentials including, a thermionic tube having a control grid and a cathode, a variable impedance connecting the control grid of said tube to said source of oscillations, a plurality of fixed impedances connected in parallel between the control grid and cathode of said tube, one of said fixed impedances being an ohmic resistance, an additional thermionic tube having an anode, a cathode and a control grid, means for connecting the anode of said additional tube to one terminal of said ohmic resistance, means for connecting the cathode of said additional tube to the other terminal of said ohmic resistance, and means for applying signal potentials to the control grid and cathode of said additional tube.

5. The combination with a source of high frequency oscillations of means for modulating the phase of said oscillations in accordance with signal potentials including, a thermionic tube having a control grid, an anode and a cathode, a variable impedance connecting the control grid of said tube to said source of oscillations, a plurality of fixed impedances connected between the control grid and cathode of said tube, one of said fixed impedances being an ohmic resistance, an additional thermionic tube having anode, cathode and control grid electrodes, means for connecting the anode of said additional tube to one terminal of said ohmic resistance, means for connecting the cathode of said tube to the other terminal of said ohmic resistance, means for applying signal potentials to the control grid and cathode of said additional tube to vary the anode to cathode impedance thereof, a tank circuit connected between the anode and cathode of said first named tube, an amplitude limiter connected with the tank circuit to compensate for any amplitude modulations inherently produced in said oscillations and a frequency multiplier connected with said amplitude limiter to increase the degree of phase modulation accomplished.

6. A device for modulating the phase of oscillations from a constant frequency source comprising, a thermionic tube having a control electrode, an alternating current input circuit comprising two parallel branches connected with said control electrode, one of said branches including a resistance the current through which may be varied, a separate circuit for impressing high frequency oscillations from said source on said control electrode, and thermionic means for varying the resistance of said one of said branches at signal frequency to thereby vary the phase of the oscillations impressed on said control electrode.

7. Signaling means comprising, a thermionic tube having input and output electrodes, a compound input circuit connected with the input electrodes of said tube, said compound input circuit including two branches, one of said branches including a resistance, the other of said branches including a direct current resistance in series with the anode to cathode impedance of a second thermionic tube, a reactance for impressing high frequency oscillations on the input electrodes of said first named tube, and means for varying the phase of the oscillations impressed on the input electrodes of said first named tube, including means for impressing signal potentials on the input electrodes of said second named tube to vary the anode to cathode impedance thereof.

8. In a phase modulation system, an electron discharge device having an anode, a cathode and a control grid, a source of oscillatory energy of carrier wave frequency, a capacitive reactance connecting said source of oscillatory energy to said control grid for applying oscillatory energy thereto, an impedance and a resistance connecting said control grid and cathode in an alternating current circuit, an additional electron discharge device having an anode, a cathode and a control grid, an alternating current circuit connecting the anode and cathode of said additional device in series with said impedance and in shunt to said resistance, a source of modulating potentials connected to the control grid and cathode of said additional device to control the impedance of said last named alternating current circuit and thereby control the phase of the oscillatory energy applied to the control grid of said first named device, and an alternating current circuit connected with the anode and cathode of said first named device.

9. In a phase modulation system, an electron discharge device having an anode, a cathode and a control grid, a source of oscillatory energy of carrier wave frequency, an inductive reactance connecting said source of oscillatory energy to said control grid for applying oscillatory energy thereto, an impedance and a resistance in series connecting said control grid and cathode in an alternating current circuit, an additional electron discharge device having an anode, a cathode and a control grid, a second alternating current circuit connecting the anode and cathode of said additional device in shunt to said resistance, a source of modulating potentials connected to the control grid and cathode of said additional device to control the impedance thereof and thereby control the phase of the oscillatory energy applied to the control grid of said first named device, and an alternating current circuit connected with the anode and cathode of said first named device.

10. A phase modulation system as recited in claim 8 in which said alternating current circuit connected with the anode and cathode of said first named device is tuned to a frequency which is a harmonic of the frequency of the oscillatory energy of said source.

11. A phase modulation system as recited in claim 9 in which said alternating current circuit connected with the anode and cathode of said first named device is tuned to a frequency which is a harmonic of the frequency of the oscillatory energy of said source.

12. A phase modulating system comprising a source of oscillations to be modulated, a tube having a cathode, an anode, and a control electrode, an output circuit connected to said anode and cathode, a condenser connected between said

source and said control electrode for subjecting said control electrode to oscillations from said source, a series circuit including a condenser and a resistance connected across said control electrode and cathode, the connection point of said series circuit to said control electrode lying on the control electrode side of said first mentioned condenser, a discharge device having a plate, a grid, and a cathode, means connecting the plate and the cathode of said device to the resistance of said series circuit, and means for applying signaling potentials to the grid of said device whereby the phase of oscillations impressed upon the control electrode of said tube through said first mentioned condenser is varied.

13. A phase modulating system comprising a source of oscillations to be modulated, a tube having a cathode, an anode, and a control electrode, an output circuit connected to said anode and cathode, an inductor connected between said source and said control electrode for conveying oscillations from said source to said control electrode, a series circuit including a condenser and a resistor connected across said control electrode and cathode, the connection point of said series circuit to said control electrode lying on the control electrode side of said inductor, a discharge device having a plate, a grid, and a cathode, means connecting the plate and cathode of said device to the resistor of said series circuit, and means for applying signaling potentials to the grid of said discharge device whereby the phase of oscillations impressed upon the control electrode of said tube through said inductor is varied.

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