Jan. 25, 1927. 1,615,645

A. NYMAN

COMBINED WIRELESS SENDING AND RECEIVING SYSTEM

Original Filed July 15, 1920 2 Sheets-Sheet 1

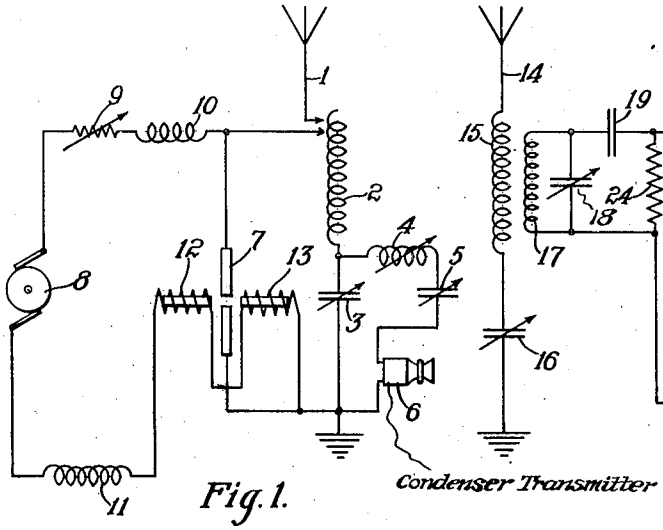



Fig. 1.

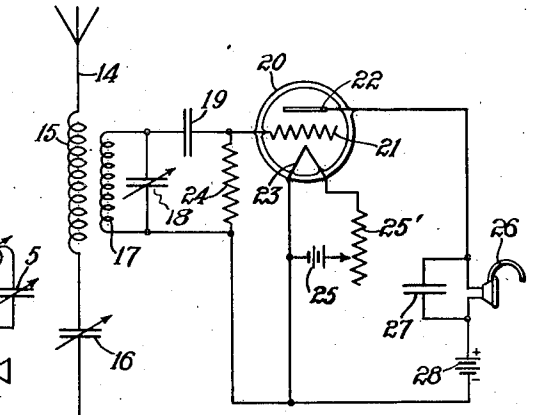



Fig. 2.

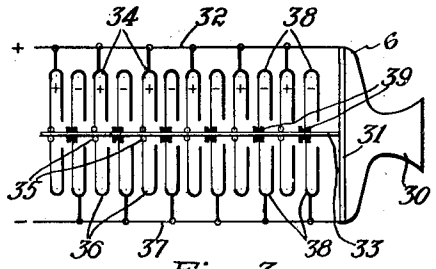



Fig. 3.

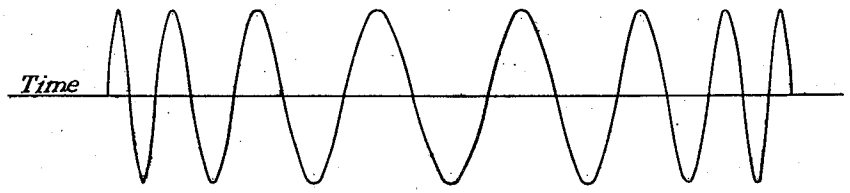



Fig. 4.

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COMBINED WIRELESS SENDING AND RECEIVING SYSTEM

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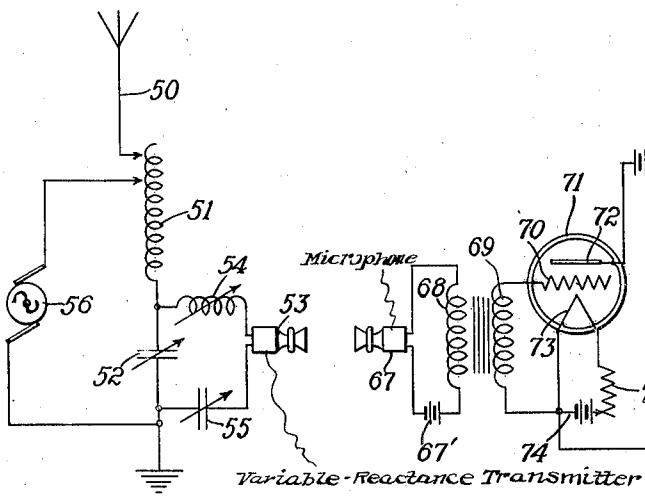



Fig. 5.

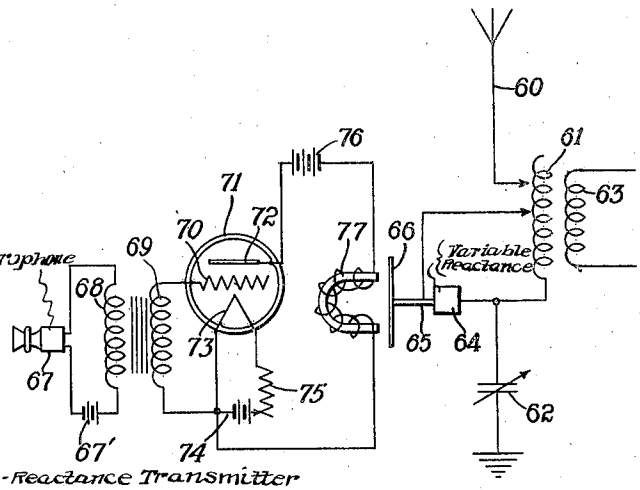



Fig. 6.

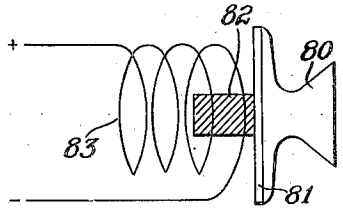



Fig. 7.

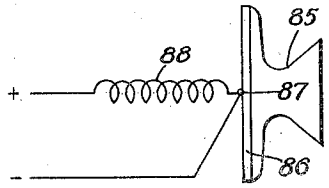



Fig. 8.

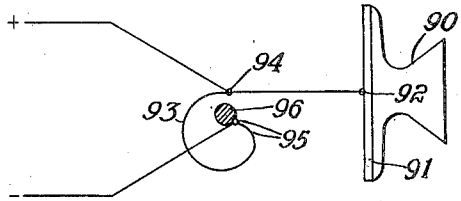



Fig. 9.

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# UNITED STATES PATENT OFFICE.

ALEXANDER NYMAN, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

## COMBINED WIRELESS SENDING AND RECEIVING SYSTEM.

Application filed July 15, 1920, Serial No. 396,530. Renewed January 28, 1926.

My invention relates to the sending and receiving of wireless signals by means of changing the lengths of the transmitted waves.

More particularly, my invention relates to a system for wireless sending and receiving of messages in which the transmitted wave is caused to vary in length in accordance with sound vibrations that are impressed upon the sending circuit to vary the length of the transmitted wave.

An object of my invention is to provide a method for the transmission and receipt of wireless signals, where the transmitted wave is varied in length in accordance with the variations in the value of reactance, corresponding to sound vibrations in the transmitting circuit and in which the receiving station is tuned to a frequency slightly above or below the average sending frequency, so that an increase or reduction in the sending frequency will either increase or reduce the strength of the current flowing in the receiving circuit.

Another object of my invention is to provide simple and practicable apparatus that will be especially adapted for changing the length of the transmitted wave in accordance with the voice vibrations.

One of the problems of wireless telegraphy has always been to, in some manner, transmit signals of audible frequency impressed upon waves of radio frequency. The radio-frequency waves have often periods less than 1/500,000 of a second and, as this is far beyond the range of audibility, it is neccessary to transmit, in some manner, vibrations of approximately 1/1000 of a second or less so that the ear can catch the signal sent. To achieve this result, it has been customary to vary the amplitude of the radio-frequency vibrations in accordance with audio-frequency vibrations, such as the voice. The voice waves were so impressed upon the radio waves that they formed an envelope that bounded the radio waves and restricted their amplitude to correspond to the voice waves. Thus, every audible signal was composed of a plurality of radio waves of an amplitude restricted in accordance with an envelope corresponding to the voice vibrations.

The customary system of wireless transmitting and receiving by varying the amplitude of the transmitted wave has caused considerable difficulty in large-power, wireless-telephone transmitting stations, for the present practice is to modulate the amplitude of the oscillations by inserting a microphone transmitter in some part of the sending circuit. Such microphones must, of necessity, handle a large amount of power and their design is difficult and their operation inefficient.

By my scheme of varying the frequency in accordance with voice vibrations by the use of a new type of microphone, which modulates the frequency instead of the amplitude smaller power need be handled and the efficiency of operation may thereby be greatly increased.

The method which I preferably employ to carry out my invention is to vary the reactance in the transmitting circuit by changing the value of either inductance or capacitance in accordance with voice vibrations impressed upon a vibrating member, such as a microphone diaphragm, and to tune the receiving station a little above or a little below the average sending frequency, so that, at the receiving station, the strength of current flowing through the receiving circuit will correspond to the changes in amplitude employed in the present type of oscillations.

The amplitude may be modulated to a certain extent if the sending circuit has more than one defined frequency but this phenomenon is merely incidental and in no wise interferes with the application of the principle of my invention. Again, in employing high-frequency generators, the supply frequency is absolutely definite. In such a case, the frequency of the oscillating circuit would be arranged to be a little above or a little below the supply frequency. The modulation of frequencies caused by the variations in value of the transmitting reactances will then either bring the oscillating circuit into resonance or throw it further off from resonance. Changes in transmitting frequency may be, in this case, quite inappreciable but, instead, the amplitude of oscillations will be affected; in other words, the oscillations transmitted will be approximately of the same nature as the oscillations in present use in wireless telegraphy. In this case, it may be advisable to

tune the receiver to the average sending frequency.

In the accompanying drawings, Figure 1 is a diagram illustrating a transmitting station in which the application of my invention to the Poulsen-arc transmitter is shown. Fig. 2 is a diagram illustrating a simple receiving station. Fig. 3 is a diagrammatic illustration of a device for varying the length of the transmitted wave by varying the effective value of the capacitance in the circuit. Fig. 4 diagrammatically illustrates, on a greatly exaggerated scale, the type of wave produced in the use of my invention. Fig. 5 is a diagram illustrating the application of my invention to a transmitting circuit employing a high-frequency generator. Fig. 6 is a diagram illustrating my invention as applied to a circuit having a changeable reactance operated by a vibrating electro-magnet device that carries the plate current of a vacuum tube, acting as an amplifier, the grid of which is subject to audio oscillations. Fig. 7 shows, diagrammatically, a device for varying the wave length by changing the magnetic flux within an induction coil. Fig. 8 diagrammatically illustrates a device for changing the inductance within a circuit by varying the length of an induction coil in accordance with audio vibrations. Fig. 9 diagrammatically shows a form of apparatus for changing the inductance in a circuit by varying the number of turns of a coil in accordance with audio vibrations.

Referring particularly to Fig. 1, there is indicated an antenna 1, connected to a variable inductance 2, and, through a variable capacitance 3, to the ground. This forms the main antenna circuit. A shunt circuit containing a variable inductance 4, a variable capacitance 5, and a variable reactance mechanism 6, is shunted across the variable capacitance 3 of the main antenna circuit. This shunt circuit constitutes the circuit for changing the wave length of the sent oscillations, and the operation of the variable reactance mechanism 6 will be more fully explained with reference to Fig. 3, which is illustrative of one type of mechanism that I employ.

Connected to the main antenna circuit is a Poulsen-arc generator of radio-frequency current, having two arc electrodes 7. Power is supplied to the electrodes of the arc by means of a generator 8, or by any other suitable source of constant current. One of the arc electrodes is connected to one generator terminal through a variable resistance 9 and a choke coil 10. The variable resistance 9 controls the power delivery to the arc, and the choke coil 10 protects the generator from induced high-potential and high-frequency currents from the arc and antenna. The other electrode of the arc is connected to the other terminal of the generator through a choke coil 11 that serves the same purpose as the choke coil 10 and through coils 12 and 13 of an electro-magnet that has its field concentrated across the arc for the purpose of deionizing the gap to produce rapid extinction of the arc upon fall of the current, as is customary in Poulsen-arc transmitters.

The operation of the variable reactance mechanism 6, which will be more fully explained, causes the value of the reactance in the antenna shunt circuit to vary in accordance with voice vibrations. This circuit handles but a small portion of the total power but the variation of frequency is sufficient to throw the receiver off resonance, even at extremely small values, say ½ of 1%, so that a small variation of say 10% in the shunt-circuit capacity, which handles 10% of the oscillating power, will be a satisfactory value. To reduce the voltage in the shunt circuit to a suitable value, the variable condenser 5 may be adjusted to properly limit this voltage.

The action of the variable-reactance mechanism will be apparent from an inspection of the construction shown in Fig. 3, which is a diagrammatic view of a form of device for varying the capacitance in accordance with voice vibrations. There is illustrated a microphone having a mouth piece 30 and a vibrating diaphragm 31. Attached to the mouth piece 30 is a support 32, a link 33 being attached to the center of the diaphragm 31 of the microphone. The link 33 is attached to the mid-portion of condenser plates 34, as indicated by numerals 35. The condenser plates 34 are attached to the support 32 that is fastened to the mouth piece 30. These plates 34 are of a peculiar construction in that the edges are bent to form inwardly-projecting faces of metal parallel to the main face of the plate, as indicated at 36. The condenser plates 34 are assumed, for purposes of description, to have positive potential applied to them. A second support 37 carries a second series of condenser plates 38, carrying the negative potential, that are provided with apertures 39, and to which link 33 is also attached without making electrical contact. The construction of the plates 38 is like that previously described in the discussion of the condenser plates 34.

In operation the voice causes the diaphragm 31 to vibrate and this, by reason of the connection of the diaphragm 31 to the plates 34 and 38, causes them to vibrate, whereby the distances between them are varied to vary the capacitance of the device. Since this device is located within a circuit carrying transmitting oscillations, the period of oscillation of the circuit is changed in accordance with the variation in the capaci-

tance, and the frequency of the transmitting waves is varied in accordance with voice vibrations.

In Fig. 2 is shown a receiving station having an antenna circuit containing an antenna 14, an inductance 15, and a variable capacitance 16, through which the circuit is connected to the ground. In inductive relation to the inductance 15 of the main antenna circuit is a receiving inductance 17. In circuit with the inductance 17 is a variable capacitance 18 and a stopping condenser 19. An electron tube 20, acting as a detector, having a grid element 21, a plate element 22 and a filament element 23, is in circuit with the inductance 17. In circuit across the condensers 18 and 19 is a resistance 24 that performs the function of the customary grid leak in grid circuits of tubes used as detectors. To heat filament 23 I provide an "A" battery 25. The amount of current flowing from the filament 23 is controlled by the insertion of a variable resistance 25'. Within the plate circuit of the electron tube 20 are located telephone receivers 26 having a capacitance 27 shunted between them. A suitable "B" battery 28 applies positive potential to the plate 22.

The received impulses induce oscillations in the inductance 17 by reason of its inductive coupling to the inductance 15. This induced current acts to affect the potential of the grid 21 of the electron tube 20 and, as proper conditions for the use of this tube 20 as a detector are present, oscillations are set up in the plate circuit corresponding to the received oscillations, and messages may be taken through the telephone receivers 26. By virtue of the adjustment of the variable capacitance 18, the circuit may be tuned to any desired frequency.

It is obvious that any method of detecting the received oscillations may be employed and that I have shown an electron tube used as a detector of radio frequency solely for the purpose of illustration and to make clear the utility of my invention and its application to the problems of radio communication.

The antenna and receiving circuits of the receiving station are tuned to a frequency slightly above or below the average frequency sent from the transmitting station. Therefore, an increase or reduction in sending frequency will either increase or reduce the strength of current flowing through the receiving circuit, and the detector in the receiver circuit will correspond to the changes in the amplitude of the present type of oscillations. Audio signals will be caught in the telephone receivers 26 in accordance with the fluctuation in frequency of the transmitted wave.

In Fig. 4 is diagrammatically illustrated, on a greatly exaggerated scale, the shape of a train of waves sent out from the transmitting station. The axis upon which the waves are propagated is the axis indicating "Time". It is apparent that the frequency, which is a reciprocal of the "Time", varies inversely as the length of the wave. Such a wave train is propagated by a transmitting station of the type shown in Fig. 1, having a capacity-varying mechanism, such as is illustrated in Fig. 2.

In Fig. 5 is shown an application of the principles of my invention to a circuit containing a high-frequency alternator of the common type. In this circuit, an antenna 50, a variable inductance 51 and a variable capacitance 52 constitute the main antenna circuit. Shunted across the variable capacitance 52 is a shunt circuit having a variable inductance 54, a variable capacitance 55 and a reactance-varying mechanism 53, which may be of the type previously described in referring to Fig. 3. A high-frequency alternator 56 is provided, through which power is delivered to the main antenna circuit.

In a high-frequency alternator, the supply frequency is absolutely definite. It has been found advisable to tune the receiver to the average sending frequency, for the changes in the transmitting frequency may, in this case, be quite unappreciable, but, instead, the amplitude of oscillations will be affected. The frequency of the oscillating circuit should be arranged to be a little above or a little below the frequency desired, then the modulations of frequency caused by the transmitting inductance will either bring the antenna into, or throw it further off from, resonance. In using this type of apparatus, therefore, the amplitude of oscillations is affected, rather than the frequency, and the transmitted oscillations will be approximately of the same nature as has heretofore been customary in wireless telephony.

In Fig. 6 is shown apparatus of a suitable type for accomplishing amplification. The antenna circuit comprises an antenna 60, a variable inductance 61 and a variable capacitance 62, through which the circuit is connected to the ground. The main sending inductance is indicated by the inductance 63, through which radio oscillations of constant frequency are supplied to the antenna. A shunt circuit, connected across the inductance 61, contains a variable-reactance mechanism 64 for varying the period of vibration of the shunt circuit. Operatively connected to the moving parts of the variable-reactance mechanism 64, is a link 65 that is attached to the middle of a flexible metal diaphragm 66. A microphone 67, having a battery 67' and an inductance 68 in circuit therewith, constitutes a microphone transmitter. An inductance coil 69 is inductively coupled to the inductance 68 and constitutes

the secondary of an audio-frequency transformer, the primary of which is the inductance 68. The inductance 69 is coupled to the grid 70 of an electron tube 71, operating as an amplifier and having a plate 72 and a filament 73. To heat the filament, a battery 74 is provided, the current from which passes through a variable resistance 75 to the filament. Within the plate circuit of this electron tube 71 is a "B" battery 76 and an electro-magnet 77 that is adapted to actuate the vibrating diaphragm 66.

The operation of this amplifier is as follows: The voice produces, in the microphone circuit, fluctuations of current that, in turn, are impressed upon the grid 70 of the electron tube 71, and, since the condition for the tube 71 to operate as an amplifier are present, amplified audio oscillations are induced in the plate circuit of this tube, and the electro-magnet 77 causes the diaphragm 66 to vibrate strongly in accordance with these changes in current. Great amplification of the fluctuation of reactance within the shunt circuit of the antenna is obtained, so that a weak sound will produce a large reactance change in the shunt circuit of the antenna, and hence, greater variation of frequency in the antenna output than a loud sound would produce under ordinary conditions.

In Fig. 7, a type of device for varying the reactance within the transmitting circuit is diagrammatically illustrated, in which the inductance within the circuit is varied. A mouth piece 80, in operative relation to a diaphragm 81 that is adapted to vibrate in accordance with voice vibrations, has a lug of magnetic metal 82 fastened at its center. The metal lug 82, preferably of iron, is adapted to pass within the interior of an induction coil 83 that carries the current in the circuit. When the voice causes the diaphragm 81 to vibrate, the position of the lug 82 within the interior of the induction coil 83 changes, and hence, the magnetic flux within the coil is changed, thus varying the inductance in the circuit, and, consequently, the frequency of oscillation.

Another type of apparatus is shown diagrammatically in Fig. 8 of the drawings, in which is provided a mouth piece 85 to direct sounds upon a diaphragm 86, at the central point 87 of which is attached one end of a helical spring 88 constituting an inductance. Upon speaking within the mouth piece, the diaphragm 86 vibrates and causes the spring 88 to be shortened and lengthened in accordance with the position of the diaphragm, so that the inductive value of the spring is changed in accordance with voice vibrations, and hence, the frequency of the circuit including this device is varied.

In Fig. 9 is diagrammatically illustrated yet another type of reactance-varying mechanism in which the inductance is changed by varying the number of turns of an induction coil. A mouth piece 90 is here indicated in operative relation to a diaphragm 91, having attached, at its central point 92, one end of a coiled-wire spring 93 the other end of which is joined, at point 95, to one of the main terminals of the circuit. The coil-wire spring 93 is fastened, at a point 94, to the other terminal of the circuit, and, likewise, at the point 95, to a stationary nonconductor indicated at 96. Since the wire 93 is of spring material the vibration of the diaphragm 92 causes it to readily conform to the vibrations, and the effective number of turns of inductance is changed in accordance with the voice vibrations, so that the period of oscillation of the circuit including the device is varied.

While I have shown several devices for varying the reactance within the transmitting circuit to change the oscillating frequency in accordance with voice vibrations, I wish it to be expressly understood that any method by which the same result may be accomplished will lie within the spirit of my invention, and I do not wish to be limited to the particular constructions which I have shown.

Since the period of vibration is controlled by varying the reactance in the circuit, it makes no difference whether the inductance or the capacitance be changed. Either inductance or capacitance may be varied and it may be found advisable to vary the values of both inductance and capacitance in the circuit simultaneously, and I wish it to be understood that such a construction is contemplated as lying within the scope of this invention.

While I have described but one embodiment of my invention, it is apparent that many modifications may be made therein by those skilled in the art without departing from the spirit thereof, and I desire, therefore, that my invention be limited only as set forth in the appended claims or by the showing of the prior art.

I claim as my invention:

1. In a system for the transmission of intelligence, the combination including a source of high-frequency carrier waves of substantially constant frequency, a tuned circuit including in series a portion of an inductance device and a capacitance device, means for connecting said source across said capacitance device and a portion of said inductance device, and a sound-responsive variable reactance element shunting one of said dveices.

2. In a system for the transmission of intelligence, the combination including a source of high-frequency carrier waves of substantially constant frequency, a capacitance device, an inductance device in series

therewith, means for connecting said source across said capacitance device and a portion of said inductance device, a radiating circuit including said capacitance device and said inductance device, and a sound-responsive variable reactance element shunting one of said devices.

3. The combination with a source of oscillatory currents, of a tuned circuit energized thereby and including a coil, and an acoustically moved conductive member capable of setting up eddy currents inductively associated with said coil for varying the inductance thereof.

4. The combination with a source of high-frequency currents, and a tuned circuit energized thereby and including a coil, of a metallic member projecting axially into said coil and acoustic means for moving said member to cause it to be more or less inductively associated with said coil to vary the tuning of said circuit.

5. The combination with a source of high-frequency currents, and a tuned circuit energized thereby and including a coil, of a magnetic member projecting axially into said coil and acoustic means for moving said member whereby it projects into said coil to a greater or less distance and thereby alters the impedance of said coil to vary the tuning of said circuit.

6. In a system for wireless transmission of signals, means for modulating the transmitted wave comprising a member vibrating according to audio impulses, an induction coil associated with the transmitting circuit and an iron core within the induction coil and extending part way along the axis of said coil and connected to the vibrating member to vary the amount of inductance within the transmitting circuit.

7. In a radio sending system, a radiating circuit including an aerial, an adjustable inductor, an adjustable condenser and a ground, a source of high-frequency current connected around said adjustable condenser and an adjustable portion of said adjustable inductor, and a shunt around said adjustable condenser, said shunt including an adjustable inductor, an adjustable condenser and an acoustically varied reactor in series, whereby said shunt may be adjusted nearly to resonance at the frequency of said source, the antenna may be adjusted to radiate energy from said source when said shunt is non-resonant, and the acoustically varied reactor will then cause modulation of the radiations.

8. In a system for the transmission of intelligence, the combination of a source of high-frequency carrier waves of substantially constant frequency, a tuned circuit including tuning devices external to said source and tuned thereby to a frequency near that of said carrier waves, whereby the amplitude of said carrier waves will be dependent upon the nearness of said frequencies, and means shunting a single one of said tuning devices for varying the natural period of said tuned circuit in accordance with the signals to be transmitted.

9. In a system for the transmission of intelligence, the combination of a source of high-frequency carrier waves of substantially constant frequency, a tuned circuit including tuning devices external to said source and tuned thereby to a frequency near that of said carrier waves, whereby the amplitude of said carrier waves will be dependent upon the nearness of said frequencies, and reactance means shunting a single one of said tuning devices for varying the natural period of said tuned circuit in accordance with the signals to be transmitted.

10. An oscillation generator comprising two or more tuned circuits, one of said circuits being such that its tuning does not materially affect the frequency of the oscillations, and means including a coil having a movable metallic core for varying the tuning of said last-mentioned circuit, whereby the amplitude of the oscillations may be varied in accordance with the signals to be transmitted.

11. In a system for the transmission of intelligence, the combination of a source of high-frequency carrier waves of substantially constant frequency, a tuned circuit including tuning devices external to said source and tuned thereby to a frequency near that of said carrier waves, whereby the amplitude of said carrier waves will be dependent upon the nearness of said frequencies, and reactance means shunting a single one of said tuning devices for varying the natural period of said tuned circuit in accordance with the signals to be transmitted, said tuned circuit being normally slightly detuned from the condition of exact resonance.

12. An oscillation generator comprising two or more tuned circuits, one of said circuits being such that its tuning does not materially affect the frequency of the oscillations, and means including a coil having a movable metallic core for varying the tuning of said last-mentioned circuit, whereby the amplitude of the oscillations may be varied in accordance with the signals to be transmitted, said last-mentioned circuit being normally slightly detuned from the condition of exact resonance to said oscillations.

In testimony whereof, I have hereunto subscribed my name this 10th day of July 1920.

ALEXANDER NYMAN.