Aug. 28, 1923. 1,465,962

E. F. W. ALEXANDERSON

WIRELESS SIGNALING SYSTEM

Original Filed April 19, 1916

Fig. 1.

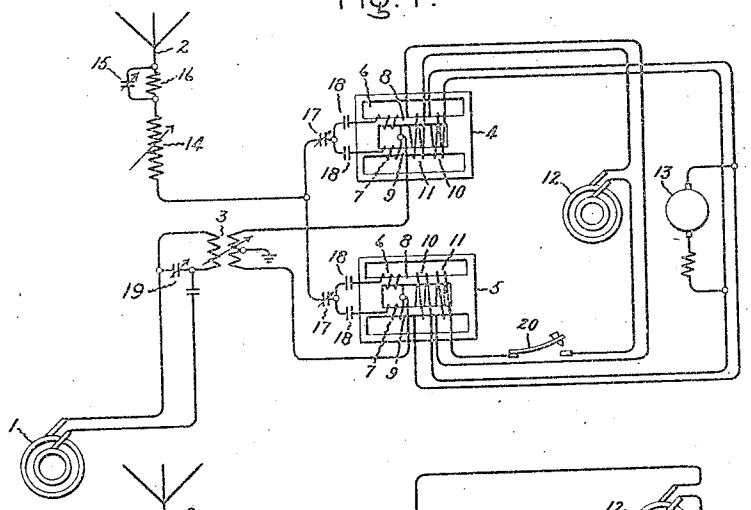


Fig. 2.

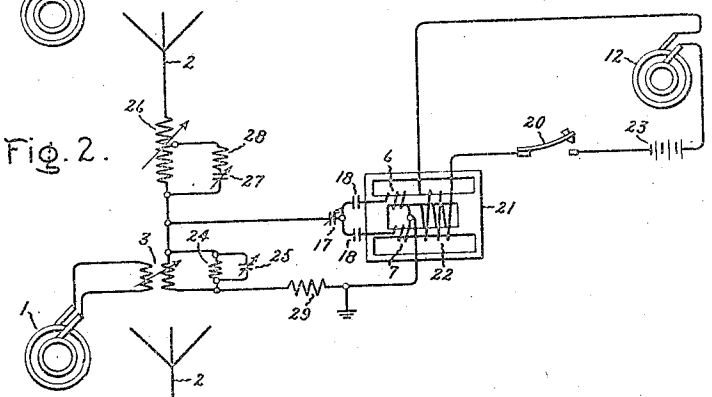
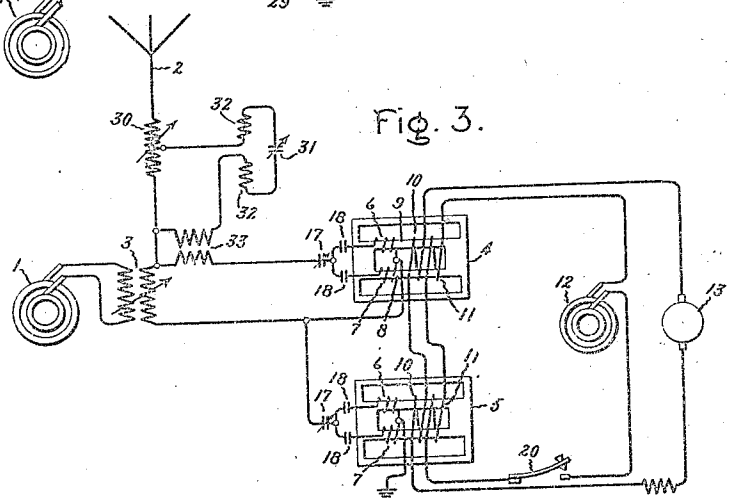


Fig. 3.



Inventor:
Ernst F. W. Alexanderson,
by Albert G. Davis
His Attorney.

Patented Aug. 28, 1923. 1,465,962

UNITED STATES PATENT OFFICE.

ERNST F. W. ALEXANDERSON, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

WIRELESS SIGNALING SYSTEM.

Original application filed April 19, 1916, Serial No. 92,156. Divided and this application filed July 15, 1918. Serial No. 244,839.

To all whom it may concern:

Be it known that I, ERNST F. W. ALEXANDERSON, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Wireless Signaling Systems (division of my prior application, Serial No. 92,156, filed April 19, 1916), of which the following is a specification.

My present invention relates to wireless signaling systems, and more particularly to a system in which means is provided for overcoming the effect of static disturbances in the receiving instruments.

Electrostatic disturbances occur continuously in the atmosphere, sending out electromagnetic waves of varying frequency, which will in the description which follows be referred to as strays. These waves are absorbed by the receiving antenna and among the variety of waves absorbed there are always some which are in resonance, that is, which have the same length as a signal which is to be received and consequently act upon the receiving devices in the same way as the signal. Having analyzed this condition both mathematically and experimentally, I have come to the conclusion that a fundamental rule must be the basis of any device used for decreasing the effect of static disturbances. Any discrimination between a wave of the same frequency originating from static and from the signal must be based on some difference in character between these two waves. If the strays were like the signals both in frequency and amplitude variation, and in addition to that stronger than the signals, there would be no way conceivable for discriminating between one and the other. The longer the period is during which the strays and the signaling waves can be compared, the greater is the chance for finding a distinguishing difference in the sequence of amplitude variations if in nothing else. In order that the device be effective for discrimination against strays, it should, therefore, be designed so that the wave trains can be distinguished by comparing their character for sufficiently long periods. The receiving devices which are at present used commercially are constructed so as to take advantage of this law to a certain extent by using a highly resonant receiving circuit on which the signal can be allowed to act for a considerable number of successive alternations. The reason why these devices do not entirely discriminate against strays is the fact that the receiving antenna is set in oscillation by static shocks and stray waves of short duration and thus the time during which the disturbances can act upon the receiving device is prolonged to about the same degree as the signal.

One of the objects of my invention is to provide a means for prolonging the time during which the signal can act with accumulative effect on the receiving device considerably beyond the time during which disturbances can act.

In attaining this object I make use of a tuned circuit of lower than radio frequency, but above audibility, for effecting the prolongation of the time during which the signal and disturbances may be compared. The desired lower frequency is provided by means of interference beats between two radio frequencies. Both of these frequencies may be produced at the sending station, or one of them may be produced at the receiving station. I also provide means for producing, transmitting and receiving both radio frequencies. An arrangement of this kind is more effective than one employing a single radio frequency because it is more selective and proof against interference, both frequencies being necessary to produce an impression in the receiver. Also when means is provided at the sending station for establishing the beat frequency a less delicate adjustment of frequency is necessary than when the beat frequency is the result of the difference between two high frequencies. A further object of my invention is to provide means for efficiently producing signals of the desired character.

The features of my invention which I believe to be patentable are pointed out with particularity in the appended claims. The invention itself, however, together with further objects and advantages thereof, will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figs. 1, 2 and 3 illustrate different modifications

of the circuit connections which may be employed in transmitting signals in accordance with my invention.

In the form of transmitting system shown in Fig. 1, an alternator 1 supplies current of radio frequency to the antenna 2 through the coupling transformer 3. This alternator is designed to furnish continuous waves of a definite frequency and amplitude. Instead of transmitting the signals by waves of this nature, however, I produce amplitude pulsations in the waves supplied by the alternator of such a nature that the resulting wave may be resolved into two waves of different frequencies which may be transmitted simultaneously. In order to accomplish this I divide the antenna circuit into two branches and in these branches connect the windings of two magnetic controllers or amplifiers 4 and 5. Each of these branch circuits include half of the secondary of transformer 3, the middle point of which is grounded. The magnetic controllers or amplifiers which I prefer to use in the present case, both as to their construction and method of operation, are described in detail in my Letters Patent of the United States, 1,328,797.

Each controller comprises a reactive winding consisting of two coils 6 and 7 wound upon independent magnetic cores 8 and 9. The two coils of each winding are connected in parallel with each other in the circuit and are so arranged that their magnetizing actions are opposite. Each magnetic controller is also provided with two controlling windings 10 and 11 wound around the magnetic cores 8 and 9 as indicated, so that magnetization produced by currents in the controlling windings will be in the same direction in both cores. Controlling windings 11 are both supplied from the same source of current, which in the present case may be an alternator 12 of much lower frequency than that of alternator 1, yet having a frequency above the range of audibility. Controlling windings 10 are supplied with direct current from any suitable source, such, for example, as the direct current generator 13 shown in the drawing. The controlling windings 10 are so connected to the generator 13 that their magnetic effects upon the two controllers are opposite with respect to the instantaneous magnetic reactions set up in the controllers by current from generator 12. The controlling windings 10 and 11 are so proportioned and the current sources 12 and 13 so chosen and adjusted that the maximum ampere turns of winding 11 is approximately equal to the ampere turns of the controlling winding 10. As a result the controller 4 will have a maximum of controlling ampere turns when the controlling ampere turns of controller 5 are practically zero and vice versa. The characteristic of the controllers 4 and 5 are such that the impedance of each high frequency winding 6 and 7 varies between practically open circuit and short circuit when the controlling excitation varies from zero to maximum. Thus when the current wave of controlling alternator 12 is a maximum one of the controllers acts as a short circuit connecting the antenna to one terminal of the secondary of transformer 3 while the other controller interposes an impedance substantially equivalent to an open circuit in the connection to the other terminal. After the phase of the controlling current wave supplied by alternator 12 is changed 180 electrical degrees the other controller acts as a short circuit and the first as an open circuit, thus reversing the polarity of the radio frequency current led to the antenna. At intermediate points the voltage varies between these two extremes in accordance with the sine wave law. The current wave thus supplied to the antenna has an amplitude pulsation substantially in accordance with the sine wave law and the impulses in every other group of waves are opposite in phase to corresponding impulses in the intermediate groups of waves. The frequency of these amplitude pulsations is equal to the frequency or a multiple of the frequency of the alternator 12. For a description in greater detail of the operation of this arrangement reference may be had to my United States Patent 1,386,330.

The wave thus produced in the antenna may be resolved into two waves of constant amplitude, one having a frequency greater than that of the alternator 1 by an amount equal to the frequency of alternator 12 and the other having a frequency as much lower than that of the alternator 1. If either one of the magnetic amplifiers 4 and 5 were used alone it would be possible to transmit from a single antenna waves of any one of three frequencies and by providing multiple tuning of the antenna waves of two or more frequencies may be transmitted simultaneously. For example, the variable inductance 14 may provide for one tuning and the variable condenser 15 in shunt to inductance 16 may provide for a second tuning at a different frequency. If, for example, alternator 1 has a frequency of 75,000 cycles and alternator 12, 5000 cycles, the antenna may be tuned for 80,000 and 75;000 cycles; 80,000 and 70,000 cycles, or 75,000 and 70,000 cycles. By providing a third tuned circuit in multiple with the antenna all three frequencies may be transmitted simultaneously. When both magnetic amplifiers are used in the manner described, the current component of fundamental frequency is suppressed and the antenna will be tuned for the two frequencies into which the resultant wave may be resolved, that is, one frequency higher than

that of the alternator 1 by an amount equal to the frequency of the alternator 12 and the other frequency as much lower than that of the alternator 1. Variable condensers 17 may be connected in series with the windings 6 and 7 of the controllers to neutralize the leakage inductance in the windings thereof so as to bring the minimum value of the impedance as near as possible to a short circuit. It may also be desirable to employ condensers 18 in series with each branch of the high frequency winding of such a value that they offer very little impedance to the flow of the high frequency current from alternator 1, but a high impedance to currents of the frequency of alternator 12, which may be induced in the closed circuit formed by the two windings 6 and 7.

With the system which has been described above, in order to produce the amplitude pulsations of current, the output delivered by the alternator 1 to the antenna must be periodically varied between a maximum and a minimum. As a result the energy output which can be obtained from the alternator is less than it would be if it delivered full power continuously. To overcome this disadvantage an oscillating circuit may be provided which is capable of storing up considerably more energy than the alternator must give out during one period of the amplitude pulsations. By this means energy may be stored up in the oscillating circuit when the energy taken by the antenna is a minimum and when the energy taken by the antenna is a maximum energy may be drawn momentarily from the oscillating circuit at a greater rate than the alternator is able to deliver. In the present case the oscillating energy storage circuit may be made up of the primary of transformer 3 and condenser 19.

In order to transmit telegraphic signals by the system described a key 20 may be inserted in the circuit of alternator 12. When this key is open the impedance of the two controllers 4 and 5 will be equal and since they are connected in opposition to each other no current will be supplied to the antenna. When the key is closed currents having amplitude pulsations will be supplied to the antenna in the manner described.

In Fig. 2 I have shown an organization in which a single magnetic controller 21 is employed to secure the desired frequency splitting. In this case a single controlling winding 22 is shown and the alternator 12 is connected to the winding in series with a battery 23 having a potential substantially the same as that of alternator 12. The controlling windings 6 and 7 of this controller are connected in shunt to the secondary of transformer 3 instead of in series as in the arrangement shown in Fig. 1. An oscillating energy storage circuit comprising inductance 24 and condenser 25 connected in shunt to the secondary of transformer 3 functions in a manner similar to that of the energy storage circuit described in connection with the arrangement of Fig. 1. Two different antenna tunings may be secured by means of the variable inductance 26 and the variable condenser 27 and inductance 28 in shunt to a portion of inductance 26.

In Fig. 3 I have illustrated another modification in which the circuit which provides the second tuning for the antenna is also utilized as an energy storage circuit. Controller 5 in this case is connected in series with the antenna and controller 4 in a circuit in shunt to the secondary of transformer 3. The main antenna tuning is made by means of variable inductance 30 and the second tuning by variable condenser 31. This condenser in connection with inductances 32 forms an energy storage circuit. When controller 4 forms a short circuit if the phase relations of the currents are properly adjusted energy will be delivered to the storage circuit by means of transformer 33 and when controller 5 forms a short circuit energy will be delivered to the antenna from the alternator and the storage circuit.

While I have indicated only three different circuit arrangements whereby my invention may be carried into effect it will be apparent that many modifications may be made in the specific apparatus and the manner in which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The method of producing an electric current wave of radio frequency having amplitude pulsations in which the impulses of alternate amplitude pulsations are opposite in phase to corresponding impulses of intermediate amplitude pulsations which consists in continuously delivering current from a source of radio frequency to a suitable electric circuit, varying the amplitudes of the impulses of current thus delivered, periodically reversing with respect to said source and with a frequency corresponding to the desired frequency of the amplitude pulsations of the wave, the direction of current flow in the circuit storing up energy from the current source in a second resonant circuit when the amplitude of the current delivered is smaller than that which the source is capable of delivering normally, and delivering the stored up energy to the first circuit when the amplitude of the current flowing therein increases beyond that normally furnished by the current source.

2. The method of producing an electric current wave which is the equivalent of two electric current waves of different frequencies and of constant amplitudes which con-

sists in continuously supplying current from a source of radio frequency to a suitable electric circuit, varying the amplitudes of the pulsations supplied to said circuit in such a way as to produce a current wave with regularly recurring amplitude pulsations and which can be resolved into two electric waves of different frequencies and constant frequencies and constant amplitudes, storing up energy from the current source in a second resonant circuit when the amplitude of the current delivered to the first circuit is smaller than that which the source is capable of delivering normally, and delivering this stored up energy to the first circuit when the amplitude of the current flowing therein increases beyond that normally furnished by the current source.

3. The method of transmitting signals which consists in producing currents of two different radio frequencies from a single source of current of radio frequency by first producing from said source a current having amplitude pulsations of uniform character in which corresponding impulses of any two adjacent groups of amplitude pulsations are apposite in phase and then conducting the current thus produced through a circuit having two branches which are resonant to the two frequencies desired whereby the current will be resolved into two currents of constant amplitude and the frequencies desired and utilizing the two currents thus produced for the transmission of signals.

4. The method of transmitting signals which consists in producing currents of two different radio frequencies from a single source of current of radio frequency by delivering current from said source to a suitable electric circuit, uniformly varying the amplitudes of the impulses of current thus delivered to produce a current wave having amplitude pulsations of a lower frequency than that of the source above audibility, and then conducting the current thus produced through a circuit having two branches which are resonant to the two frequencies desired whereby the current wave will be resolved into two currents of constant amplitude and of the frequencies desired and utilizing the two currents thus produced for the transmission of signals.

5. The method of producing currents of two different frequencies from a single source of current of radio frequency which consists in delivering current from said source to a suitable electric circuit, uniformly varying the amplitude of the impulses of current thus delivered to produce a current wave having amplitude pulsations of a lower frequency than that of the source but above audibility, storing up energy from the current source in a second resonant circuit when the amplitude of the current delivered is smaller than that which the source is capable of delivering normally, delivering the stored up energy to the first circuit when the amplitude of the current flowing therein increases beyond that normally furnished by the current source and conducting the current thus produced through a circuit having two branches which are resonant to the two frequencies desired whereby the current wave will be resolved into two currents of constant amplitude and of the frequencies desired.

6. Means for producing an electric current wave of radio frequency having amplitude pulsations in which the impulses of alternate amplitude pulsations are opposite in phase to corresponding impulses of intermediate pulsations, comprising a source of continuous current of radio frequency, an electric circuit connected thereto, means for varying the amplitudes of the impulses of current delivered to said circuit, means for periodically reversing with respect to the current source and with a frequency corresponding to the desired frequency of the amplitude pulsations of the wave, the direction of current flow in the circuit, a second resonant circuit associated with the first circuit for storing up energy from the current source when the current flowing in the first circuit is smaller than that which the source is capable of delivering normally, and delivering energy to the first circuit when the amplitude of the current flowing therein increases beyond that normally furnished by the current source.

7. Means for producing an electric current wave which is the equivalent of two electric current waves of different frequencies and of constant amplitudes, comprising a source of continuous current of radio frequency, an electric circuit associated therewith, means for uniformly varying the amplitudes of the pulsations supplied to said circuit in such a way as to produce a current wave with regularly recurring amplitude pulsations, and a second resonant circuit associated with the first circuit for storing up energy from the current source when the amplitude of the current delivered therefrom to the first circuit is smaller than that which the source is capable of delivering normally, and delivering energy to the first circuit when the amplitude of the current flowing therein is greater than that normally furnished by the current source.

8. Means for transmitting signals comprising means for producing currents of two different frequencies comprising a single source of current of radio frequency, an electric circuit associated therewith, means for delivering to said circuit a current having amplitude pulsations of uniform character in which corresponding impulses of any two adjacent amplitude pulsations are opposite in phase, said electric cir-

cuit having two branches which are resonant to the two frequencies desired whereby the current furnished thereto may be resolved into two currents of constant amplitude and of the frequencies desired and means for utilizing said currents for the transmission of signals.

9. Means for transmitting signals comprising means for producing currents of two different radio frequencies comprising a single source of current of radio frequency, an electric circuit associated therewith, means for uniformly varying the amplitudes of the impulses of current delivered to said circuit to produce a current wave having amplitude pulsations of a lower frequency than that of the source but above audibility, said circuit comprising two branches which are resonant to the two frequencies desired whereby the current wave may be resolved into two currents of constant amplitude of the frequencies desired and means for utilizing currents thus produced for the transmission of signals.

10. Means for producing currents of two different radio frequencies comprising a single source of current of radio frequency, an electric circuit associated therewith, means for uniformly varying the amplitudes of the impulses of current delivered to said circuit to produce a current wave having amplitude pulsations of a lower frequency than that of the source but above audibility, said circuit comprising two branches which are resonant to the two frequencies desired, whereby the current wave may be resolved into two currents of constant amplitude and of the frequencies desired, and a second circuit associated with the first which is resonant to the frequency of the current source for storing up energy from said source when the amplitude of the current delivered is smaller than that which the source is capable of delivering normally, and delivering energy to the first circuit when the amplitude of the current flowing therein increases beyond that normally furnished by the current source.

11. The combination in a system for transmitting signals of a source of high frequency current, an electric circuit associated therewith, a source of controlling current of lower frequency than the first mentioned source, means for alternately diverting by means of said controlling current the effective path for the flow of current in said circuit from one terminal of said source to the other terminal thereof at a frequency corresponding to the frequency of said controlling current, and a signaling device in circuit with said source of controlling current.

12. The combination in a system for transmitting signals of a source of high frequency current, an electric circuit associated with said source, a source of controlling current associated therewith of lower frequency than the first mentioned source, electromagnetic means operatively related to said circuit and operable by means of said controlling current for changing the effective path for the flow of current in said circuit from one terminal of said source to the other terminal thereof, and a signaling device in circuit with said source of controlling current.

13. The combination in a system for transmitting signals of a source of high frequency current, an electric circuit including two parallel paths for the flow of current, said two parallel paths being electrically associated at one end with opposite terminals of said source and electrically connected together at the opposite end, a source of controlling current of lower frequency than the first mentioned source, means for varying the impedance of said parallel paths in accordance with variations in said controlling current and a signaling device in circuit with said source of controlling current.

14. The combination in a system for transmitting signals of a source of high frequency current, an electric circuit including two parallel paths for the flow of current, said two parallel paths being electrically associated at one end with opposite terminals of said source and electrically connected together at the opposite end, a source of controlling current of lower frequency than the first mentioned source, a magnetic controller associated with each of said parallel paths, means for varying the impedance of each of said magnetic controllers in accordance with variations in said controlling current, and a signaling device in circuit with said source of controlling current.

In witness whereof, I have hereunto set my hand this 13th day of July, 1918.

ERNST F. W. ALEXANDERSON.