E. F. W. ALEXANDERSON.

METHOD OF AND APPARATUS FOR RELAYING HIGH FREQUENCY CURRENTS.

APPLICATION FILED JUNE 9, 1911.

1,042,069.

Patented Oct. 22, 1912.

2 SHEETS—SHEET 1.

Fig. 1.

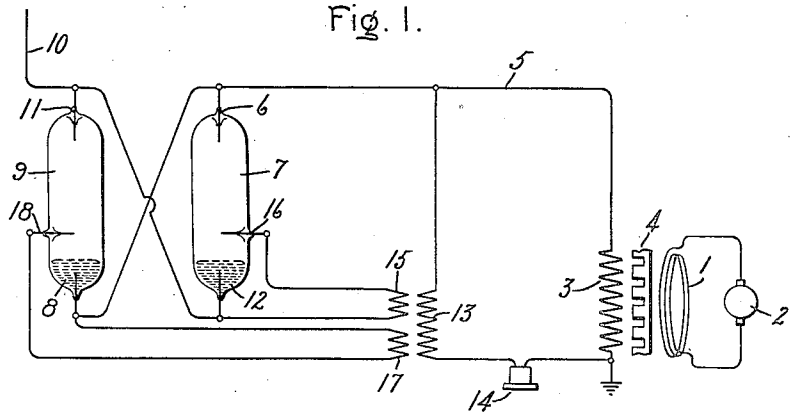


Fig. 2.

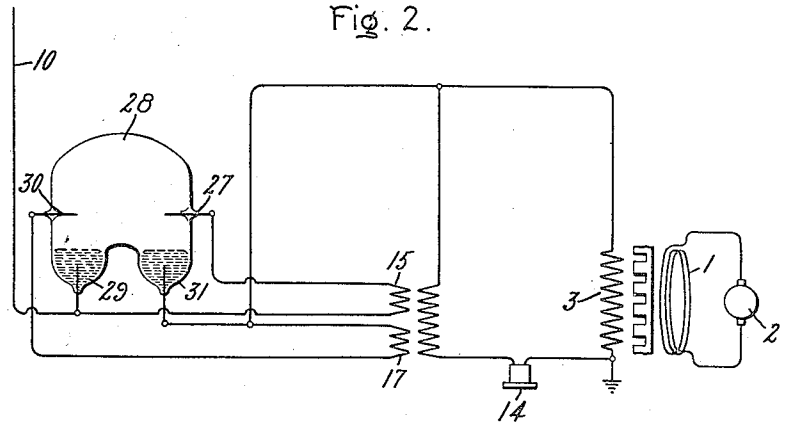
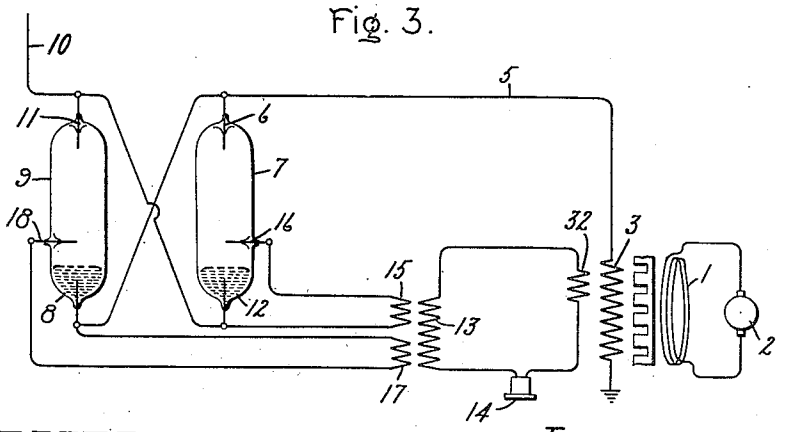


Fig. 3.



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2 SHEETS—SHEET 2.

Fig. 4.

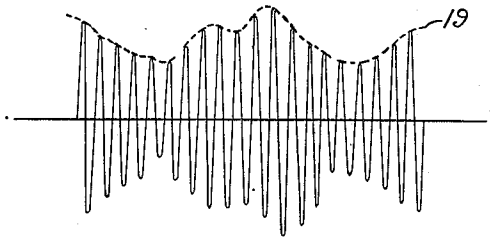


Fig. 5.

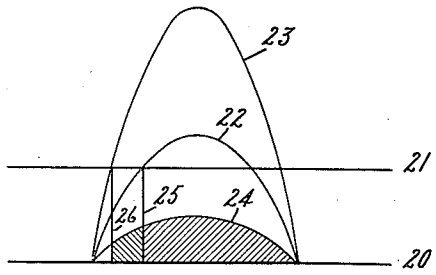
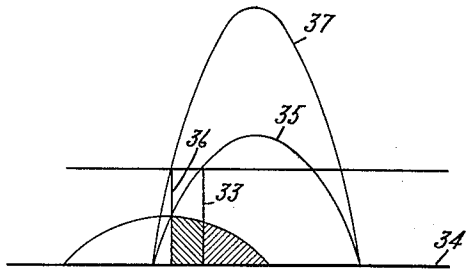


Fig. 6.



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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR RELAYING HIGH-FREQUENCY CURRENTS.

1,042,069. Specification of Letters Patent. Patented Oct. 22, 1912.

Application filed June 9, 1911. Serial No. 632,208.

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 Methods of and Apparatus for Relaying High-Frequency Currents, of which the following is a specification.

The present invention involves the application of high frequency currents to signaling and comprises a method of and apparatus for utilizing comparatively large amounts of energy in the form of high frequency pulsations for the transmission of speech, or for sending signals in general.

My invention will be best understood when considered in connection with its application to wireless telephony.

When a high frequency pulsating current of constant frequency and amplitude is transmitted through a telephone transmitter of variable resistance, such as the carbon microphone, the amplitude of the high frequency waves will vary in accordance with the variations of resistance in the microphone. The tops of the high frequency waves will define a curve corresponding with the variable sound waves. The amount of energy which can be carried through a microphone transmitter is limited, however, by the conductivity and heat radiating capacity of the transmitter. In accordance with my invention, larger amounts of energy than can be carried by the microphone without heating can be transmitted.

I employ the transmitter current to render conductive a device having an initial high resistance which when broken down drops to a low value, for example, a mercury arc, or similar vapor electric device, and transmit through said device high frequency waves which are in step with the exciting waves. The slope of the exciting waves varies with their amplitude, thereby varying the time interval required for the voltage of the exciting wave to rise to the value necessary for rendering the vapor device conductive by the starting of a high voltage spark, a side branch arc, or whatever means may be used. As the main arc will not start until the ionizing discharge occurs, and ceases when the voltage falls below the value necessary to maintain an arc, that is, at the end of each wave, varying portions of the waves are transmitted, these portions varying in value in accordance with the wave amplitude of the telephone current. These current waves can be utilized by suitable apparatus for the production of electromagnetic waves.

My invention is explained more fully by the following description taken in connection with the accompanying drawings which illustrate a system employing alternating current, but it will be understood that the invention is equally applicable to a pulsating current which does not reverse in sign.

Figure 1 is a diagram illustrating a high frequency generator connected to two mercury arc devices in a system of space telephony; Fig. 2 is a modified system employing a single mercury arc, the device having two mercury electrodes; Fig. 3 illustrates another modification in which the exciting current can be displaced in phase with respect to the main current; Fig. 4 is a diagram illustrating the variation in amplitude of the high frequency waves in the transmitter circuit; Fig. 5 diagrammatically illustrates the relation of the main and exciter waves when they are in phase with each other; and Fig. 6 illustrates the relation of main and exciter waves when out of phase.

Fig. 1 illustrates an alternator of the inductor type having a stationary field winding 1 connected to a suitable source of exciting current such as a direct current generator 2, and having a stationary armature winding 3 and a movable inductor 4. The armature winding is connected by conductor 5 to the anode 6 of mercury arc device 7 and the cathode 8 of mercury arc device 9. The antenna 10 is connected to the anode 11 of the mercury arc device 9 and cathode 12 of mercury arc device 7. One end of the armature winding 3 is earthed as indicated. A branch circuit connected across the armature winding as indicated contains the primary 13 of an air core transformer and a microphone telephone transmitter 14. One of the secondary windings 15 of the transformer is connected to the auxiliary anode 16 of the mercury arc device 7 and its cathode 12. Another secondary 17 of this transformer is connected to an auxiliary anode 18 of the mercury arc device 9 and its main cathode 8. When high frequency currents of uniform amplitude traverse the branch cir-

cuit containing the microphone transmitter 14, the variation of resistance of the transmitter, when sound waves are impressed upon it, produces a variation in amplitude of the waves,—a low resistance in the transmitter corresponding with a wave of relatively great amplitude, or voltage, and a high resistance in the transmitter corresponding with a wave of relatively low amplitude, or voltage. As the frequency of the waves is higher than the audible frequency, their tops define a curve, as shown in the figure by the dotted line 19, corresponding with the variable wave current in a telephone system using direct current. The voltage in the secondaries 15 and 17 and the gaps from the auxiliary anodes to the corresponding cathodes in the mercury arc devices are so proportioned that the voltage of the high frequency waves is sufficient to start an arc across the vacuous space in the arc devices. However, this arc will not be started until the voltage of the high frequency waves has arisen to a value corresponding with the break-down resistance across the gap between the auxiliary anode and the cathode. A wave of comparatively great amplitude or voltage will, because of its steeper slope, rise in value to the break-down voltage sooner than a wave of lower amplitude and gentler slope. In other words, referring to Fig. 5, if the line 20 represents zero voltage and the line 21 the break-down voltage, and assuming voltage and current to be in phase, it will be seen that it will require a somewhat longer time interval for an exciting wave having the shape of wave 22 to attain a voltage equal in value to the break-down voltage than will be required for curve 23. As the main wave 24 will not start until the space in the mercury arc device has been rendered conductive by the auxiliary arc, a larger portion of the main wave will pass through the device and to the antenna when the exciting wave has a steep slope than when its slope is gentle. This is clearly indicated in Fig. 5 by the shaded portions of the main wave bounded respectively by lines 25 and 26. The variation in resistance in the telephone transmitter 14 therefore times the starting of the main arcs in the mercury arc devices 7 and 9, thereby determines the relative amounts of energy transmitted and in that manner controls the intensity of the electromagnetic waves radiated from the antenna 10. The variation in the electromagnetic waves is, of course, receivable by appropriate receiving devices at a distant point as speech or other signals.

As shown in Fig. 2, the secondary 15 of the transformer is connected to an auxiliary anode 27 of a mercury arc device 28 and to a mercury electrode 29. The secondary 17 is connected to an auxiliary anode 30 and to a second mercury electrode 31. The antenna 10 is connected to the mercury electrode 29. The armature winding 3 is connected to the mercury electrode 31. The mercury electrodes 29 and 31 both alternate in polarity according to the direction of the alternating current, the electrode 31 being positive and the electrode 29 negative during one-half wave and each electrode being reversed in sign during the other half wave. The operation of this device is similar to that already described in connection with Fig. 1, the electrodes 27 and 30 acting alternately as anodes to strike an auxiliary arc to whichever mercury electrode is negative, thus rendering the device conductive and starting the main arc.

Fig. 3 illustrates the telephone transmitter 14 as being placed in circuit with a separate armature winding 32 which is movable with respect to the main armature winding 3. By giving an angular displacement to the winding 32 with respect to the winding 3, the exciting current may be displaced in phase with respect to the main current. This makes it possible to obtain even greater differences in the fractions of the waves of the main current transmitted to the antenna through the mercury arc device with a variation in the amplitude of the exciting telephone current. As shown by Fig. 6, only the portion of the main wave bounded by the line 33 and the zero line 34 is transmitted when the exciting wave has the slope of wave 35 and the portion bounded by line 36 and the zero line 34 is transmitted when the exciting wave has the slope of wave 37.

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

1. The method of controlling high frequency current for signaling and the like which consists in rendering conductive an arc device by high voltage, high frequency pulsations varying in amplitude in accordance with the signals to be transmitted, thereby varying the length of time required for the voltage of each pulsation to rise to the value requisite for rendering the device conductive and impressing upon the main electrodes of said mercury vapor device a pulsating current of considerable energy, the periods of said current being in step with the exciting pulsations, thereby causing variable portions of said high energy current to be transmitted.

2. The method of signaling through space, which consists in impressing upon a vapor electric device high frequency pulsations which periodically fall to a voltage less than that required to sustain an arc, rendering the space in said device conductive to current during each wave of current, retarding or advancing the point in the wave interval at which the space is rendered conductive in accordance with the signal to be sent, thus

transmitting variable portions of the pulsations and utilizing said pulsations for the production of electromagnetic waves.

3. The method of controlling the energy of high frequency pulsations for signaling or other purposes, which consists in rendering conductive a device having a high break-down resistance by high frequency pulsations occurring in step with the pulsations to be controlled, attaining a voltage high enough to break down the resistance of said device and render it conductive and varying the wave slope of said exciting pulsations, thus varying the time intervals required for said exciting waves to attain the break-down voltage and thereby transmitting shorter or longer impulses of current as required.

4. The combination of a source of high frequency electrical pulsations of uniform amplitude, a control circuit carrying pulsations in step with said high frequency pulsations, means in said control circuit for varying the slope of the wave form of the pulsations in said circuit, and means for controlling the transmission of high frequency pulsations from said source in accordance with said variations of slope of the pulsations in the control circuit.

5. The combination of a source of high frequency pulsating current of considerable energy, means characterized by a high initial resistance subject to reduction by the passage of electrical energy therethrough, means for furnishing high voltage exciting pulsations in step with the main pulsating current for rendering said device conductive for current from said source during each pulsation, and means for varying the slope of the wave form of said exciting pulsations at will, thereby varying the time with respect to the beginning of each wave of main current that said means is rendered conductive and thus controlling the amount of energy transmitted.

6. In a system of space telephony, the combination of a source of high frequency pulsating current, a mercury vapor device having a cathode and an anode connected thereto, an auxiliary anode coöperating with said anode, exciting means connected thereto for furnishing a high voltage pulsating current for rendering said device conductive during each pulsation of current from said source by a discharge from the auxiliary anode to the cathode, and a telephone transmitter in the circuit of the exciting means for varying its resistance, thereby timing the starting of the auxiliary arcs with respect to the time that the voltage of the pulsations of said source fall below a value sufficient to maintain an arc.

7. In a system of aerial communication, the combination of a source of high frequency pulsating current, a vapor electric device included in circuit therewith, means for rendering the space in said vapor device conductive during each pulsation from said source by high frequency pulsations which are in step with the pulsations in the main supply circuit of said device, and means for varying the wave form of said exciting pulsations in accordance with the signals to be sent, whereby varying portions of the pulsations from said source are transmitted by the mercury vapor device.

8. In a system of wave telephony, the combination of a source of high frequency pulsating current, a mercury vapor device in circuit therewith, means for supporting an auxiliary exciting arc in said device, a circuit connected thereto carrying high frequency pulsations which are in step with the pulsations in the supply circuit of said vapor device, and a microphone in electric circuit with said auxiliary arc for varying the resistance encountered by the exciting arc pulsations, thereby varying the time intervals during which said mercury vapor device is excited or rendered conductive.

9. The combination of a source of high frequency pulsations, a mercury vapor device having main electrodes electrically connected thereto, an auxiliary electrode, exciting means connected thereto for furnishing a current pulsating in step with the pulsations of said main high frequency source, a variable resistance in circuit with said exciting means for varying the slope of the exciting waves in accordance with the signals to be sent, thereby timing the instant of excitation with respect to the beginning of each current wave and thus varying the amount of energy transmitted by the mercury vapor device.

In witness whereof, I have hereunto set my hand this 8th day of June, 1911.

ERNST F. W. ALEXANDERSON.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.