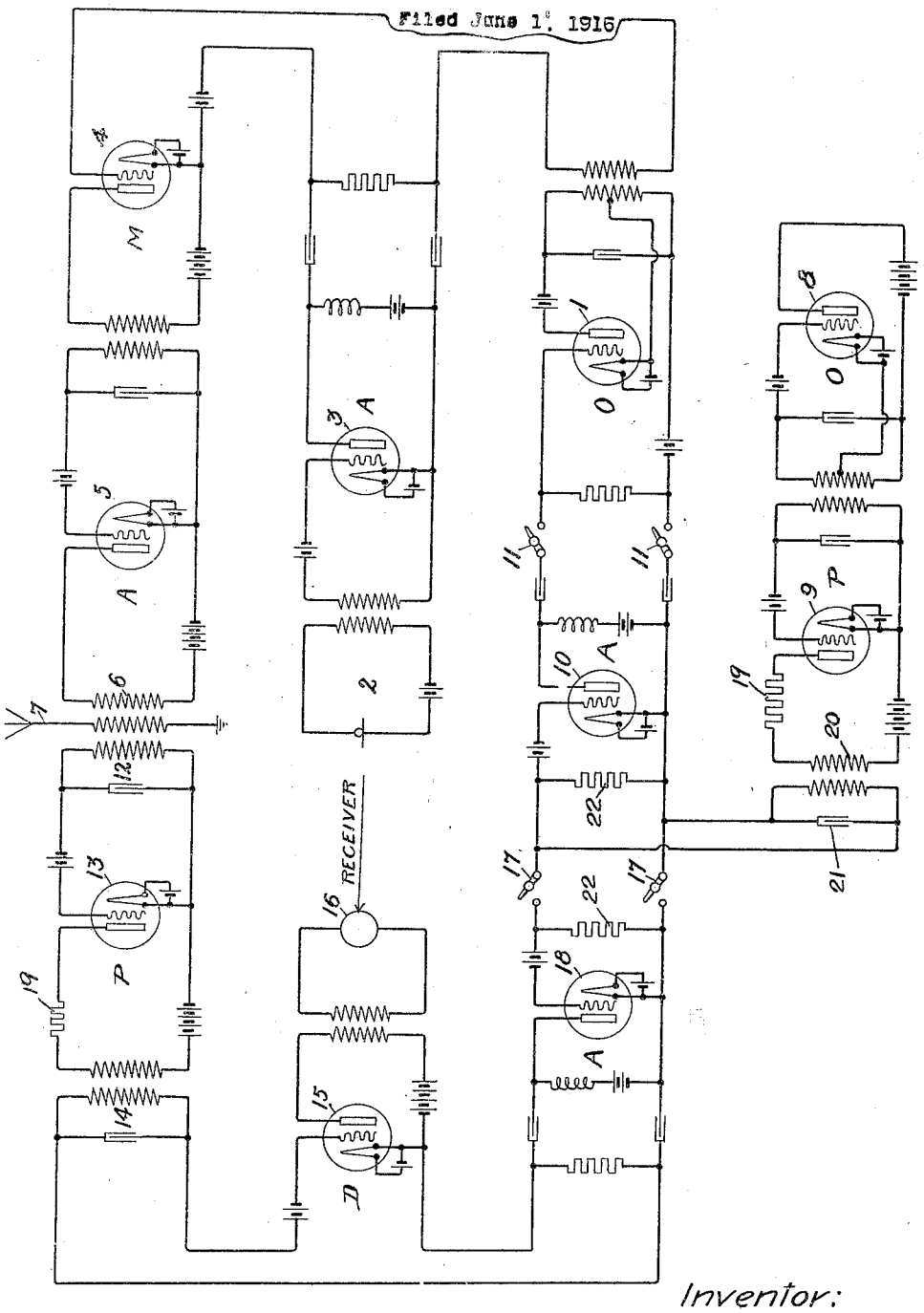
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J. MILLS

WAVE TRANSFERRING CIRCUITS FOR COMMUNICATION SYSTEMS

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WAVE-TRANSFERRING CIRCUITS FOR COMMUNICATION SYSTEMS.

Application filed June 1, 1916. Serial No. 101,181.

To all whom it may concern:

Be it known that I, JOHN MILLS, a citizen of the United States, residing at Wyoming, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Wave-Transferring Circuits for Communication Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to radio transmission and one object is to secure simultaneous sending and receiving without the use of several antennæ. This object is accomplished by employing novel means for alternately connecting the transmitting and receiving apparatus to the antenna in rapid succession.

Other objects will appear from a perusal of the following detailed description, after which the features believed to be allowable are set forth in the claims.

This invention will be more clearly understood by reference to the drawing which represents a combined transmitting and receiving system constructed in accordance with this invention. Referring to the figure, 1 represents a generator of high frequency oscillations which may be of any suitable form, but is here shown as an oscillating vacuum tube. The oscillation generator comprises a closed tuned circuit having an inductance and a capacity serially included therein with the anode and grid of a thermionic repeater connected respectively to the terminals of the capacity and the filamentary cathode connected to an intermediate point in the inductance. A space current battery is included in the anode-cathode circuit. 2 represents a microphone circuit in which are produced alternating currents of telephonic frequency. By means of a transformer this circuit 2 is connected to the input terminals of a thermionic amplifier 3 whose function is to increase the effective amplitude of the telephone currents produced in circuit 2. The telephone currents in circuit 2 cause a corresponding voltage to be impressed across the grid and cathode of the amplifying tube, thereby causing corresponding but greater changes of current and voltage in the output circuit connected to the anode and the cathode thereof. The means shown typifies any suitable amplifying means which might be utilized. The output circuit of amplifier 3 is connected to the input circuit of a thermionic modulating device 4 by which connection the impedance of the tube 4 is made to vary in accordance with the signals originating in the circuit 2. The output circuit of the high frequency generator 1 is also connected to the input circuit of the modulator 4 with the result that in the output circuit of the latter there appear high frequency oscillations, modulated in amplitude in accordance with the signal waves due to the microphone. These modulated waves in the output circuit 4 are next impressed upon the input circuit of an amplifier or a system of amplifiers 5 whose common output circuit contains a coil 6 which is coupled to a coil in the antenna 7.

The method of periodically connecting this transmitting system to the antenna consists in rendering the generator 1 alternately efficient and inefficient by means of the apparatus next to be described. It is well-known that if the potential of the grid of a thermionic amplifier is made to take a sufficiently high negative value with respect to the potential of the cathode, the space current in the amplifier may be reduced to zero, and consequently its efficiency is also reduced to zero. When the space current of the tube of the generator 1 is thus diminished, it will be clear that no signals will be transmitted from the antenna 7. The method of securing this periodic reduction in space currents will now be explained. 8 represents a generator of oscillations of frequency above the limit of audibility, but considerably below the frequency generated by the generator 1. It is proposed to impress these oscillations upon the input circuit of the generator 1 and thereby cause the resultant voltage over that circuit to vary periodically by an amount sufficient to reduce the space current to zero during half the time of operation. The generator 8 would normally furnish from its output circuit an approximately sinusoidal current whereas it is desirable that the electromotive force impressed upon the input circuit of generator 1 shall be an approximately flat topped wave. A flat topped wave is one which has a substantially constant potential for each half wave. When the flat topped wave is negative, the vacuum tube is rendered inoperative and here it is not altogether essential that the wave be flat topped, that is, that the potential be constant provided that the potential is sufficiently negative to keep the tube in-

operative. When the flat topped wave is positive, however, the tube is operative but here it is essential that the wave be flat topped, that is, that the voltage be constant so that only the variable signal currents will apply a variable potential to the tube whereby the space current in the tube will be controlled only by the variable signal current. When the halves of the wave act alternately to render inoperative each of a pair of vacuum tube devices, it is therefore preferable that both halves of the wave be flat topped.

As explained, page 62 et seq.—Byerly's "Fourier's Series," a flat topped wave may be represented by the equation

$$Y=A\ (\sin x+\tfrac{1}{3}\sin 3x+\tfrac{1}{5}\sin 5x, \text{ etc.})$$

where A is a numeric and x represents an angle. This equation may be represented by the infinite series

$$\sum_{N=0}^{N=\infty}\frac{A}{2N+1}\sin(2N+1)x,$$

where N is an integer.

This form of wave is secured by connecting the output circuit of generator 8 to the input circuit of a power limiting device 9. The device 9 may consist of a thermionic repeater having a high resistance 19 in the output circuit. Such a resistance limits the output current to a definite maximum value even though high potentials are applied to the input circuit. Any other suitable arrangement, however, may be utilized as a power limiting device for effecting the flattening of the wave. Such a device has the effect of cutting off the top of the wave at a predetermined value. The device 9 limits the power and produces a flat topped wave, since, for current above a given value, the fall of potential across the resistance 19 becomes effective to prevent further substantial increase of the current. The frequency generated by the device 8 will be above the limit of audibility as hereinbefore stated and preferably of the order of 10,000 to 30,000 cycles per second. Transformer 20 serves to impress the flat topped wave upon the input resistances 22 of the amplifying devices 10 and 18. A condenser 21 connected across the secondary of transformer 18 may have any suitable value of capacity, but preferably a small value. A flat topped wave then appears in the output circuit of the power limiting device 9, and is impressed upon the input circuit of the generator 1 through the amplifier 10 and switch 11, whose functions are to provide for the tuning of the system without the added complication of the control generator 8 and its associated circuits. The function of amplifier 10 is to adjust the controlling voltage at the terminals of generator 1 to the correct value.

In receiving signals, a tuned circuit 12 is coupled to the antenna and supplies power to the input circuit of a power limiting device 13, whose function is to prevent excessive disturbances in the receiving system when messages are being transmitted from the local station. The power limiting device 13 may be similar to the device 9 as shown, or may be any suitable device for limiting the transferred energy. The output circuit is coupled through another tuned circuit 14 to the input circuit of the detector 15. The output circuit of this detector is coupled to a translating device 16, for example, a telephone receiver.

It is desired to make the detector 15 operative only during the time that signals are not being transmitted by the transmitting circuits, and for that purpose the control wave due to generator 8 is caused to apply a negative potential to the grid of the detector 15 and the grid of the generator 1 alternately. This is accomplished by connecting the output circuit of the power limiting device 9 through switches 17 and the amplifier 18 to the input circuit of the detector 15, the connections being such that the voltages produced by the control source of electromotive force and impressed upon the input circuit of detector 15 are in opposite phase to those impressed upon the input circuit of the generator 1. By this means the generator 1 will be in efficient transmitting condition when the efficiency of the detector 15 is zero and vice versa.

In adjusting this system for operation it will be desirable first to tune for receiving signals with the switches 17 and 11 open and with the transmitting arrangement cut out, then to close these switches and adjust the frequency of the control generator 8 until signals are heard distinctly. It will then be possible to transmit and receive without interference.

The arrangement disclosed may be regarded as a system for two-way repeating to and from a line. The antenna 7 constitutes a signaling conductor or line from which incoming waves pass through the power limiting device 13 and the detector 15 to the receiver 16. When the grid of the detector is made negative by the auxiliary channel 8, the detector is inoperative. When the detector is operating the energy of the high frequency waves passing through it is in part transformed into low frequency energy and supplied to the receiver 16. On the other hand, waves from the microphone circuit 2 are amplified by the amplifier 3 and combined with waves from the generator 1 to produce modulated high frequency waves at the modulator 4. The modulated high frequency waves are transferred through the amplifier 5 to the antenna circuit. When the generator 1 is inoperative, no high frequency waves will be produced and the path 4, 5 will have a negligible transferring effi-

ciency for the speech waves from the circuit 2 because of the relatively high attenuating effect of the tuned circuit between the tubes 4 and 5. Waves transferred through the input circuit, therefore, have their frequency changed during transmission by detection while the outgoing waves are changed in part by modulation.

Although the invention has been described as applied to a duplex radio signaling system, it is apparent that many of the features are equally well adapted to use in other radio systems than the kind described and also in wire systems employing high frequency currents varying in accordance with signals. It is also apparent that several features of the invention are capable of general application not only to various kinds of signaling systems, but also to use in other transmission systems.

What is claimed is:

1. A two-way signal transmission system comprising separate channels for transmitting in each direction, a space discharge device cooperating with each channel and functioning as an essential element for maintaining efficient transmission therethrough, an electrode in each of said devices, and electrical arrangements whereby at a given instant of time one only of said electrodes is established at such a potential as to render the corresponding device inoperative and thereby render the channel with which said device is associated incapable of efficient transmission.

2. The method of repeating electrical variations by means of a repeating device which comprises continuously applying the waves to be repeated to said device, and automatically periodically rendering said device inoperative at a frequency widely different from the frequency of the waves to be repeated.

3. The method of utilizing a thermionic repeater for the transmission of signals which are transferred by electrical waves which comprises alternately rendering the repeater operative and inoperative at a frequency which is low as compared with the wave frequency but is so high that each inoperative period is short compared to the shortest signal element desired to be transmitted.

4. The method of operating a thermionic repeater which comprises continuously supplying waves to be repeated to the input circuit thereof, and automatically supplying a substantially flat topped wave to the input circuit.

5. The method of operating a thermionic repeater which comprises continuously supplying waves to be repeated to the input circuit thereof, supplying to said repeater at times a substantially constant voltage of a value adapted to maintain said repeater in an efficient repeating condition, and rapidly and cyclically changing said voltage to a substantially constant voltage of a value adapted to render said repeater of negligible efficiency.

6. In combination, a plurality of thermionic repeaters, a plurality of sources of waves to be repeated by said repeaters respectively, and means for rendering said repeaters substantially inoperative in cyclic order.

7. A space discharge repeater, a source of waves to be repeated thereby, and means for alternately rendering said repeater operative and inoperative for periods large as compared with the time required for the transmission of several successive waves to be repeated.

8. A system comprising a repeater having an input and an output circuit, a source of approximately flat topped voltage waves, automatic means for applying said waves to said circuit, a separate source of waves to be repeated, and means for deriving repeated waves from said output circuit.

9. A thermionic repeater including a plurality of electrodes, a circuit connected between two of said electrodes, a source of approximately flat topped voltage waves, and automatically operative means for applying to said circuit, waves from said source of a sufficiently large value to render said repeater inoperative.

10. A space discharge device including a cathode and an impedance controlling element, and automatic means connected to said element for varying the potential thereof with respect to the potential of said cathode in accordance with a curve represented by the infinite series

$$\sum_{N=0}^{N=\infty} \frac{A}{2N+1} \sin (2N+1)x,$$

and of a maximum value sufficient to render said repeater inoperative.

11. A two-way signal transmission system comprising separate channels for transmitting in each direction, a space discharge device cooperting with each channel and functioning as an essential element for maintaining efficient transmission therethrough, means for establishing a controlling field of force for each of said devices, and electrical arrangements whereby at a given instant of time one only of said fields of force is given such a value as to render the corresponding device inoperative.

12. A system including a space discharge repeater, a circuit for supplying waves to be repeated to said repeater, a source of waves of ultra-audible frequency and flat topped wave form, and means for applying said ultra-audible waves to said repeater.

13. In a duplex transmission system, means for accomplishing transmission in one

direction including a space discharge device, means for accomplishing transmission in the opposite direction including a second space discharge device, and means acting independently of the operation of the aforesaid means for causing said devices to be operative and inoperative alternately.

14. A signaling system comprising a plurality of paths for the transmission of electrical waves, a space discharge device connected in each of said paths, a source of energizing current for said devices, and an auxiliary source of electrical waves for cyclically rendering said devices inoperative.

15. A transmission system comprising a plurality of transmission paths, separate means for supplying waves to each path to be transmitted therethrough, a space discharge repeater connected to each path, a source of voltage of a value sufficient to render said repeaters inoperative, and means for applying said voltage to said repeaters cyclically.

16. A communication system comprising a plurality of circuits having a fixed state of continuity and including complete apparatus for the transmission of electrical waves through each of said circuits, and an independent source of current for alternately rendering said paths opaque to the waves to be transmitted.

17. A system comprising a plurality of normally asymmetrically transmitting wave-transferring circuits having a fixed state of continuity, and means for cyclically causing said circuits to have negligible wave transferring power in the normally transmitting direction thereof.

18. Means for use in transmission systems comprising a source of waves to be repeated, a space discharge repeater for repeating said waves, said repeater including an impedance controlling element, and means for alternately applying to said element and removing therefrom a negative potential of a higher order than the amplitude of the waves to be repeated at a frequency differing from the frequency of said source by a difference greater than an audible frequency.

19. In a signaling system, means for signaling in one direction and means for signaling in another direction, each of said means including a vacuum tube, and means for acting upon said tubes alternately to render them substantially inoperative at a frequency which does not interfere with the transmission of signals.

20. In a signaling system, means including a vacuum tube for signaling in one direction and means including a second vacuum tube for signaling in another direction, a generator of alternating current, and means for supplying current of opposite phases from said generator to said tubes.

21. A duplex signaling system, comprising a generator of high frequency waves, means for modulating the high frequency waves, a signaling conductor, a receiving circuit containing a detector associated with said conductor, and a second generator for controlling the efficiency of said first generator and said detector.

22. A duplex signaling system, comprising a generator of high frequency waves, means for modulating the high frequency waves, a signaling conductor, a receiving circuit containing a detector associated with said conductor, said generator and said detector being normally operative, and a second generator connected to alternately render said first generator and said detector inoperative.

23. A duplex signaling system, comprising a generator of high frequency waves, means for modulating the high frequency waves, a signaling conductor, a receiving circuit containing a detector associated with said conductor, said generator and said detector being normally operative, and a second generator connected to alternately render said first generator and said detector inoperative at a rate above the limit of audibility.

24. A duplex signaling system, comprising a generator of high frequency oscillations, means for modulating the high frequency waves, an amplifier, a signaling conductor, a receiving circuit containing a detector associated with said conductor and a second generator of frequency above the limit of audibility, so connected as to render said first generator operative and the detector inoperative when its electromotive force is in one direction and to render said first generator inoperative and the detector operative when its electromotive force is in the opposite direction.

25. A duplex signaling system, comprising a generator of high frequency waves, means for modulating the high frequency waves, an amplifier, a signaling conductor, a receiving circuit containing a detector associated with said conductor, a power limiting device in said receiving circuit to prevent excessive passage of power from the transmitting circuit to the detector, said generator and said detector being normally operative, and a second generator connected to alternately render said first generator and said detector inoperative at a rate above the limit of audibility.

26. A duplex signaling system, comprising a thermionic oscillator for generating high frequency currents, means for modulating the output of said oscillator, an amplifier, a signaling conductor, means for impressing said amplified output upon said conductor, and a receiving circuit including a thermionic detector, a second generator of frequency above the limit of audibility so as-

sociated with said thermionic oscillator and detector as to alternately render them inoperative.

27. A duplex signaling system, comprising a thermionic oscillator for generating high frequency currents, means for modulating the output of said oscillator, an amplifier, a signaling conductor, means for impressing the amplifier output upon said conductor, a receiving circuit including a thermionic detector, and a second generator of frequency above the limit of audibility and so connected to the input circuits of the first generator and detector as to render said first generator operative and the detector inoperative when its electromotive force is in one direction and to render said first generator inoperative and the detector operative when its electromotive force is in the opposite direction.

28. The method of obtaining an alternating voltage of approximately the characteristic given by the infinite series

$$\sum_{N=0}^{N=\infty} \frac{A}{2N+1} \sin (2N+1)x,$$

which consists in generating a uniform voltage of an approximately sinusoidal characteristic, eliminating all voltages above a certain low maximum and amplifying the remainder to the desired value.

29. An alternating voltage generator for obtaining a voltage curve with a flat-topped characteristic comprising a generator of uniform alternating voltage, and a power limiting device for cutting off all voltages above a specified maximum.

30. An alternating voltage generator for obtaining a voltage curve of a flat-topped characteristic comprising a generator of uniform sinusoidal alternating voltage, a power limiting device for cutting off all the voltages above a low maximum, and an amplifier for amplifying the remainder to any desired value.

31. A voltage generator for obtaining an alternating voltage of approximately the characteristic given by the infinite series,

$$\sum_{N=0}^{N=\infty} \frac{A}{2N+1} \sin (2N+1)x,$$

comprising a generator of alternating voltage of substantially constant frequency and amplitude, a power limiting device upon the input circuit of which said alternating voltage is impressed, whereby all voltages above a certain low maximum are eliminated, and an amplifier associated with the output circuit of said power limiting device.

32. Means for producing a voltage wave having a flat topped characteristic comprising a uniform source of sinusoidal voltage of large maximum amplitude as compared with the maximum amplitude of the desired form, a power limiting device whose maximum current capacity corresponds to the maximum amplitude of the desired wave, and means for applying said sinusoidal voltage to said device.

33. A system comprising a line, repeating means associated therewith, and means for automatically reversing the operative repeating direction of said repeating means with respect to said line while repeating without changing its circuital state of continuity with respect to said line.

34. A modulating system comprising a source of high frequency waves to be modulated, a source of low frequency modulating waves, means to modulate said high frequency waves in accordance with said low frequency waves, an essential element of said system being incapable of functioning when an electromotive force of a certain amplitude and polarity is applied thereto, a source of electromotive force, and means for intermittently applying to said element from said source an electromotive force of sufficient amplitude and such polarity as to prevent the functioning of said element.

35. The method of cyclically rendering inoperative a plurality of energy transferring channels while maintaining their state of continuity unchanged which consists in cyclically establishing and disestablishing in the space occupied by a portion of each of said channels, a field of force of such a nature as to prevent transmission therethrough.

36. A generator of intermittent oscillations comprising a space discharge device having a plurality of electrodes including an electrostatic control electrode, circuit arrangements connected thereto appropriate for the generation of oscillations, and means separate from said generator for intermittently causing one of said electrodes to assume a potential not permitting the generation of oscillations while maintaining fixed the circuit connections of said generator, said generator automatically resuming its generating function when said electrode resumes its normal potential.

37. A high frequency carrier wave transmission system comprising a space discharge device having metallic circuit connections and a feed-back connection for generating and supplying carrier oscillations, a source of space current for said generator, and a continually acting means other than said source for automatically causing said device to alternately become operative and inoperative while maintaining the state of continuity of its metallic circuit connection unvaried.

38. A signaling system including a detector, means for supplying waves to be detected to said detector, a separate local source of waves, and means for automatically sup-

plying waves from said source to said detector, said means comprising elements adapted to furnish waves of such amplitude and polarity as to intermittently prevent the efficient detection of the waves to be detected.

39. A two-way transmission system comprising an incoming channel for receiving incoming waves and an outgoing channel for transmitting outgoing waves, a source for supplying to said outgoing channel waves to be transmitted, a separate local source of waves, and means for impressing waves from said source upon each of said channels.

40. A wave transmission system including a space discharge device comprising a source of waves to be transmitted, a second space discharge device constituting a detector for received waves, and continually acting means for rendering said devices operative and inoperative alternately.

41. A radio system comprising a space discharge amplifier having conductive circuit connections and a feed back connection from its output circuit to its input circuit, a source of space current for said device, and a continually acting means other than said source for impressing a periodic electromotive force upon said device to periodically render it alternately active and inactive to feed back and reamplify oscillations from its output circuit to its input circuit while maintaining unvaried the physical state of continuity of its conductive circuit connections.

42. A receiving system for high frequency waves comprising a vacuum tube detector having anode, cathode, and electrostatic control electrodes, suitable circuits connecting said electrodes, means including a vacuum tube repeater and a source of waves for varying the electrical condition of a circuit connecting said electrodes at a given frequency much lower than the frequency of the waves to be received, but above the usual audible range and of such intensity as to vary the impedance of said circuit at said given frequency, and an output circuit connected to said detector circuits including a device for producing an audible indication having an audible frequency independent of small changes in said given frequency.

43. The method of receiving high frequency electromagnetic waves by means including a detector which comprises supplying energy derived from the received waves to said detector, also supplying to said detector periodic electrical energy of frequency much lower than the frequency of the waves to be received but above the usual audible range and of such an intensity as to alternately render said detector efficient and inefficient, and deriving from said detector an audible indication having a frequency independent of small changes in the frequency at which the detector is rendered inefficient.

In witness whereof, I hereunto subscribe my name this 31st day of May, A. D. 1916.

JOHN MILLS