March 4, 1924. 1,485,485

H. G. CORDES

RADIOSIGNALING

Filed Sept. 29, 1919 2 Sheets-Sheet 1

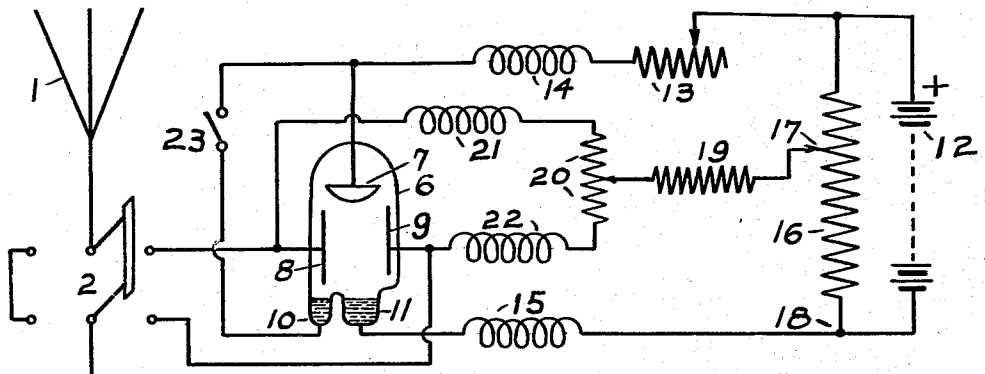


FIG. 1.

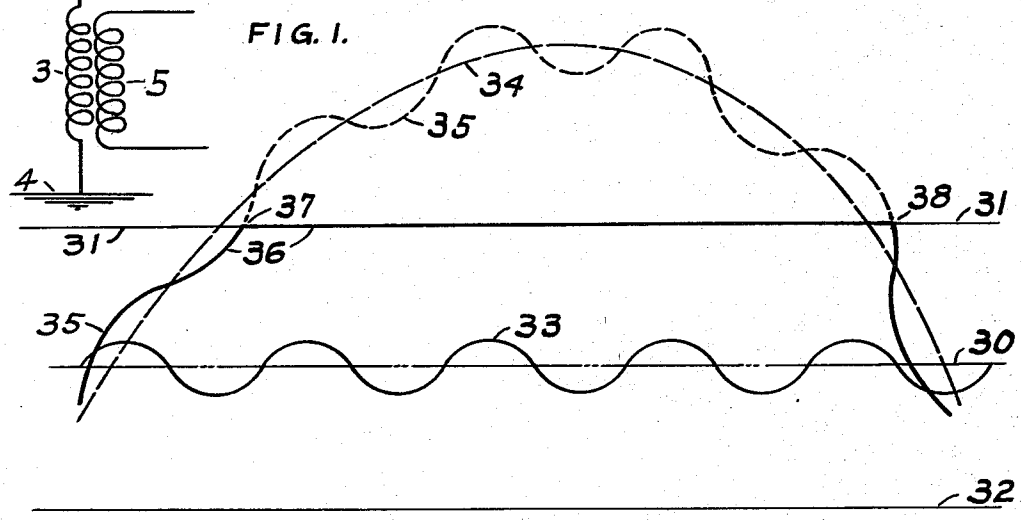


FIG. 2.

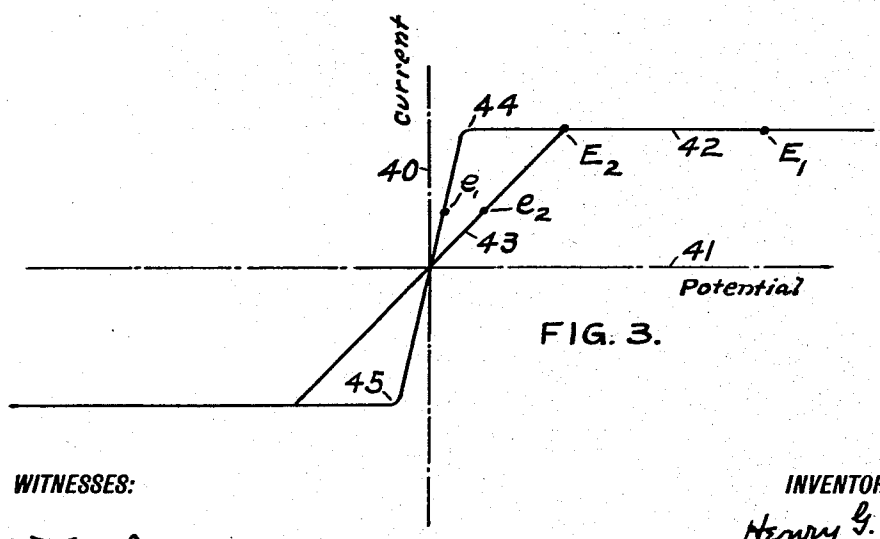


FIG. 3.

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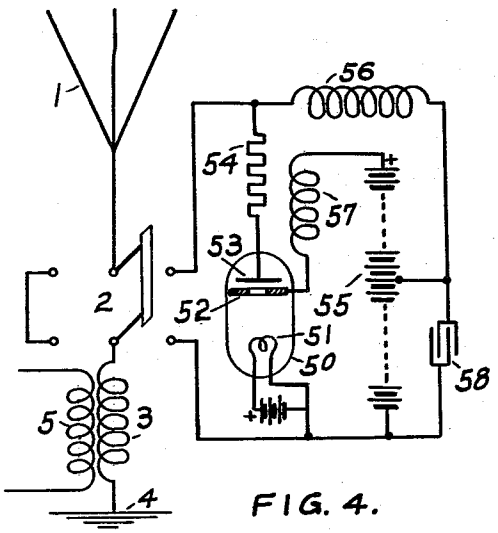


FIG. 4.

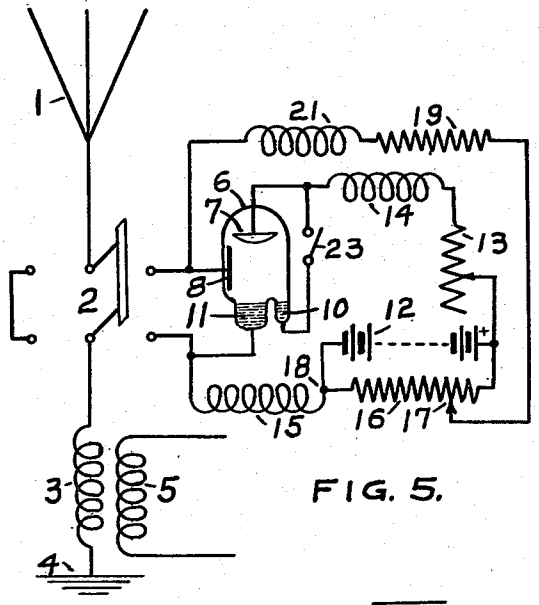


FIG. 5.

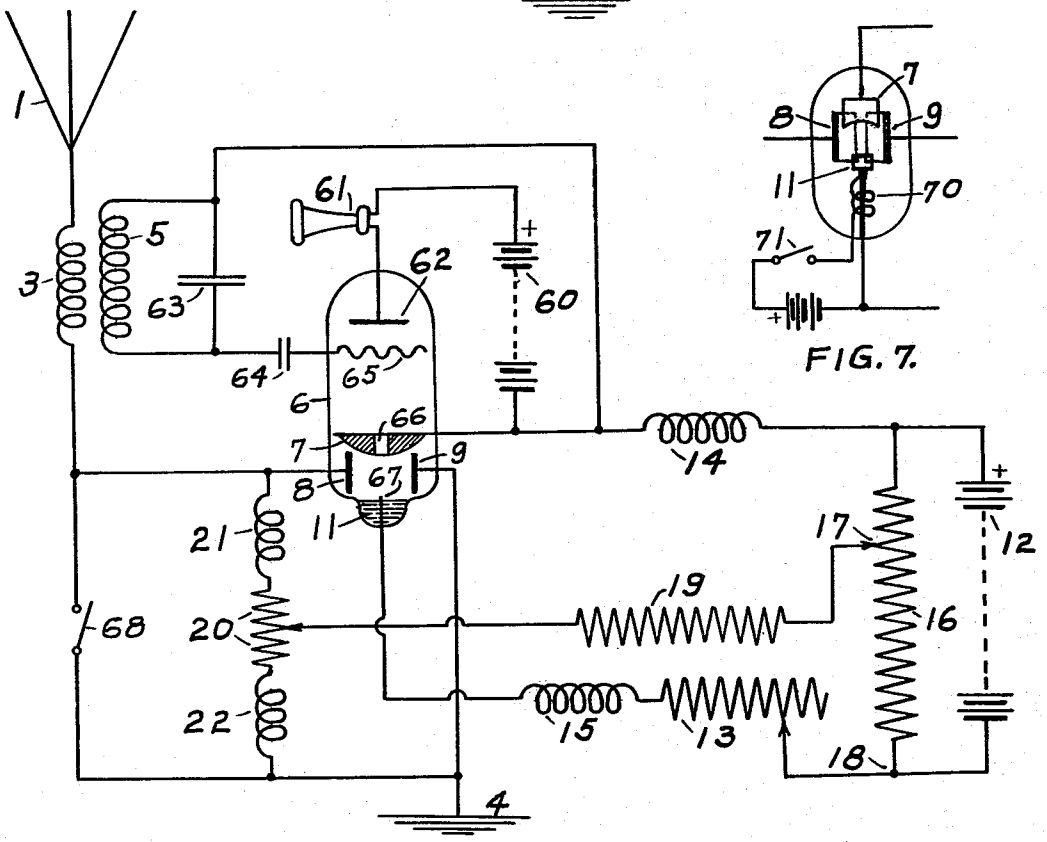


FIG. 6.

FIG. 7.

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Patented Mar. 4, 1924. 1,485,485

UNITED STATES PATENT OFFICE.

HENRY G. CORDES, OF BREMERTON, WASHINGTON.

RADIOSIGNALING.

Application filed September 29, 1919. Serial No. 327,313.

To all whom it may concern:

Be it known that I, HENRY G. CORDES, a citizen of the United States, residing at Bremerton, in the county of Kitsap and State of Washington, have invented a new and useful Improvement in Radiosignaling.

My invention relates to a signal sifter in the receiving antenna circuit of a radio signal receiving system.

The object of my invention is to prevent or reduce the effect in a receiving system of undesirable signals of comparatively short duration and great intensity such as are produced by certain electrical atmospheric disturbances or static while the effect of desirable signals is only slightly reduced.

This object is attained by placing a signal sifter in series with the receiving antenna circuit so that signals tending to produce current exceeding a predetermined amplitude can not pass thru the sifter or are made to pass thru the sifter with increased difficulty as the intensity of the undesirable signal increases. The presence of the sifter in the antenna circuit introduces only a small additional resistance into the circuit for currents of comparatively small amplitude which are produced by the desirable signals.

The sifter is particularly adapted for use in receiving sustained or constant amplitude waves. The energy of a signal appears initially in a receiving antenna circuit as electrostatic energy. In case of desirable sustained wave signals a comparatively small amount of energy is received during each period of the natural period of the antenna circuit. In case of electrical impacts of comparatively short duration and great intensity which cause undesirable signals there is a large amount of energy received by the antenna circuit which is dissipated in a train of oscillations having a high initial amplitude and persisting during a correspondingly long period. These oscillations consist in electrostatic energy being converted into electromagnetic energy and the electromagnetic energy converted again into electrostatic energy and so forth until all of the energy has been dissipated. The advantage of limiting the antenna circuit current is that only a limited part of the initial electrostatic energy due to impact is converted into electromagnetic energy and therefore the train of oscillations is limited in intensity and duration which is a great advantage in a receiving system.

The arrangement and use of the sifter will be further explained by reference to the accompanying drawings forming part of this specification. Figure 1 shows an elementary diagram of a receiving antenna circuit and signal sifter circuits. Figure 2 shows current-time curves of currents in Figure 1. Figure 3 shows current-potential relations in Figure 1. Figure 4 shows a signal sifter using a thermionic current vacuum tube. Figure 5 is a modification of Figure 1. Figure 6 shows a combined signal sifter and receiver. Figure 7 shows a modified form of sifter vacuum tube.

In Figure 1 when the switch 2 is thrown to the left the receiving antenna circuit consisting of the antenna 1, antenna primary coil 3 and ground connection 4 constitutes a receiving antenna circuit of the present radio art. The secondary coil 5 is part of the usual receiving system. Coil 5 withdraws useful signal energy from the antenna circuit. To introduce the signal sifter into the antenna circuit throw switch 2 to the right.

The signal sifter comprises a vacuum tube, an arc circuit and an amplitude limiting circuit. The vacuum tube 6 has an anode 7, three auxiliary anodes 8, 9 and 10 and a mercury cathode 11. The arc circuit comprises a source 12 of direct current, a variable resistance 13, choke coils 14 and 15, the arc anode 7 and the arc cathode 11. A resistance 16 is placed in shunt with the source 12 so that a variable potential is available between points 17 and 18. The amplitude limiting circuit comprises a source of variable potential between points 17 and 18, a high resistance 19, a divided resistance 20, choke coils 21 and 22, anodes 8 and 9, cathode 11 and choke coil 15. The third auxiliary anode 10 is a mercury anode used for starting an arc from 7 to 11 and is similar to the usual starting anode of a mercury arc rectifier.

The operation of the sifter is as follows. Let 12 be a source of 20 to 30 volts direct current. Adjust resistance 13 so that a current of 5 to 10 amperes flows in the arc circuit. Close switch 23 and tilt the vacuum tube in the usual manner to start an arc from anode 7 to cathode 11. Open switch 23. Adjust the point 17 by a sliding contact so that 800 micro-amperes flow in the

amplitude limiting circuit. Divide resistance 20 so that the current from auxiliary anodes 8 and 9 to cathode 11 is approximately equal. Choke coils 14 and 15 prevent high frequency antenna current from flowing in the arc circuit while choke coils 21 and 22 prevent high frequency current from flowing externally between anodes 8 and 9.

It is well known that when an arc is established between anode 7 and cathode 11 that current will flow, due to a comparatively low potential, from auxiliary anodes 8 and 9 to cathode 11 but very little from cathode 11 to anodes 8 and 9. The difference of potential between the auxiliary anodes and the cathode remains practically constant for varying values of current flowing from 8 or 9 to 11. The direct current flowing from the auxiliary or amplitude limiting circuit anodes 8 and 9 to cathode 11 is the amplitude limiting current. The current flowing from 8 or 9 to 11 is the resultant of the amplitude limiting current and the antenna circuit current. This resultant current will be designated, for convenience, the sifter current. When the maximum amplitude of the antenna circuit current equals 400 micro-amperes the sifter current fluctuates between zero and 800 micro-amperes. Since current cannot flow from 11 to 8 or 9 the sifter current cannot have a negative value. If the direct current thru anode 8 is greater than the direct current thru anode 9 then the anode 9 sifter current will have a greater maximum value than the anode 8 sifter current. The resistance between auxiliary anode 8 or 9 and cathode 11 varies practically inversely as the sifter current. The arc vapor between sifter anode 8 and cathode 11 and the arc vapor between sifter anode 9 and cathode 11 constitute two unidirectional current conductors in series with the antenna circuit.

In Figure 2 abscissas represent time and ordinates represent current amplitude. Line 30 represents zero antenna current. Line 31 represents zero anode 8 sifter current and line 32 represents zero anode 9 sifter current. With switch 2 thrown to the left, curve 33 represents desirable signal antenna current, curve 34 represents undesirable signal current and curve 35 is the resultant of curves 33 and 34. Throw switch 2 to the right and the anode 8 sifter current is represented by line 36. During the interval from 37 to 38 the curve 36 is a straight line which indicates that the desirable signal current cannot pass thru the sifter during this interval. If the undesirable signal is of short duration and comparatively infrequent occurrence this blanking of the desirable signal is not objectionable. The antenna current due to the undesirable signal is limited by line 36. The maximum initial current amplitude of a train of free oscillations due to an undesirable signal is limited also by lines 31 and 32.

In Figure 3 the distance of any point from line 40, measured on a line parallel to line 41, represents potential and the distance of any point from line 41, measured on a line parallel to line 40, represents current. Curve or line 42 represents the average potential difference between amplitude limiting anodes 8 and 9 during a half cycle, and curve or line 43 represents the average potential consumed by the primary coil 3 during a half cycle. Let the average potential consumed by the sifter be e_1 and the average potential consumed by coil 3 be e_2. For undesirable signals of comparatively great intensity let the values of e_1 and e_2 be E_1 and E_2 respectively while the current is limited by the line 42.

The basis of my invention consists in the fact that the potential e_1 is less than e_2 for desirable signal current and E_1 is greater than E_2 for undesirable signal current. In the first instance the useful energy withdrawn from the antenna circuit is greater than the useful energy dissipated in the sifter. In the second instance the useless or undesirable energy dissipated in the sifter is greater than the undesirable energy consumed by coil 3. The sifter also stops the conversion of much electrostatic undesirable energy into electromagnetic energy. For desirable signal potentials impressed upon the antenna circuit the line 42 should nearly coincide with line 40 but for undesirable signal potentials line 42 should be parallel to line 41. The arrangement of Figure 1 gives the required constant potential difference for small variable current due to desirable signals and uni-directional conductivity to maintain constant current for variable high potentials due to undesirable signals. Any other arrangement which gives a bend in curve 42 at the point 44 or 45 may be used but a practically right angle bend is the ideal bend. The current-potential curves of crystal detectors and thermionic currents approaching saturation give bends which may be utilized, provided that on part of the curve there is but a very slight potential variation for a comparatively large variation of current. The energy consumption of the sifter and coil 3 may be considered to vary practically as the average potentials altho the instants of maximum energy consumption of sifter and coil 3 for desirable signals are about 45 degrees out of phase. The potential E_2 is limited to the average value indicated by the intersection of lines 42 and 43 in Figure 3. The presence of the sifter in the antenna circuit does not reduce the maximum instantaneous potential impressed upon coil 3 by undesirable signals.

Figure 4 shows a signal sifter arrange-

ment using a thermionic current vacuum tube 50 which has an incandescent filament 51, an anode 52, and a plate 53. This type of vacuum tube is described in the Proceedings of the Institute of Radio Engineers of February, 1918, and is there designated as a "dynatron." Figure 4 is similar to Figure 1 when the switch 2 is thrown to the left. The potential between the filament 51 and anode 52 and between filament 51 and plate 53 is adjusted for zero current thru the non-inductive resistance 54. The voltage of battery 55 is 100 volts or more. Inductance coil 56 allows direct current to pass to adjust the direct current thru 54 to zero or other suitable value to stabilize the dynatron while it does not allow high frequency antenna current to pass. A choke coil 57 is placed in series with the anode to prevent induced high frequency current from flowing in this circuit. The large condenser 58 shunts part of the battery 55 for high frequency antenna current.

The sifter is introduced into the antenna circuit by throwing switch 2 to the right. A low potential impressed upon the antenna circuit by desirable signals is nearly all consumed by coil 3 but a high potential impressed upon the circuit is mostly consumed by the sifter and the maximum amplitude of the undesirable signal current is limited for a comparatively large range of high impressed potential. A small antenna current thru non-inductive resistance 54 causes a large potential difference between the terminals of 54 which may be utilized instead of coil 3 for withdrawing energy from the antenna circuit.

Figure 5 is similar to Figure 1 except that the amplitude limiting circuit has only one anode and consists of a source of variable potential between points 17 and 18, high resistance 19, choke coil 21, anode 8, cathode 11 and choke coil 15. The amplitude relations of Figure 2 apply to Figure 5 except that either line 31 or 32 is omitted, that is, the current amplitude is limited only in one direction. Current in the antenna circuit is not limited in the direction from anode 8 to cathode 11 but it is limited in the direction from cathode 11 to anode 8. This arrangement prevents free oscillations having a high initial amplitude and the energy loss in the sifter due to desirable signal current is only one half of the loss of Figure 1. The disadvantage of this arrangement is that a secondary circuit coupled to the antenna circuit may receive an impact due to an undesirable signal and oscillate with a high initial amplitude at its own natural frequency which is as undesirable in a secondary circuit as in the antenna circuit. This arrangement is therefore suitable only for an antenna circuit having no secondary oscillatory circuit.

Figure 6 shows an arrangement in which a single vacuum tube is used for both detector and sifter. The sifter arrangement is similar to Figure 1. The arc circuit consists of battery 12, choke coil 14, anode 7, cathode 11, choke coil 15 and resistance 13. The amplitude limiting circuit comprises the source of variable potential between points 17 and 18, the resistance 19, the divided resistance 20, choke coils 21 and 22, anodes 8 and 9, cathode 11, choke coil 15 and resistance 13. The function of the above arrangement is the same as in Figure 1.

The receiving system shown is described in detail by G. W. Pierce in Patent No. 1,112,549, dated October 6, 1914. A battery 60 and telephone receiver 61 are connected in series between anode 7 and plate 62. A condenser 63 is connected in parallel with coil 5 to form the usual secondary oscillatory circuit of a receiving system. The condenser 63 and coil 5 are connected in series with a small condenser 64 between the anode 7 and grid 65. The oscillatory current in 5 and 63 due to desirable signal current varies the conductivity of the rarefied gas path from plate 62 to anode 7 by varying the potential between anode 7 and grid 65. As the potential varies between 7 and 65 the direct current varies thru the telephone receiver 61 and produces audible sound. The arc anode 7 is provided with a hole 66 thru which the space above 7 becomes properly ionized. A platinum point 67 holds the cathode spot in the center of the mercury pool. The advantage of this arrangement is that the same vacuum arc is used for both the detector and the sifter. The sifter may be cut out of the antenna circuit by closing the switch 68.

Figure 7 shows a vacuum tube having a tungsten cathode 11 in rarefied argon. The filament 70 is heated by closing switch 71 to facilitate starting an arc between the anode 7 and cathode 11. The amplitude limiting circuit anodes 8 and 9 are placed close to the arc and have a semi-cylindrical form. The energy required to maintain a proper arc in this tube is less than in the tube of Figure 1.

The function of the sifter can be made still more clear by comparing it with a sieve. Small particles pass thru the mesh of a sieve without exerting much pressure on the mesh but large particles do not pass thru and exert a pressure on the mesh. This is analogous to small amplitude current passing thru the signal sifter without much potential difference between the terminals of the sifter while large amplitude current cannot pass thru the signal sifter and the potential difference between the terminals is comparatively large as shown by Figure 3. The large particles also prevent small particles from passing thru the mesh of a sieve. Sim-

ilarly, a high potential impressed upon the antenna circuit tending to produce large amplitude current prevents small amplitude current from passing thru the sifter, as shown by Figure 2. The duration of the impressed high potential may be compared to the speed with which large particles pass over the mesh. Many large particles passing over a single mesh sieve at slow speed compared to the speed of small particles would seriously interrupt the sifting of small particles. Similarly, many electrical impacts of comparatively long duration will interrupt reception of the desirable signal. If an arrangement were used which would give that part of line 42, Figure 3, which is parallel to line 41 a positive and decreasing slope as the amplitude of the current increased then undesirable signal current would pass thru the sifter with increased difficulty as the amplitude of the current increased. This may be compared to a flexible mesh thru which particles would pass with increasing difficulty as the size of the particles increased. The strength of the amplitude limiting current corresponds to the size of a mesh of a sieve.

The sifter can be used in a receiving circuit which is in proximity to a sending station only when means are provided to reduce the amplitude of the interfering signal current in the receiving antenna circuit, as is done in duplex signalling. If the interfering signal is a constant frequency sinoidal wave having a low rate of change of amplitude then a parallel resonance circuit tuned to the interfering wave and placed in series with the receiving antenna circuit will counteract the interfering signal.

The construction of the sifter vacuum tube or valve presents no special features not found in the construction of vacuum tube rectifiers generally. The amplitude limiting circuit anodes should be placed close to the cathode spot so that the space between anodes and cathode is thoroly ionized but the anodes must be kept cool enough to prevent an objectionable amount of inverse current.

A galvanometer may be placed in series with the amplitude limiting circuit to measure the maximum current which can flow in the antenna circuit.

The capacitance between the terminals of the sifter due to capacitance of leads, distributed capacitance of coils and capacitance between terminals inside the tube should be reduced to a minimum especially when the capacitance of the antenna circuit is small.

Energy to actuate a radio signal detector is generally withdrawn from the antenna circuit by means of a coupled reactance. Energy is dissipated by the sifter in the form of heat. All energy in a receiving antenna circuit is either withdrawn to actuate a detector. dissipated as heat or re-radiated when prevented from being transformed into electromagnetic energy in the antenna circuit.

The terms "oscillating current" and "oscillatory circuit" as used in this specification refer respectively to the current in a circuit or to a circuit which comprises inductance and capacitance and has less than the critical resistance required to make the current in the circuit non-oscillatory. The general term "rarefied gas conductor" refers to either a vacuum arc vapor conductor or to a thermionic current conductor, that is, the conductivity in rarefied gas may be due either to ionization by collision or to pure electron conduction which is generally considered to be independent of the presence of gas, or it may be due to both gas and electron conduction as in Fig. 7.

The novel features of my invention are more definitely stated in the following claims.

I claim:

1. The combination of an alternating current circuit, means for impressing both high and low electromotive forces upon said circuit, means for limiting the current in said circuit when said high electromotive force is impressed upon said circuit and means for reducing to a nearly zero value the resistance of said second-mentioned means to the flow of alternating current in said circuit when said low electromotive force only is impressed upon said circuit, said second-mentioned means being connected serially in said circuit.

2. In an alternating current amplitude limiter, a conductor having unidirectional conductivity, means for producing a flow of direct current thru said conductor and means for superposing alternating current of limited amplitude upon said direct current thru said conductor; said conductor having the property of a constant instantaneous potential drop for variable current of limited amplitude thru said conductor.

3. An alternating current circuit in combination with means for limiting positive and negative amplitudes of alternating current in said circuit and means for keeping a nearly constant instantaneous potential drop thru said first-mentioned means only when said current has an amplitude of limited value, said first-mentioned means being serially connected in said circuit.

4. An alternating current amplitude limiter comprising a rarefied gas container having a cathode, a plurality of anodes and auxiliary means for producing arc vapor in said container in combination with means for producing a flow of direct current from said anodes to said cathode.

5. The combination of an oscillatory circuit comprising inductance and capacitance

and means for limiting the amplitude of oscillating current in said circuit; said means having the property of introducing less than the critical non-oscillatory resistance into said circuit.

6. In means for limiting the amplitude of current in an oscillating current circuit the combination of two conductors in series in said circuit, the potential drop for limited current thru one of said conductors being positive, the potential drop for limited current thru the other of said conductors being negative and the total drop for limited current thru said conductors in series being nearly zero; said conductors comprising a rarefied gas conductor.

7. An alternating current circuit wherein are combined an anode, an arc vapor conductor, a cathode, a second arc vapor conductor and a second anode in series connected serially with said circuit, auxiliary means for producing said vapor and a source of direct current connected to said anodes and to said cathode.

8. Means for translating radiant energy into oscillating current energy, said means comprising a radiant-energy-absorbing oscillatory circuit and means for limiting the rate at which said radiant energy can be translated into electromagnetic energy in said circuit.

9. The method of reducing the duration of a train of free oscillations in an oscillatory circuit of a radio receiving system which consists in limiting the amount of electrostatic energy in an oscillatory circuit which can be transformed into electromagnetic energy.

10. The method of varying the current limit in an oscillatory circuit comprising a current amplitude limiter which consists in superposing an oscillating current upon a direct current and varying the value of said direct current.

11. The method of limiting the amplitude of oscillating current by means of a conductor having unidirectional conductivity and whose resistance varies practically inversely as the current thru said conductor which consists in superposing an oscillating current whose amplitude is to be limited upon a direct current thru said conductor.

12. The method of minimizing the effective resistance introduced into an alternating current circuit by placing a current amplitude limiter in series therewith, said limiter comprising a conductor having unidirectional conductivity which consists in passing said current having an amplitude less than a fixed value thru said limiter at nearly zero instantaneous potential drop during a complete cycle of said current and passing said current tending to have an amplitude greater than said fixed value at a substantial potential drop.

13. The method of limiting the current thru the capacitance of an oscillatory circuit having a conductor comprising rarefied gas in series with said circuit which consists in discharging a limited charge on said capacitance thru said conductor at nearly zero potential drop and discharging a charge on said capacitance which is materially greater than said limited charge thru said conductor at a potential drop of a substantial value.

14. The method of overcoming undesirable effects in an oscillatory circuit comprising inductance and capacitance which consists in limiting the amplitude of oscillating current thru said inductance and capacitance when comparatively large electromotive forces are impressed on said circuit and in securing the cumulative effects of comparatively small electromotive forces impressed on said circuit.

15. An alternating current circuit in combination with means for limiting both positive and negative current amplitudes in said circuit, said means comprising a conductor having the properties of unidirectional conductivity and constant potential drop for a variable current of limited amplitude.

16. The combination of an antenna circuit, means for translating energy from said circuit to a secondary circuit and means for limiting the rate of translating said energy to said secondary circuit; said last-mentioned means comprising a unidirectional current conductor in series with the antenna circuit and having the property of a practically constant potential drop when variable current of limited amplitude flows thru said conductor.

This specification signed and witnessed this 22nd day of September, 1919.

HENRY G. CORDES.

Witnesses:
G. W. PRESSER,
H. A. FISCHER.