No. 823,402. PATENTED JUNE 12, 1906.

L. DE FOREST.

STATIC VALVE FOR WIRELESS TELEGRAPH SYSTEMS.

APPLICATION FILED DEC. 9, 1905.

2 SHEETS—SHEET 1.

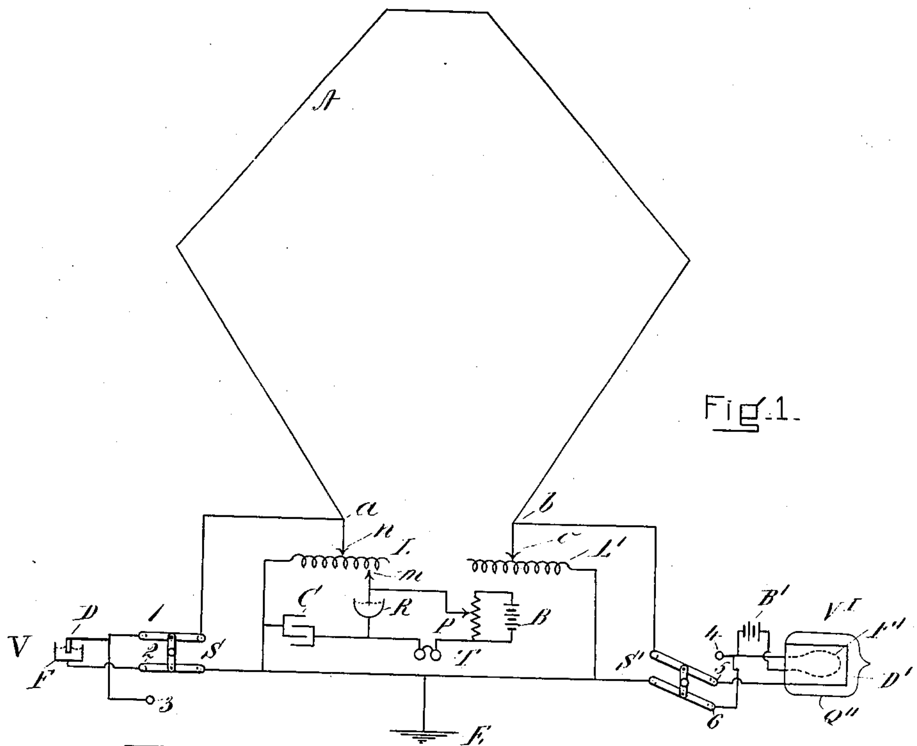

Fig. 1.

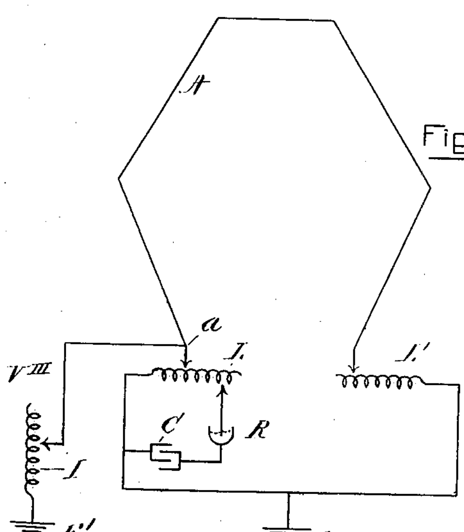

Fig. 3.

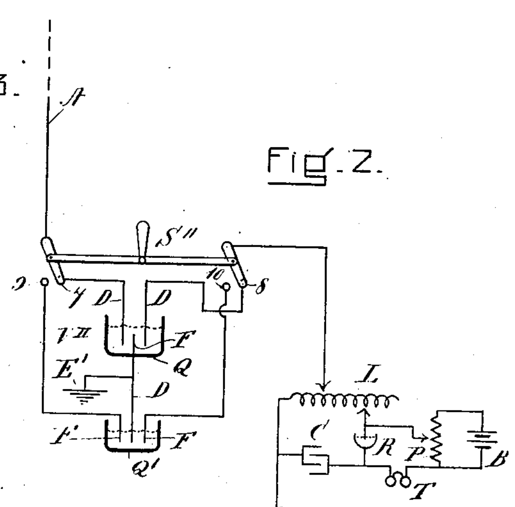

Fig. 2.

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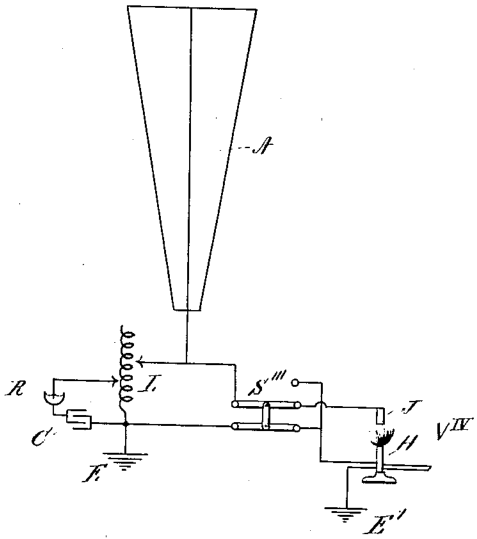

Fig. 4.

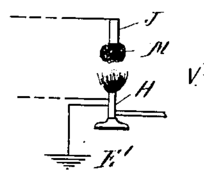

Fig. 4a.

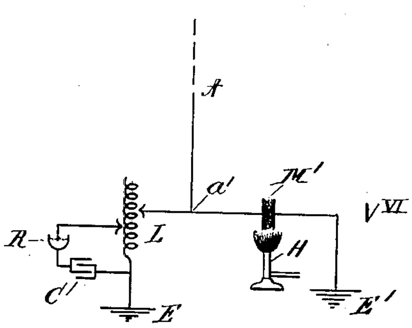

Fig. 5.

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UNITED STATES PATENT OFFICE.

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STATIC VALVE FOR WIRELESS-TELEGRAPH SYSTEMS.

No. 823,402. Specification of Letters Patent. Patented June 12, 1906.

Application filed December 9, 1905. Serial No. 291,067.

To all whom it may concern:

Be it known that I, Lee de Forest, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Static Valves for Wireless-Telegraph Systems, of which the following is a specification.

My invention relates to wireless-telegraph receiving systems, and more especially to apparatus and circuit arrangements whereby atmospheric electricity or static disturbances may be minimized or eliminated.

It is well known that the receiving antennæ of commercial wireless-telegraph systems often become charged with static electricity by such natural causes as the passage of charged clouds in the vicinity of the antennæ, lightning discharges which may be even far distant from the receiving-station, the impingement upon the antennæ of winds, especially hot winds, laden with ionized air, &c. Very often such static charges so accumulated by the antennæ seriously interfere with the reception of signals transmitted by electromagnetic waves from distant stations, and sometimes, especially in tropical and semitropical climates, these static effects become so pronounced as to entirely prevent the reception of such signals.

The object of the present invention is to provide means for preventing by static valves or leaks any deleterious effect on the reception of signals by static or other natural or artificial electrical forces.

My invention may best be understood by having reference to the drawings which accompany and form a part of this specification and which conventionally represent various forms of static valves or leaks which I have found efficient for carrying out the hereinbefore-stated objects, although it is to be understood that I do not limit myself to the specific embodiments of my invention shown in said drawings, inasmuch as many other embodiments thereof may be devised by those skilled in the art without departing from the spirit of my invention.

In the drawings, Figure 1 represents a wireless-telegraph receiving system provided with two forms of static valve or leak. Fig. 2 represents a wireless-telegraph receiving system provided with an electrolytic static valve or leak. Fig. 3 represents a wireless-telegraph receiving system in which an iron spiral is employed as a static leak. Fig. 4 represents a wireless-telegraph receiving system in which a flame is used as a static valve or leak. Fig. 4ª shows a modification of the device illustrated in Fig. 4, and Fig. 5 represents a wireless-telegraph receiving system in which heated mineral wool or the like is employed as a static leak.

For the purpose of more fully disclosing the present invention I have shown in Fig. 1 two embodiments of the same applied to a receiving system of my invention which comprises a loop antenna, although, as shown in Figs. 2, 4, and 5, the present invention is not limited to any particular kind of receiving system, being capable of application to any type of receiving system.

In Fig. 1, A is a loop antenna, the two sides of which are adjustably connected to the inductances L L′, which are connected to earth at E. Across any desired portion of the inductance L the tuned receiving-circuit C R L, including the variable condenser C and responder or oscillation-detector R, is adjustably connected, and by means of the adjustable contact *m* and said variable condenser C the natural period of said tuned receiving-circuit is made equal to that of the loop antenna, while by means of the adjustable contacts *n* and *o* the natural period of said loop antenna is made equal to that of the electromagnetic waves to be received. Across the terminals of the responder R is connected the local receiving-circuit, including the telephone T and any desired portion of the potentiometer resistance P, which regulates the potential of the battery B to be impressed upon the responder. A static leak V or V^{I} is connected between the earth E and any suitable point *a* or *b* of the antenna located between the top of the antenna and the adjustable contacts *n* or *o*, and preferably near said adjustable contacts. One static leak only may be employed with a loop antenna, as shown in Fig. 3, and if two are used they may be of the same or of different types. If the receiving system is provided with an open antenna, only one static leak is used, as shown in Figs. 2, 4, and 5.

A variety of devices may be used as static leaks, and I shall now specifically describe the six devices V, V^{I}, V^{II}, V^{III}, V^{IV}, V^{V}, and V^{VI}, shown in the drawings, although it is to be understood that many other devices may be employed.

V is a static valve or leak consisting of an electrolytic cell comprising an electrode F, which may form a cup of aluminium, tantalum, iron, or other suitable metal, an electrode D of carbon, platinum, or other suitable material and an electrolyte coöperating with said electrodes and consisting of ammonium phosphate, caustic soda or potash, or any other suitable chemical solution. A cell so constructed has the well-known property of permitting electric currents of given polarity to pass through it in one direction—for example, from the carbon electrode to the aluminium electrode—more readily than in the opposite direction—in short, such a cell is an electric valve or asymmetric resistance.

The reversing-switch S coöperates with the contacts 1 and 3, which are connected to the electrode D, and the contact 2, which is connected with the cup F, and enables the operator to connect either the electrode D to the antenna and the electrode F to earth or the electrode F to the antenna and the electrode D to earth. For the purpose of describing the operation of the cell V it will be assumed that the electrode D, which is connected to the antenna in the position of the switch shown in Fig. 1, is carbon and that the electrode F, which is connected to earth in said position of the switch, is aluminium. With a cell so constructed and so connected a positive charge of electricity developed in the antenna will readily pass through the cell to earth and will therefore be prevented from affecting the responder R; but a negative charge of electricity developed in the antenna will not pass through the cell to earth and might, therefore, affect the responder R. If with the switch set in the position shown in Fig. 1 the operator should detect the effects of static disturbances, he would throw the switch so as to coöperate with the contacts 2 and 3, thereby connecting the aluminium electrode F to the antenna and the carbon electrode to earth, in which position of said switch a negative electric charge developed in the antenna would pass to earth. Thus the position of the switch must be determined empirically by the operator in accordance with observed phenomena.

It will be noted that when the switch is set so that the cell will conduct a positive charge to earth the positive half-waves developed in the antenna by the electromagnetic waves to be received will also be conducted to earth and will not assist in producing signals and that when the connections of the cell are reversed, so as to conduct negative electric charges to earth, the negative half-waves developed in the antenna by said electromagnetic waves will also be conducted to earth, so that the static valve results in wasting approximately half the received energy. I have found, however, that the remaining energy absorbed by the antenna from the electromagnetic waves is sufficient to operate the responder, and I have been enabled with a system provided with said static valve employed as above set forth to receive signals under conditions of static disturbance which otherwise would have rendered such reception impossible.

It will be noted that if, as indicated in Fig. 1, two static valves are employed with a loop antenna each must be connected so as to pass currents or charges of the same polarity, for if they were connected so as to pass currents or charges of opposite polarities one-half the energy of the waves would pass to earth by way of one valve and the other half by way of the other. Generally but one valve will be sufficient, and while it may be connected to earth from either the point *a* or the point *b* (see Fig. 1) it is preferred to connect it to earth from the point *a*, so that its circuit will form a shunt around that portion of the antenna with which the responder-circuit is associated.

The static valve shown at V^{II} in Fig. 2 is another form of electrolytic asymmetric resistance consisting of two cups Q Q′ of insulating material, the cup Q containing two electrodes D D of the same materials as above set forth in connection with the static valve V of Fig. 1 and also containing one electrode F of the same materials as the electrode F of the said valve V, and the cup Q′ containing one electrode D and two electrodes F F of the same materials, respectively, as the electrodes of the cup Q.

The operation is as follows: When the receiving operator perceives that static effects are interfering with the reception of signals, he throws the switch S″ over to the contacts 7 8 of the device Q, and if the static effects are positive they will pass to earth E′ by way of contact 7, carbon electrode D, and aluminium electrode F, while the negative half-waves developed in the antenna by the electromagnetic signal-waves will pass to earth E by way of the contact 7, electrode D, the electrolyte, electrode D, contact 8, and inductance L, thereby causing oscillations in the tuned receiving-circuit C R L and operating the receiver. If, however, the said static effects continue to interfere with the reception of signals when the device Q is connected in circuit, as above set forth, the receiving operator will know that the static effects are negative and will therefore proceed to throw the switch over to the contacts 9 10, in which case said negative static effects will pass to earth E′ by way of the contact 9, aluminium electrode F, and carbon electrode D, while the positive half-waves developed in the antenna by the electromagnetic signal-waves will pass to earth E by way of the contact 9, electrode F, the electrolyte, electrode F, contact 10, and inductance L, thereby creating oscillations in the tuned receiving-circuit C R L and operating the receiver.

It will be seen in view of the foregoing that any electrical rectifier, asymmetric resistance, or "electric valve," electrolytic or otherwise, may be utilized in carrying out the above-stated objects of my invention, and I shall now describe several forms of electric valve that are not electrolytic in nature.

The device V^{I}, (shown in Fig. 1,) connected between the antenna at the point *b* and earth, is an asymmetric resistance or electric valve which has been fully described by J. A. Fleming in a paper published in the *Proceedings of the Royal Society of London*, March 16, 1905, to which reference may be had for a more complete description thereof than need be set forth herein. Suffice it to say that the exhausted glass vessel Q″ contains the filament F′, heated to incandescence by the battery B′, and a metal cylinder D′, which surrounds said filament F′. This type of valve passes positive electricity from the cold terminal D′ to the heated terminal F′ more readily than in the opposite direction, and hence when the switch S′ makes contact, as shown in Fig. 1, with the contacts 5 and 6 positive static effects will pass to earth by way of the elements D′ and F′ of said valve, while if the connections be reversed by throwing the switch so as to contact with 4 and 5 negative static effects will pass to earth by way of the elements F′ and D′ of said valve.

In Figs. 4 and 4^{a} the valves V^{IV} and V^{V} depend upon somewhat the same principle as the valve V^{I}. In these figures H is a lamp or Bunsen burner, the flame of which may be made more conducting by the addition of sodium or other salts, and J is a conductor placed near said flame. M is a bunch of asbestos or mineral wool which may be attached to said conductor J. In these devices positive electricity passes more readily from the element J to the flame, and hence to earth E′, than in the opposite direction. S‴ is a reversing-switch whose function is the same as that of the switch S.

In Fig. 5 the device M′ consists of mineral wool or asbestos placed between two plates and heated by the lamp H. This device is practically non-conducting when cold, but becomes a partial conductor when heated. The oscillations developed in the antenna by the electromagnetic signal-waves will have but little tendency to pass to earth by way of the shunt *a*′ M′ E′; but heavy static charges induced in the antenna have an effect on the device M′ somewhat analogous to the phenomenon of coherence (although it is not a contact device) in that they increase the conductivity of said device, so that the latter becomes a very efficient static leak. The passage of the heated gases from the lamp H through the fibrous material of the device M′ maintains said device in its sensitive high-resistance condition, and thereby prevents the shunting around to inductance L of the oscillations intended to operate the responder.

In Fig. 3 I have shown still another static leak V^{III}, which I have effectively employed for the purpose of carrying my invention into effect. In this figure the arrangement of receiving-circuits is the same as in Fig. 1, and from the point *a* I connect to earth E a shunt-circuit including the adjustable inductance-coil, I of iron or other paramagnetic material or of a non-magnetic material plated with a paramagnetic material or of a non-magnetic material having a paramagnetic core. Such an inductance opposes enormous impedance to the passage of the high-frequency oscillations developed in the receiving system by the electromagnetic signal-waves, but offers but little impedance to the passage of the slow frequency or practically unidirectional currents resulting from the static charges induced in said system by atmospheric electricity, and hence eliminates the effect of said currents on the receiver.

By the term "static valve" as used in the specification and claims of this application I desire to be understood as meaning means offering greater opposition to electric currents of one character than to electric currents of different character—such, for example, as the asymmetric resistances described in connection with Figs. 1, 2, 4, and 4^{a}, the spiral I, described in connection with Fig. 3, and the coherer-like device M′, described in connection with Fig. 5; but it is to be understood that the particular devices hereinbefore specifically described are merely examples of a few of the static valves which may be employed for the purposes of the present invention.

I claim—

1. In a wireless-telegraph receiving system, the combination with an oscillation-detector of an electrolytic static valve.

2. In a wireless-telegraph receiving system, an oscillation-detector and an electrolytic static valve so associated therewith as to protect the same from static effects.

3. In a wireless-telegraph receiving system, a receiving-antenna, an inductance included therein, a tuned receiving-circuit associated with said inductance, an oscillation-detector in said tuned receiving-circuit, and means offering greater opposition to electric currents of one character than to electric currents of different character connected between the earth and a point in said antenna above the point of connection of said inductance to said antenna.

4. In a wireless-telegraph receiving system, an oscillation-detector, and means offering greater opposition to electric currents of one polarity than to electric currents of the opposite polarity so associated with said detector as to protect said detector from the effects of the currents of that polarity to which said means offers the greater opposition.

5. In a wireless-telegraph receiving system, an oscillation-detector, and an asymmetric resistance so associated therewith as to protect the same from static effects.

6. In a wireless-telegraph receiving system, an oscillation-detector, a static valve connected therewith and means for reversing the connections of the terminals of said static valve with said oscillation-detector.

7. In a wireless-telegraph receiving system, an oscillation-detector, an asymmetric resistance so connected therewith as to protect the same from static effects, and means for reversing the connections of the terminals of said asymmetric resistance with said oscillation-detector.

8. In a wireless-telegraph receiving system, an oscillation-detector, and an electrolytic asymmetric resistance so associated therewith as to protect the same from static effects.

9. In a wireless-telegraph receiving system, an oscillation-detector, an electrolytic asymmetric resistance so connected therewith as to protect the same from static effects, and means for reversing the connections of the terminals of said electrolytic asymmetric resistance with said oscillation-detector.

10. In a wireless-telegraph receiving system, a receiving-antenna, an oscillation-detector associated therewith, and an electrolytic static valve connected between the earth and a point in said antenna above the point of association of said detector with said antenna.

11. In a wireless-telegraph receiving system, a loop antenna, an inductance included in each side thereof, an oscillation-detector associated with said loop antenna, a connection from each side of said loop antenna around each said inductance to earth and a static valve in each said connection.

12. In a wireless-telegraph receiving system, a loop antenna, an oscillation-detector associated therewith, a static valve associated with each side thereof, and means for reversing the connections of each said static valve with its respective side of said loop antenna.

13. As a static valve for a wireless-telegraph receiving system, an electrolytic asymmetric resistance.

14. As a static valve for a wireless-telegraph receiving system, an asymmetric resistance.

15. In a wireless-telegraph receiving system, a loop antenna, an inductance included in each side thereof, an oscillation-detector associated with said loop antenna, a connection from one side of said loop antenna around one inductance to earth and a static valve in said connection.

16. In a wireless-telegraph receiving system, a loop antenna, an inductance included in each side thereof, a tuned receiving-circuit associated with said loop antenna, an oscillation-detector in said tuned receiving-circuit, and a static valve connected between the earth and a point in said antenna above the point of connection of said inductance to said antenna.

17. In a wireless-telegraph receiving system, a receiving-antenna, an inductance included therein, a tuned receiving-circuit associated with said inductance, an oscillation-detector in said tuned receiving-circuit, and a static valve connected across the terminals of said inductance.

In testimony whereof I have hereunto subscribed my name this 6th day of December, 1905.

LEE DE FOREST.

Witnesses:
LESTER TESTEET,
PHILIP FARNSWORTH.