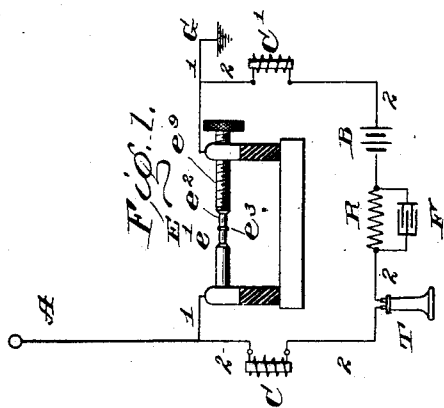
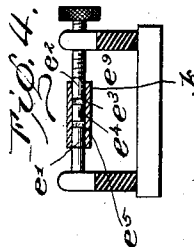
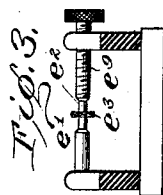


L. DE FOREST & E. H. SMYTHE.
 APPARATUS FOR COMMUNICATING SIGNALS THROUGH SPACE.

(Application filed July 5, 1901.)

(No Model.)

2 Sheets—Sheet 1.



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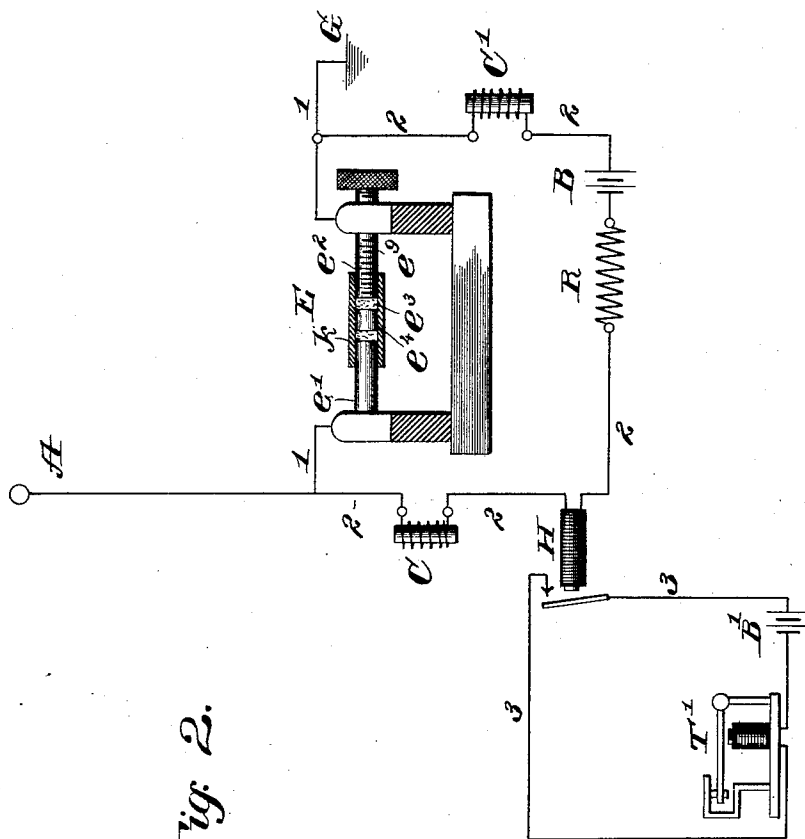


Fig. 2.

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR COMMUNICATING SIGNALS THROUGH SPACE.

SPECIFICATION forming part of Letters Patent No. 716,000, dated December 16, 1902.

Application filed July 5, 1901. Serial No. 67,136. (No model.)

To all whom it may concern:

Be it known that we, LEE DE FOREST, residing at Chicago, in the county of Cook, and EDWIN H. SMYTHE, residing at Freeport, county of Stephenson, State of Illinois, citizens of the United States, have invented a new and useful Apparatus for Communicating Signals Through Space, of which the following is a specification.

This invention relates to an improvement in apparatus for communicating signals through space, and particularly to an improved responsive or receiving device for detecting electrical oscillations or Hertzian waves.

One of the objects of the invention is to provide a responsive device or receiver which is simple in construction and reliable and permanent in action.

A further object is to provide an apparatus which may be operated at a high and practically unlimited rate of speed.

A further object is to provide an apparatus which is sensitive and responsive to weak electrical impulses, thereby increasing the range or distance through which signaling may be effected.

Other objects of the invention will appear more fully hereinafter.

In systems of space-signaling heretofore known and used it has been customary to employ at the receiving-station a responsive device known as a "coherer," included in a local circuit and also in the ground or capacity connection of a receiving aerial conductor. The resistance of the coherer under normal conditions is sufficiently high to arrest or retard the flow of current in the local circuit; but when excited by an electric impulse or oscillation the resistance is decreased, thus allowing an increased flow of current in the local circuit and the consequent actuation of a signal-receiving device included therein. The resistance of the coherer, however, continues low after the impulse which caused the decrease has ceased, and in order to restore the coherer to its normally high resistance and sensitive condition, so that it may respond to another impulse, it is necessary to

subject it to a mechanical shock, or, as it is termed, "decohere" it, this being usually effected by auxiliary apparatus provided for that purpose. In this respect the coherer and all similarly-operating devices are subject to the limitation that the speed of response of the receiving apparatus to successive impulses must necessarily be limited by the lag of the decohering mechanism. Thus in practice the average speed attained by the coherer systems of wireless telegraphy probably does not exceed some ten or twelve words per minute, whereas in ordinary telegraphy an operator is able to send and receive at several times that rate. Moreover, the decohering mechanism is ordinarily electromagnetically actuated, and the sparks which occur when the circuit through this electromagnetic mechanism is broken, as well as those generated at the contacts of the Morse relay and in the receiving-circuit proper, interfere with the proper operation of the coherer unless special means and precautions be used to prevent such disturbances. It is among the special purposes of our invention to avoid these objections and to increase the rate of speed of operation of the receiving or responsive device. We accomplish this result by providing an apparatus which instantly and automatically returns to its normal condition after each impulse without requiring the use of any auxiliary apparatus and wherein the resistance (which is normally low) rises during excitation and falls again to its normal condition immediately the exciting impulse ceases. In other words, its period of response is practically coextensive with the duration of the received oscillation. Consequently no matter how rapidly within wide limits the exciting impulses succeed one another each is separately recorded in the signal-receiving device.

We will now describe our invention particularly by reference to the accompanying drawings, and that which we regard as new will be pointed out in the appended claims.

Referring to the accompanying drawings, Figure 1 is a diagrammatic view of a receiving-circuit including a responsive device or

receiver embodying the principles of our invention. Fig. 2 is a similar view showing a slightly-modified arrangement of apparatus embodying the principles of our invention. Figs. 3, 4, and 5 show modified forms of our receiver. Fig. 6 is an enlarged broken detail view of a modified form of the construction shown in Fig. 4.

The same part is designated by the same reference-sign wherever it occurs throughout the several views.

In systems wherein electrical oscillations are utilized for signaling through space it is customary to employ an aerial receiving-conductor adapted to be cut by the electrical oscillations sent out from the generating or transmitting apparatus. This aerial conductor is provided with a grounded or capacity connection in which is placed the responsive device or detector, this being also included in a local circuit which contains a source of current and a signal-receiving device. To cause the electrical oscillations generated in the aerial receiving-conductor, as far as possible, to traverse only the part of the local circuit containing the responsive device, self-induction or choke coils are included in that part of the local circuit which would otherwise shunt the responsive device with respect to the received oscillations. In the accompanying drawings we have illustrated an arrangement embodying these general features, wherein A designates the aerial receiving-conductor, G the ground or capacity connection of said conductor, and E designates the responsive device of our invention, which comprises generally electrodes e' e^2 , separated from each other, and an interposed medium e^3 , which will be fully described hereinafter. B designates the local battery; C C', the self-induction or choke coils; R, a resistance which we have found convenient to include in the local circuit in order to reduce the current flowing therein; F, a condenser shunting the resistance, the object of which we will explain presently, and T T' the signal-receiving device. This signal-receiving device is represented in Fig. 1 as an ordinary telephone-receiver and in Fig. 2 as a telegraph-sounder in a local circuit with a battery B', this circuit being controlled by a relay H, included in the first-mentioned local circuit. It is obvious that the signal-receiving device may be any suitable device responsive to the changes in the current-flow governed by responsive device E.

As shown in Fig. 1, aerial conductor A is connected with the ground or capacity connection G by conductor 1, which includes the electrodes e' e^2 and interposed medium e^3 of detector E, in series therein. At a point intermediate of aerial conductor A and detector E conductor 2 is connected with conductor 1 and is again united with conductor 1 at a point intermediate of detector E and ground G, including serially in its length choke-coil C, signal-receiver T, resistance R, across the

terminals of which is connected condenser F, battery B, and choke-coil C' and constituting the local circuit.

The circuit connections in Fig. 2 are represented as similar to those of Fig. 1, excepting that condenser F is omitted, and instead of signal-receiver T' being included in local-circuit conductor 2 it is placed in a secondary circuit 3, which is controlled by a relay H, included in conductor 2 between choke-coil C and resistance R.

Referring now more particularly to the responsive device or detector of our invention, we have found that when two metallic electrodes are slightly separated and included in series in a circuit containing a source of current and a suitable medium is interposed in series between their opposed surfaces minute metallic particles are torn off from the anode and carried across the gap separating the electrodes to the cathode, where they build up little trees and bridges, which extend out toward and soon reach the anode, thus bridging the gap. As long as these bridges continue between the electrodes the resistance of the device is comparatively low; but if it is subjected to the influence of an electrical impulse or oscillation, such as results when a spark passes between the terminals of an induction-coil, the metallic bridges between the electrodes are instantly disrupted, and the resistance of the device increases greatly. If a signal-receiving device be included in the local circuit with the detector, this change in resistance is made manifest, and the passage of the impulse is signaled. Between each spark at the apparatus employed in the production or generation of the oscillations these bridges between the electrodes are again built up, or rather on the cessation of the impulse or oscillation the metallic particles again form into chains across the gap, and so automatically restore the conductivity of the device.

In our first experiments with a responsive device of this type we used water in the gap between the electrodes. The results, however, were not entirely satisfactory, for while the device would continue sensitive to electrical impulses for a short time it would soon cease to be responsive. In order to determine the cause of this action and to develop a detector which would be reliable and permanent in its action, we made a number of experiments and microscopical examinations. In the course of these we have found that when water is employed between the electrodes as the action described above proceeds the gap between the electrodes in a very short space of time becomes filled with these minute particles, the anode being eaten away and the cathode correspondingly built up by deposition, and that when the impulses are weak the device soon ceases to respond to them. An actual coherence between the minute particles seems to occur, and the electrical oscillations or impulses are unable to disrupt the bridges, the device thus becoming "clogged" or un-

sensitive. We have also found that the "clogging" effect in the gap between the electrodes occurs more quickly when the impulses are weak. In order to overcome this difficulty and to increase and maintain the sensitivity of the device, we have tried the effect of interposing a great many different media in the gap between the electrodes and have found a number which give satisfactory results.

Among these are various viscous liquids, such as glycerin and heavy oils, viscous semisolids, as vaseline, porous solids, non-conducting or poorly-conducting powders, as sulfur and the oxids of lead, fibers and fabrics, and combinations of the above, as fibers or fabrics saturated with glycerin, and a mixture of the oxids of lead, (PbO_2) commonly known as "litharge," and glycerin. We have also used collodion and gelatin with very fair results.

Such media apparently act to support the chains of metallic particles, to retain the particles in operative relation with the electrodes and with each other, to limit the number of chains between the electrodes, and to confine the energy of the received impulse to these sensitive connecting-links. We have found that by employing media of this nature in the gap between the exposed surfaces of the electrodes the bridges across the gap are built up in the manner as above explained, but the promiscuous filling of the gap by the metallic particles does not occur, and that when a comparatively few bridges have formed the current confines itself to these. When the electrical impulse passes, these bridges or chains instead of being badly and violently broken up or disrupted and the particles composing them scattered broadcast such particles are retained and supported in the near vicinity of or in proximity to each other and at the cessation of the impulse rapidly re-form into their original bridging relation. If the medium interposed in the gap is non-conducting or of small conductivity, the opposed electrodes are in a manner insulated from each other except where the gap is bridged by the chains of conducting particles, and the energy of the oscillation or impulse is therefore probably more concentrated upon these chains.

This tends to prevent the clogging of the device when the received impulses are weak and to make the action uniformly more sensitive and to prevent agglomeration of the conducting particles.

In our microscopical investigations of the action occurring in the gap between the separated electrodes we have noticed that when the local current is flowing the passage of the impulse or oscillation causes a sudden evolution of bubbles of gas at the cathode and among the metallic particles forming the chains which bridge the electrodes. It is apparently to this sudden generation of gas among the metallic particles that the disruption of the chains by the oscillations is due, and it is our theory that the action in the device is largely one of disruptive electrolysis in a film or

stratum of electrolytic or electrically-decomposable liquid which we believe lies between each metallic particle and its neighbor. To supply such a liquid, the presence of which, according to our theory, is necessary to the peculiar action of our responsive device, we sometimes mix with the supporting medium interposed between the electrodes a small amount of water or other suitable electrically-decomposable body. It is not always necessary to do this, however, as many of the media employed contain such a constituent either rightfully or as an impurity—as, for instance, commercial glycerin. The presence of the gas which is thus evolved during the action appears to play some part in bringing about the clogged or non-sensitive condition of the device, the probable explanation being that after continuous action the minute particles forming the bridges become surrounded by a gaseous instead of by a liquid envelop and that when this occurs the electrical impulses effect an actual coherence between the particles instead of the normal disruptive action. At any rate we have found it desirable to provide some means for disposing of this gas and preventing its accumulation in the gap. In one case where the liquid interposed between the electrodes was distilled water it was observed that all the gas was given off at the cathode or at the secondary cathodes among the minute particles bridging the gap. In accordance with the well-known laws of electrolysis this gas should be, and probably is, hydrogen. The oxygen liberated apparently entered into combination with the metal of the anode. When the medium interposed between the electrodes is glycerin with a slight percentage of water mixed with it, the action is apparently the same, except that in this case the chemical activity of the nascent oxygen may be sufficient to cause it to abstract hydrogen from the glycerin to form water. The hydrogen, however, is apt to accumulate and eventually interfere with the operation of the device unless means are provided to prevent it. We have found several agents which accomplish this result in a satisfactory manner, among which are the oxids of lead, previously mentioned as serving well in the capacity of supporting and retaining media. We have also employed manganese dioxid and potassium chlorate, but thus far have obtained the best results with the oxids of lead. The action of any of these substances is apparently that of a depolarizer, and the operation of the detector when such an agent is used with it would seem to indicate that depolarization or its equivalent is continuously carried on. This depolarizing medium may be interposed directly between the active surfaces of the electrodes where, if it is of the proper nature, it may serve as a supporting medium to retain and support as well as to depolarize, or it may be merely brought into close proximity to the active surfaces of the electrodes, in

which position, as we have discovered both microscopically and experimentally, it still exerts a depolarizing effect. The removal of the electrolytic gas above referred to may also be effected by the use of an absorbent material, which may be interposed between the electrodes, and thus serve in the double capacity of a supporting medium and an absorbent or depolarizer. Powdered sulfur and other inert solids in a state of fine division, which we have interposed between the electrodes as a supporting medium with good results, probably act also in an absorbent capacity.

The electrodes which we employ with the various forms of our responsive device are preferably about one-eighth of an inch in diameter. In the forms represented in Figs. 1 and 3 the opposed surfaces of the electrodes are preferably flat and separated from each other by about two to five one-thousandths of an inch. In the forms represented in Figs. 2, 4, and 6 the opposed surfaces of the electrodes are preferably roughened and separated from each other by about one-sixteenth to one eighth of an inch.

It is sometimes advantageous to make the exposed or juxtaposed surface of one of the electrodes—preferably the negative one, as e^7 , Fig. 5—cup-shaped, as shown at e^5 , having a narrow edge surrounding the cup or recess and opposed to the plane surface of the other electrode e^8 . The cup or recess is filled with a mass of lead-oxid and glycerin to a point flush with the surface of the surrounding edge.

Provision may be made for changing the relative separation of the electrodes. This may be accomplished by screw-threading the stems of one or both of the electrodes, as shown at e^9 , and tapping the same through the support on which said electrode is mounted.

We have found it advantageous to employ a number of sensitive elements in series arrangement. An illustrative form of apparatus embodying this idea is shown in Figs. 2 and 4. This comprises an insulating-tube k , into the ends of which the electrodes e' e^2 project, and one or more auxiliary pieces or electrodes e^4 , placed in said tube and between the electrodes e' e^2 , being separated from said electrodes by spaces of, say, from one-sixteenth to one-eighth of an inch. In these spaces we place a mixture of rather coarse metal filings and a powder, such as litharge, in about equal proportions, by bulk. This mixture is made into a rather fluid paste by means of glycerin or vaseline, with a slight amount of an electrically-decomposable body, such as water or alcohol, added. If desired, however, the auxiliary electrode or piece e^4 may be omitted, as shown in Fig. 6. In both cases the effect of a series-multiple arrangement is secured, the metallic fragments or filings forming substantially auxiliary or secondary electrodes and bridging the space be-

tween the main electrodes with multiple metallic conducting chains, each chain being composed of metallic fragments in series relation with respect to each other.

In Fig. 1 the medium e^3 , (represented as interposed between electrodes e' and e^2), may be glycerin, oil, or vaseline containing a small amount of water or other electrically-decomposable body. The medium represented as interposed between the electrodes in Fig. 3 may be fiber or a fabric, as silk cloth, saturated with, say, glycerin containing a small amount of water. The proportion of water which we have found convenient to mix with the glycerin when employed in the forms shown in Figs. 1 and 3 is about one part to four or five of glycerin. In the form shown in Figs. 2, 4, and 6 the proportion of water or decomposable body desirable is considerably less.

The most satisfactory metals, both for the electrodes and for the conducting particles or fragments to be interposed between the electrodes, we have found to be tin, silver, and nickel, in the order named; but we do not desire to be limited to the use of any particular metals, as others may be found equally suitable.

The current employed in the local-battery circuit is preferably small—say from one-tenth to one milliamper. When we employ two cells of battery, we have found it desirable to make the resistance of the local circuit from twelve thousand to fifteen thousand ohms.

We have found the most satisfactory electrolytes or decomposable bodies employed in connection with the interposed medium to be water, commercial alcohol, and ammonia or a mixture of these, such bodies acting as electrolytic conducting solutions on account of the presence in them of ions, either from impurities, as in the case of ordinary hydrant-water and commercial alcohol, or, rightfully, as in the case of ammonia. It is obvious, however, that other bodies may be found equally satisfactory. We do not desire, therefore, to be limited in this respect. Commercial glycerin ordinarily contains water in sufficient amount to make it suitable for our purpose, or, if desired, water or alcohol, or both, may be mixed with the glycerin. Chemically-pure glycerin is non-conducting and may be classed as a non-conducting liquid or a non-conducting viscous liquid; but commercial glycerin is pure glycerin with which is mixed water and impurities which render it conducting. Commercial glycerin may therefore be classed as a viscous conducting liquid or a viscous electrolyte. The terms "conducting solution," "electrolyte," and "electrically-decomposable liquid or substance," as used herein, are, in a way, synonymous, as electrolytic conduction is probably always attended by a decomposition of the conducting solution or substance, and a

substance in an electrically-decomposable condition may be assumed to be an electrolyte.

In the foregoing description we have referred to the use of a condenser in shunt around the resistance placed in the local circuit. The function of this condenser is to prevent the sound in the receiving-signal device, if a telephone, from being muffled and to render the same sharp and clear. This result it accomplishes by acting as a shunt around the resistance for the rapidly-fluctuating currents produced by the sudden changes in resistance of the excited responder, permitting such rapidly-varying currents to traverse the circuit and actuate the telephone or other signal-receiving device almost as effectively as though the resistance were not included. We have found this use of the condenser to be quite advantageous. A detector or receiver of Hertz oscillations, such as above described, is instantly responsive and instantly and automatically restored to its normal condition at the cessation of an impulse, and the successive variations in resistance due to the influence of the receiving energy waves are comparatively uniform and substantially proportioned to the energy of said successive waves. In the use of the apparatus when a telephone-receiver is employed in connection therewith the listening operator hears a distinct and separate click for every spark produced at the transmitting end or station. If a long series of such sparks be made at the sending instrument, the receiving-operator hears a similar series of sounds or clicks in the telephone, which may represent a dash, for instance, of the Morse code. A short series of sparks at the transmitting or generating station may represent a dot of the Morse code, and hence the speed of transmission and receipt of the message is limited only by the ability of the operators to send and receive signals.

In the foregoing description we have referred to the use of metallic particles interposed between the electrodes. By the use of the word "metallic," however, we do not desire to be limited to pure metal, as it may be possible that these particles are metal in chemical combination with other elements—as, for instance, oxygen.

Having now set forth the object and nature of our invention and various embodiments of the principles thereof, what we claim as new and useful and of our own invention, and desire to secure by Letters Patent, is—

1. In a receiver for electrical oscillations, the combination with suitably-separated electrodes having exposed juxtaposed surfaces, of metallic particles arranged between such exposed surfaces, and means for supporting said metallic particles in normally low-resistance conducting-paths between and in series with said electrodes, as and for the purpose set forth.

2. In a receiver for electrical oscillations,

the combination with electrodes, of conducting particles, and a supporting medium interposed between said electrodes, said supporting medium operating to maintain said conducting particles in normal low-resistance relation with respect to said electrodes, as and for the purpose set forth.

3. In a receiver for electrical oscillations, suitably-separated electrodes, in combination with a supporting medium interposed directly between the opposed surfaces of said electrodes, and conducting particles maintained by said medium in normally low-resistance relation with respect to said electrodes, as and for the purpose set forth.

4. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, and conducting particles in series between the exposed surfaces thereof, of a supporting medium for maintaining said particles between said electrodes, and an electrically-decomposable substance contained in said supporting medium, as and for the purpose set forth.

5. In a receiver for electrical oscillations, the combination with electrodes and conducting particles between the active surfaces thereof, of a supporting and retaining medium interposed between said active surfaces for retaining said particles in operative relation with said electrodes, as and for the purpose set forth.

6. In a receiver for electrical oscillations, the combination with suitably-separated electrodes having roughened juxtaposed surfaces, of a supporting medium interposed between said surfaces, and metallic particles supported in said medium, as and for the purpose set forth.

7. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of a supporting-liquid body interposed between said electrodes, and metallic particles supported therein, said body acting to maintain said metallic particles in operative relation between and in series with said electrodes, as and for the purpose set forth.

8. In a receiver for electrical oscillations, suitably-separated electrodes, a supporting viscous liquid interposed between said electrodes, and metallic particles supported by said viscous liquid between the exposed surfaces of said electrodes and in series therewith, said viscous liquid operating to maintain said particles in normally low-resistance relation with respect to said electrodes, as and for the purpose set forth.

9. A receiver for electrical oscillations including separated electrodes, a viscous substance interposed between said electrodes, conducting particles supported in said substance, and an electrolyte contained in said substance, as and for the purpose set forth.

10. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of a viscous supporting medium interposed between said electrodes, and metal-

lie particles supported by said supporting medium in operative relation with respect to said electrodes, as and for the purpose set forth.

11. In a receiver for electrical oscillations, the combination with electrodes and a viscous liquid interposed between said electrodes, of metallic particles adapted to bridge said electrodes, said particles being maintained by said liquid in normally low-resistance relation with respect to said electrodes, as and for the purpose set forth.

12. In a receiver for electrical oscillations, the combination with electrodes, of glycerin interposed between the juxtaposed surfaces thereof, and metallic particles supported in said glycerin, as and for the purpose set forth.

13. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of conducting particles bridging said electrodes, and a non-conducting supporting medium for said particles interposed between said electrodes and operating to support and maintain said particles in normally low-resistance conducting relation between said electrodes, as and for the purpose set forth.

14. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of conducting particles bridging said electrodes, a non-conducting supporting medium for said particles interposed in series between said electrodes, said non-conducting supporting medium containing an electrolyte, as and for the purpose set forth.

15. In a receiver for electrical oscillations, suitably-separated electrodes, in combination with a non-conducting viscous liquid interposed in series between said electrodes, and an electrically-decomposable substance contained in said liquid, as and for the purpose set forth.

16. In a receiver for electrical oscillations, suitably-separated electrodes, in combination with a non-conducting liquid interposed in series between the juxtaposed surfaces of said electrodes, said liquid containing a conducting solution, as and for the purpose set forth.

17. In a receiver for electrical oscillations, suitably-separated electrodes, in combination with a non-conducting liquid containing a conducting solution, and metallic particles contained in said liquid and interposed in series between the juxtaposed surfaces of said electrodes, as and for the purpose set forth.

18. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of a neutral liquid having an electrolyte dissolved therein, and metallic particles contained in said liquid and interposed in series between said electrodes, as and for the purpose set forth.

19. In a receiver for electrical oscillations, the combination with electrodes, of a viscous electrolyte interposed between said electrodes, and metallic particles contained in

said electrolyte, as and for the purpose set forth.

20. In a receiver for electrical oscillations, the combination with electrodes, of a supporting medium interposed between the active surfaces of said electrodes, said medium consisting of a mixture of viscous non-conducting liquid and electrically-conducting liquid, and metallic particles, as and for the purpose set forth.

21. In a receiver for electrical oscillations, the combination with electrodes, of a medium interposed in series between the active surfaces of said electrodes, said medium comprising a mixture of glycerin, litharge, metallic filings, and an electrically-decomposable liquid, as and for the purpose set forth.

22. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of metallic particles conductively uniting said electrodes, an electrolyte, and an absorbent material interposed between said electrodes and associated with said particles, as and for the purpose set forth.

23. In a receiver for electrical oscillations, suitably-separated electrodes, electrolytic conducting material, and a depolarizing agent interposed between the surfaces of said electrodes, as and for the purpose set forth.

24. In a receiver for electrical oscillations, the combination with electrodes, of an electrolyte interposed between said electrodes, and means associated with said electrolyte for neutralizing a product of the electrolytic decomposition, as and for the purpose set forth.

25. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, an electrolyte interposed between said electrodes, conducting particles contained therein, and means associated with said electrolyte for neutralizing a product of the electrolytic decomposition, as and for the purpose set forth.

26. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of an electrolyte interposed in series between the active surfaces of said electrodes, metallic particles contained in said electrolyte and adapted to bridge the space or gap between said electrodes, a circuit including said electrodes, a source of current included in said circuit, and means associated with said electrolyte and operating to neutralize a product of the electrolytic decomposition, as and for the purpose set forth.

27. In a receiver for electrical oscillations, the combination with two electrodes, of a chain of metallic particles extending between and conductively uniting the electrodes, an electrolyte between the particles of the chain, and a relatively non-conducting substance interposed between said electrodes and surrounding said chain of metallic particles, whereby the electrical impulse is concentrated upon said chain of metallic particles, as and for the purpose set forth.

28. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of a supporting medium interposed between the active surfaces of said electrodes, and metallic particles supported and retained by said medium in normal low-resistance conducting relation with respect to said electrodes, and means for relatively adjusting said electrodes, as and for the purpose set forth.

29. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of a supporting medium interposed between the active surfaces of said electrodes, metallic particles contained in said medium, said medium operating to support and retain said metallic particles in normally low-resistance multiple-conducting chains between and in series with said electrodes, said chains being disrupted and the resistance between the electrodes increased under the influence of the electrical oscillations, as and for the purpose set forth.

30. In an apparatus of the class described, a responsive device including a plurality of suitably-separated electrodes, conducting particles interposed between the surfaces of adjacent electrodes, and a supporting medium for said particles, said supporting medium operating to support and maintain said particles in series relation and in normal low-resistance conducting relation with respect to said electrodes, as and for the purpose set forth.

31. In a receiver for electrical oscillations, a local circuit, electrodes suitably separated from each other and arranged in said circuit, a receiving-conductor, a ground or capacity connection therefor, in combination with metallic particles occupying the space between said electrodes, and a supporting medium for normally maintaining said metallic particles in low-resistance-conducting relation with said electrodes, as and for the purpose set forth.

32. In a receiver for electrical oscillations, suitably-separated electrodes, a local circuit including said electrodes, a receiving-conductor, a ground or capacity connection therefor, said electrodes being also included in said ground or capacity connection, in combination with metallic particles occupying the space between said electrodes, and a supporting-body interposed between said electrodes and operating to normally retain said metallic particles in conducting-chains in series between the exposed surfaces of said electrodes, said chains being disrupted under the influence of electrical oscillations, as and for the purpose set forth.

33. In a receiver for electrical oscillations, a local circuit, a signal device and a responsive device included in said local circuit, said responsive device including suitably-separated electrodes having an interposed body of viscous liquid between the exposed surfaces

thereof, and metallic particles normally supported and retained by said viscous liquid in low-resistance conducting relation in series with respect to said electrodes, in combination with a receiving-conductor, a ground or capacity connection therefor, said ground or capacity connection including said responsive device, as and for the purpose set forth.

34. In a receiver for electrical oscillations, the combination with electrodes, of a viscous supporting medium interposed between said electrodes, metallic particles maintained by said supporting medium in normally low-resistance conducting relation with respect to said electrodes, and a circuit including said electrodes and medium with a source of current, as and for the purpose set forth.

35. In a receiver for electrical oscillations, the combination with electrodes, of metallic particles, an electrolytic supporting medium for said particles, said medium interposed directly between said electrodes, and a circuit through said electrodes and medium including a source of current, said medium operating to support and maintain said particles in operative relation with respect to said electrodes, as and for the purpose set forth.

36. In a receiving apparatus for electrical oscillations, the combination with a responsive device comprising electrodes, metallic particles, and an electrolytic supporting medium for said particles interposed directly between said electrodes, said medium operating to support and maintain said particles in normally low-resistance conducting relation in series between said electrodes, of a circuit including said responsive device and a source of current, a resistance arranged in said circuit, and a condenser shunted around said resistance, as and for the purpose set forth.

37. In an apparatus for receiving signals communicated by electrical oscillations, the combination with a receiver comprising electrodes, metallic particles, and an electrolytic supporting medium therefor interposed directly between said electrodes, said medium operating to support and retain said particles in normal operative relation in series between said electrodes, of an electrical circuit through said receiver, and a signal device included in the circuit and controlled by said receiver, as and for the purpose set forth.

38. In an apparatus for receiving signals communicated by electrical oscillations, the combination with a receiver comprising electrodes, metallic particles, an electrolytic supporting medium therefor interposed directly between said electrodes, said medium operating to support and retain said particles in normal operative relation in series between said electrodes, of a receiving-conductor connected to one of said electrodes, a ground or capacity connection to the other of said electrodes, a source of current, a signal device, and a local circuit, said local circuit including the aforesaid receiver, source of current

and signal device, as and for the purpose set forth.

39. In an apparatus for receiving signals communicated by electrical oscillations, the combination with a receiver comprising electrodes, a viscous electrolytic supporting medium interposed between said electrodes, and metallic particles normally supported in said viscous medium in conducting relation with respect to said electrodes, of a receiving-conductor connected to one of said electrodes, a ground or capacity connection to the other of said electrodes, a local circuit for said receiver, said circuit including a source of current, a signal-receiving device and choke-coils, said choke-coils being respectively connected to said electrodes, as and for the purpose set forth.

40. In an apparatus for receiving signals communicated by electrical oscillations, the combination with a receiver comprising electrodes, a supporting liquid interposed between said electrodes, and metallic particles adapted to be normally held in operative relation with respect to said electrodes, of a local circuit including said receiver, a source of current, a signal device and a resistance, and a capacity connected across the terminals of said resistance, as and for the purpose set forth.

41. In a receiving apparatus for electrical oscillations, the combination with a circuit including a source of current and a signal device, of a responsive device controlling said circuit, said responsive device comprising electrodes, a paste maintained between said electrodes, said paste being made of a viscous electrolytically-conducting substance and a depolarizing agent, and metallic fragments supported in the aforesaid paste between the electrodes, the resistance between the electrodes and said responsive device being normally low and being increased when said responsive device is subjected to the influence of electrical oscillations, whereby the signal device in the circuit is actuated, as and for the purpose set forth.

42. In a receiving apparatus for electrical oscillations, the combination with a circuit including a signal device and a source of current, of a detector controlling said circuit, said detector comprising electrodes, a paste interposed between said electrodes, said paste being composed of an electrolytically-conducting liquid and a porous solid, and solid conducting particles contained in the aforesaid paste, the resistance between the electrodes and said detector being normally low and being increased when said detector is subjected to the influence of electrical oscillations, whereby the signal device is actuated, as and for the purpose set forth.

43. In a receiving apparatus for electrical oscillations, the combination with a circuit including a source of current and a signal device, of a responsive device controlling said

circuit, said responsive device comprising electrodes, commercial glycerin interposed between said electrodes, and litharge and tin filings in said glycerin, as and for the purpose set forth.

44. In a receiver for electrical oscillations, the combination with electrodes, of metallic particles interposed between said electrodes, and a supporting medium therefor, said supporting medium operating to retain said particles from agglomeration, as and for the purpose set forth.

45. In a receiver for electrical oscillations, suitably-separated electrodes, in combination with a supporting medium interposed directly between the opposed surfaces of said electrodes, and metallic particles contained in said medium and supported thereby in series with said electrodes to form normally low-resistance conducting-chains between the electrodes, said chains being disrupted under the influence of electrical oscillations, as and for the purpose set forth.

46. In a receiver for electrical oscillations, the combination with electrodes, and conducting particles forming normally low-resistance chains between the active surfaces thereof, of a supporting and retaining medium interposed directly between said active surfaces for maintaining said particles in operative relation with said electrodes, as and for the purpose set forth.

47. In a receiver for electrical oscillations, suitably-separated electrodes, a viscous liquid interposed between said electrodes, an electrolyte contained therein, and metallic particles supported by said viscous liquid between the exposed surfaces of said electrodes and in series therewith, as and for the purpose set forth.

48. In a receiver for electrical oscillations, the combination with suitably-separated electrodes, of a viscous supporting medium interposed between said electrodes, and an electrolyte and conducting particles contained in said supporting medium, as and for the purpose set forth.

49. A receiver for electrical oscillations, including electrodes, metallic particles interposed therebetween, and a supporting-electrolyte operating to maintain said particles in normally low-resistance conducting-chains between said electrodes, as and for the purpose set forth.

50. In a receiver for electrical oscillations, the combination with electrodes, of glycerin interposed between the juxtaposed surfaces thereof and containing an electrolyte, and metallic particles supported in said glycerin, as and for the purpose set forth.

51. In a receiver for electrical oscillations, the combination with relatively adjustable electrodes, of a supporting medium interposed between the active surfaces of said electrodes, and metallic particles supported in said medium, whereby such metallic par-

ticles normally form multiple conducting-chains between and in series with said electrodes, said chains being disrupted and the resistance between the electrodes increased under the influence of electrical oscillations, as and for the purpose set forth.

52. In a receiver for electrical oscillations, the combination with relatively adjustable electrodes, of a supporting medium interposed between the active surfaces of said electrodes, and metallic particles supported in said medium to normally form multiple conducting-chains between and in series with said electrodes, said chains being disrupted and the resistance between the electrodes increased under the influence of electrical oscillations, as and for the purpose set forth.

53. In a receiver for electrical oscillations, the combination with electrodes, of metallic particles interposed between said electrodes, and a supporting medium therefor, said supporting medium operating to prevent the clogging of said particles, as and for the purpose set forth.

54. In an apparatus of the class described, a responsive device including a plurality of separated electrodes, a supporting medium interposed between the surfaces of adjacent electrodes, and conducting particles contained therein, said supporting medium operating to support and maintain said conducting particles in series relation with said electrodes to normally form conducting-chains therebetween, as and for the purpose set forth.

55. In a receiver for electrical oscillations, a local circuit, a signal device and a responsive device included in said local circuit, said responsive device including suitably-separated electrodes having an interposed body of viscous liquid between the exposed surfaces thereof, and metallic particles normally supported or held by said viscous liquid in conducting-chains in series with said electrodes, in combination with a receiving-conductor, a ground or capacity connection therefor, said ground or capacity connection including said responsive device, and means for preventing the electrical oscillations in said receiving-conductor from traversing said local circuit, as and for the purpose set forth.

56. In a receiver for electrical oscillations, the combination with electrodes, of a viscous medium containing an electrolyte interposed between said electrodes, conducting particles held in said viscous medium in normally low-resistance conducting-chains in series with said electrodes, and a circuit including said electrodes and medium with a source of current, as and for the purpose set forth.

57. In a receiving apparatus for electrical oscillations, the combination with a responsive device comprising electrodes, a supporting medium interposed between said electrodes, metallic particles supported by said medium in normally operative relation in se-

ries between and with respect to said electrodes, of a circuit including said responsive device and a source of current, a resistance arranged in said circuit, and a condenser shunted around said resistance, as and for the purpose set forth.

58. In an apparatus for receiving signals communicated by electrical oscillations, the combination with a receiver comprising two electrodes, and a viscous substance containing an electrolytically-decomposable element interposed between said electrodes, of a local circuit including said receiver, a source of current, a signal device, a resistance, and a capacity connected across the terminals of said resistance, as and for the purpose set forth.

59. In a receiving apparatus for space-signaling, a receiving-conductor, a ground or capacity connection therefor, and a sensitive member in said circuit affected by the electrical oscillations to decrease its conductivity during the passage of each oscillation, as and for the purpose set forth.

60. An apparatus for detecting electrical oscillations, including separated electrodes, metallic particles contained in the space separating said electrodes, and means for maintaining said particles in a normal condition of comparatively low resistance, and operating to create a condition of comparatively high resistance under the influence of the electrical oscillation, as and for the purpose set forth.

61. In an apparatus for detecting electrical oscillations, suitably-separated electrodes, means for normally maintaining a comparatively low-resistance condition between said electrodes, and operating to increase the resistance under the influence of each electrical oscillation to be detected, as and for the purpose set forth.

62. In an apparatus for signaling through space, a receiving device of normally low-resistance condition, said device operating under the influence of each received energy wave to increase its resistance, as and for the purpose set forth.

63. In an apparatus for signaling through space, a receiving device, a local circuit therefor, said device, under the influence of said local circuit, being normally maintained in comparatively low-resistance condition, and having its resistance increased under the influence of each received energy wave, as and for the purpose set forth.

64. In an apparatus for signaling through space, a receiving device including a local circuit, suitably-separated electrodes arranged in said circuit, means for normally maintaining the circuit between said electrodes in low-resistance condition, each received energy wave operating to increase said resistance, as and for the purpose set forth.

65. In an apparatus for space-signaling, a

receiving device, a local circuit therefor, said
receiving device being normally maintained
in comparatively low-resistance condition,
said resistance condition being variably in-
5 creased under the influence of received en-
ergy waves in proportion to the strength of
such waves, as and for the purpose set forth.
In witness whereof we have hereunto set

our hands, this 28th day of June, 1901, in the
presence of the subscribing witnesses.

LEE DE FOREST.
EDWIN H. SMYTHE.

Witnesses:

CHAS. H. SEEM,
S. E. DARBY.