Oct. 3, 1933. E. L. CHAFFEE 1,928,963

ELECTRICAL SYSTEM AND METHOD

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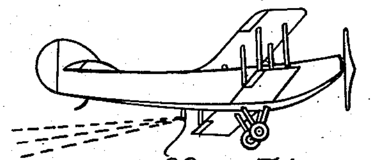
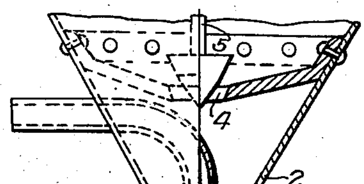


Fig. 4.



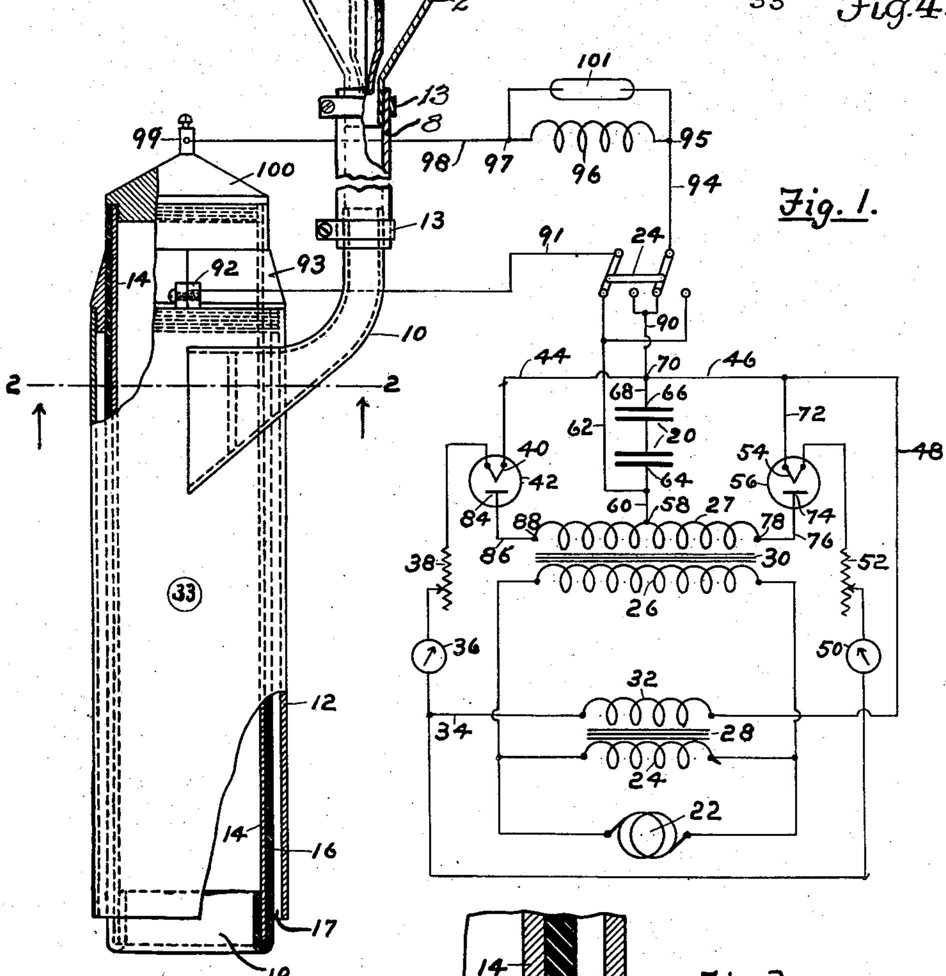


Fig. 1.

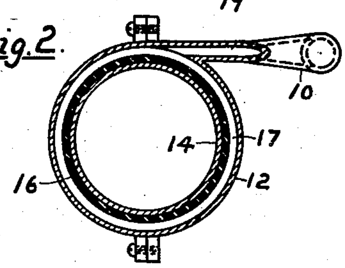


Fig. 2.

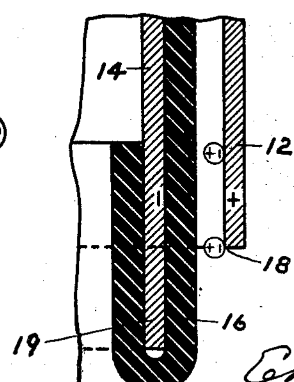


Fig. 3.

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Fig. 5.

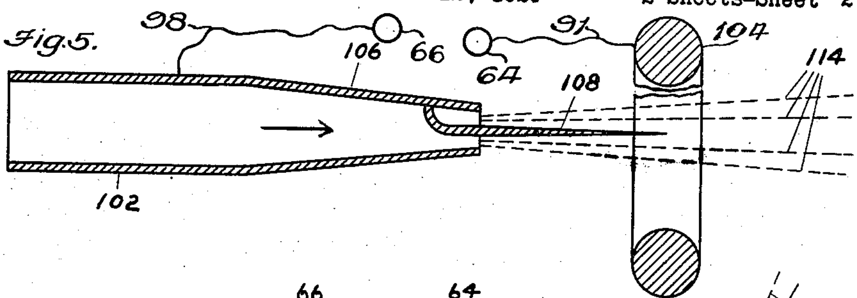


Fig. 6

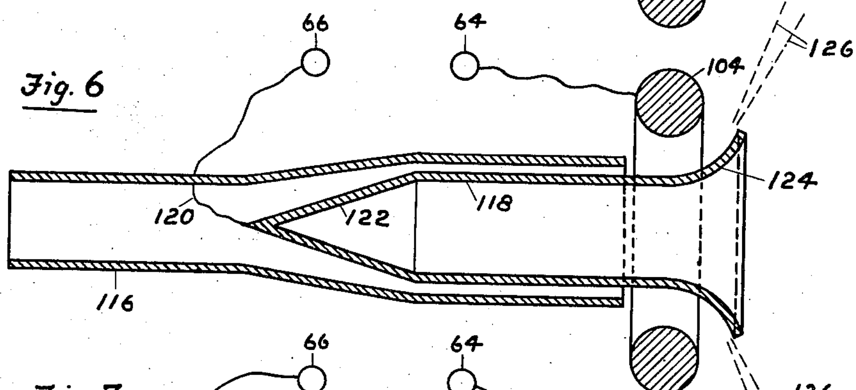


Fig 7

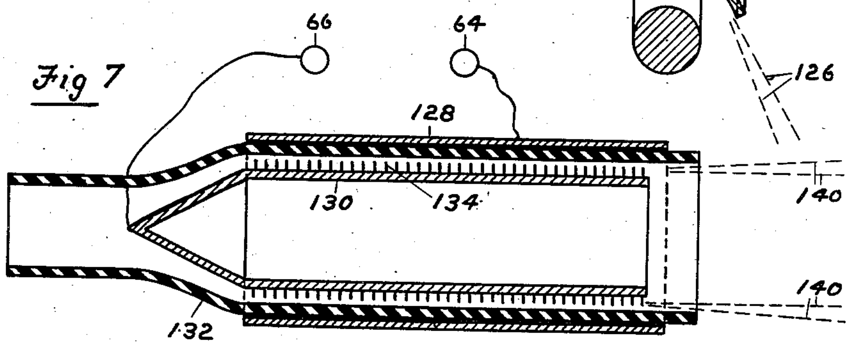


Fig. 8

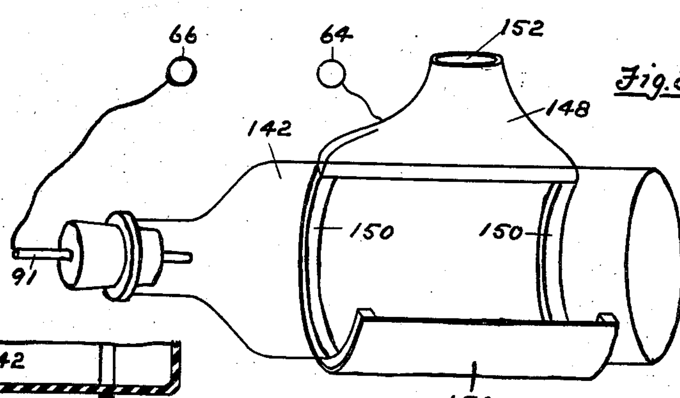
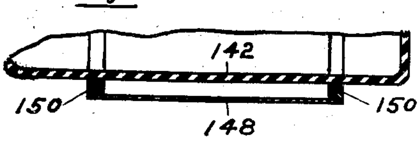


Fig. 9



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UNITED STATES PATENT OFFICE

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ELECTRICAL SYSTEM AND METHOD

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Application January 12, 1925. Serial No. 1,890

46 Claims. (Cl. 175—265)

The present invention relates to electrical systems and methods, particularly to systems for and methods of producing electrical charges, and more specifically to the production of electrical charges on discrete particles of matter. The invention is particularly adapted to charging particles of matter having a relatively low electrical conductivity. From a more limited aspect, the invention aims to dissolve clouds and fogs, to produce rain, and otherwise change atmospheric conditions, and to scatter particles in a charged condition for other purposes also, the charged condition bringing about a repulsion of the particles and hence a more even scattering of the particles, etc.

It is generally believed that atmospheric moisture or water vapor or particles as large as, or larger than, about 0.04 millimeters in diameter are too heavy to remain long suspended in the air, and they fall to the ground as rain drops, coalescing with other drops as they fall. Clouds and fogs are constituted of moisture particles suspended in the atmosphere, the diameter of which, it is estimated, is less than about 0.04 millimeters. These moisture particles are sometimes electrically charged and sometimes they are neutral. If the electrical charges on some particles are of opposite sign to the charges on other particles, the oppositely charged particles coalesce by mutual attraction to form larger units, and the larger units fall to the ground as rain. Coalescence may also take place, from one cause or another, when the moisture particles are neutral, though more time is required to bring about the precipitation.

When the charges of the moisture particles are all of the same sign, whether positive or negative, the particles are kept apart by repulsion. A cloud or fog of this character may remain as such for an indefinite period, until atmospheric or other disturbances bring about a change in electrical conditions, or until the winds cause the cloud to move to other regions.

According to the present invention, other small or finely divided particles or nuclei, like sand, clay, marble dust, cement dust, and other media, and even finely divided liquid particles, are highly charged with charges opposite in sign or polarity to the charges of the moisture particles, and are then scattered into the cloud through a substantial area to react upon the surrounding atmosphere. The charge on each of the scattered particles may be many thousand times as great as the charge on a single moisture particle,—say 30,000 or 40,000 times as great. Each of such charged sand or other particles will therefore cause, say, 30,000 or 40,000 moisture particles to condense around it as a nucleus, with rapid consequent precipitation. Neutral clouds may be treated, first with particles having a charge of one sign and then with particles having a charge of opposite sign, when the same coalescence or condensation and precipitation will be produced. All such artificially charged particles, unless otherwise stated, will, for brevity, be hereinafter denoted by the term "sand", used in a generic sense.

If desired, electrically charged particles of both polarities may be scattered simultaneously, the charges of opposite sign being scattered in separate strata.

Similar results may be produced in vapor-laden atmospheres other than clouds or fogs. Assuming the vapor-laden atmosphere to be properly supercooled, the use of charged particles, according to the present invention, will hasten or increase the formation or condensation of a visible cloud, and then of rain. The vapor particles will condense around the charged sand particles as nuclei, the condensation being hastened by the charges on the particles. If the products of this condensation are sufficiently heavy, they will fall as rain drops; otherwise, additional charged sand particles may be used as heretofore described, the charges of these additional particles being opposite in sign to the charges of the sand particles that served originally as nuclei.

The invention is obviously not restricted in its use to clouds formed of water or moisture particles. Dust clouds, smoke clouds, and the like, may be dissolved in similar manner. Any such formation containing finely divided particles that are electrically charged, or that may become charged by the use of sand particles,—using the term "sand" as before defined,—may be dissipated or dissolved by the use of the present invention. To avoid circumlocution of language, all such formations will hereinafter be included when used in the specification and the claims, under the generic term "cloud".

As is well known, sand,—using the term in the restricted sense,—is constituted largely of silicon dioxide, and this is an insulator. The same is true of many other "sand" particles, the term being now used in its generic sense. Insulating substances, as is well known, cannot easily be charged electrically except by friction; and this is true when the sand particles are perfectly dry. The sand particles employed should be somewhat moist or wet,—which is ordinarily the case,—and when in this condition, they are surrounded by a thin film or films of moisture. It is these moisture films that, it is believed, take up the charge.

The larger the sand particles, the larger will be the maximum charge that they can carry. In fact, this maximum charge is proportional to the square of the radius of the particle; for, as is well known, a charge is always found on the outside surface and never in the interior of the charged substance. Small sand particles, on the other hand, can be scattered more widely into a cloud than large particles, thus affording a larger number of nuclei about which the cloud particles may condense or collect. For practical considerations, therefore, the particles should be large enough to carry a sufficiently large charge, and small enough to permit wide scattering. Sand particles that will pass through sieves of from 50 to 200 mesh have been found to yield satisfactory results.

The invention will now be described further in connection with the accompanying drawings, in which Fig. 1 is a diagrammatic view of circuits and apparatus constructed according to a preferred embodiment of the present invention, the apparatus being shown in side elevation, partly broken away; Fig. 2 is a cross section taken upon the line 2—2 of Fig. 1, looking in the direction of the arrows; Fig. 3 is an enlarged cross section of one side of the lower end of the nozzle shown in Fig. 1, showing two sand particles being charged; Fig. 4 is a view of an air plane showing the nozzle projecting through the lower side of the fusilage and distributing the charged sand; Figs. 5 to 8 inclusive, are views of modifications of nozzles; and Fig. 9 is a fragmentary longitudinal section of the modification shown in Fig. 8.

The most convenient method known of reaching the clouds or other supersaturated atmospheric zones or strata in order to dissolve or disperse them is by using aeroplanes, balloons, or other dirigible aircraft, but the invention is obviously not restricted to this known method. One such aeroplane is illustrated in Fig. 4. The airplanes or balloons should be supplied with a suitable sand-charging mechanism and the charged sand may be scattered into a cloud through one or more nozzles 33. The invention is not limited to the particular mechanisms illustrated and described herein, as other mechanisms may equally well be employed within the spirit and scope of the invention. The mechanisms described herein have been chosen for illustrative purposes in order that the invention may more fully be described, as required by the statutes.

According to the preferred embodiment of the invention illustrated in Fig. 1, the sand particles may be caused to fall in a continuous stream by gravity from a hopper 2, in which the sand is contained, through a valve 4 which, under the control of a rod 5 and handle (not shown), regulates the amount of sand that may be passed from the hopper into the electrical charging mechanism through a tube 8 made of some flexible substance like rubber and fixed in place by clamps 13, and down a chute 10 into the interior of a cylindrical nozzle conductor 12. Within the cylinder 12 is a second cylindrical conductor 14. The cylindrical conductors 12 and 14 are separated by an air space 17, and have conforming surfaces that are opposed to each other throughout a relatively large distance. In the air space is located an insulating cylinder 16. The sand is thus caused to travel between the inner surface of the cylinder 12 and the outer surface of the cylindrical insulator 16, in the air space 17. The cylindrical conductors 12 and 14 are electrically charged with charges of different sign. Simultaneously with the travel of the sand in the space 17, therefore, it is subjected to the action of a very strong electric field. One of the cylindrical conductors, as the conductor 14, acts as an inducing electrode or terminal, and the other, the conductor 12, as a charging electrode or terminal. The sand comes into intimate contact with the charging electrode 12 and, traveling over the said relatively large distance in such contact, becomes thereby charged. In order to increase the contacting effect between the sand and the charging cylinder 12, the sand is caused to spiral around the insulating cylinder 16, in the space 17, during its travel between the cylinders 12 and 16. This spiral effect may be produced by constructing the chute 10 so that it shall extend tangentially into the air space 17, at an angle to the axes of the cylinders as shown in Fig. 2, and forcing the sand through the chute 10, into the air space 17, under pressure. The source of pressure may be compressed air, carbon dioxide, or other gas, entering through an aspirator or orifice 6, and driving the sand before it into the chute 10. The particles of sand travel in charged condition, spirally out of the air space 17, and may thus be scattered, sprayed or disseminated widely into or above the upper or other portion of a cloud, fog, mist, etc., as the aeroplane traverses thereover or therethrough. If the sand particles are charged oppositely to the polarity of the cloud particles, the latter will coalesce, as before described, and the cloud will become dissolved.

The conductors 12 and 14 may be constituted of brass or any other suitable metal or other conducting material. The insulating cylinder 16 may be constituted of glass, mica, rubber, or any other desired insulating material. If glass is employed, the conductor 14 may be constituted of a silvered surface upon the interior of the glass cylinder. It is preferred, however, to employ a separate cylindrical conductor 14. The insulating cylinder 16 may, in fact, be entirely omitted below the upper portion of the chute 10 as the centrifugal action to which the sand is subjected may be sufficient to maintain the sand out of contact with the cylinder 14 and in contact with the cylinder 12. Above the upper portion of the chute, the cylinder 16 maintains the cylinders 12 and 14 insulated from each other while rigidly held in position.

A storage condenser system 20 serves as the medium for maintaining the cylinders 12 and 14 charged at opposite polarity. The condenser system 20 may comprise one or more condensers. The source of energy for the condenser is an alternating-current generator 22, driven from the airplane engine, or in any other desired manner. The alternating current is rectified by two two-element, vacuum-tube rectifiers 42 and 56. A reversing switch 24, interposed between the condenser system 20 and the cylinders 12 and 14, serves to reverse the polarity of the cylinders and, therefore, the charge imparted to the sand particles.

The generator 22 supplies energy to primary windings 24 and 26 of a filament transformer 28 and a high-voltage transformer 30, respectively. The secondary winding 32 of the filament transformer is connected by a conductor 34, through an ammeter 36 and a rheostat 38, to the filament 40 of the two-element, vacuum-tube rectifier 42. It is not essential that the filament 40 be energized direct from the generator 22, but the illustrated connections avoid the use of filament storage batteries, and are therefore advantageous for use on aeroplanes.

From the filament 40, the circuit continues by conductors 44, 46, and 48 back to the secondary winding 32 of the filament transformer 28. In parallel with the ammeter 36, rheostat 38 and the filament 40, are a second ammeter 50, a second rheostat 52, and a second filament 54 of the two-element rectifier tube 56. The filaments 40 and 54 are thus energized from the secondary winding 32 of the filament transformer 28.

From a tap 58, disposed at about half way of the secondary winding 27 of the high-voltage transformer 30, conductor 60 leads to one terminal 64 of the condenser system 20. The circuit continues from the other terminal 66 of the condenser system 20 by a conductor 68, to a terminal point 70. At the terminal point 70, the current divides. One branch travels by way of conductors 46 and 72, to the filament 54 and the other branch by way of the conductor 44 to the filament 40. The current continues from the filament 54 to the plate 74 of the vacuum-tube rectifier 56, and by a conductor 76 to a terminal 78 of the said secondary winding 27. From the filament 40, the circuit continues to the plate 84 of the rectifier 42, and by a conductor 86, to the terminal point 88 of the secondary 26. The current can travel through the rectifier in one direction only, namely, when the plates 74 and 84 are positive with respect to the corresponding filaments, currents in the opposite direction being suppressed by the action of the rectifiers. The current, therefore, passes through one of the rectifiers during one half-cycle and through the other rectifier during the next half-cycle, alternately. The tap 58 is the return point of the currents through both rectifiers. The condenser system 20 is therefore energized by one of the portions of the secondary winding 27 during one half-cycle, and by the other portion during the next half-cycle, alternately. The first-named portion is between the terminals 58 and 88 and the second-named portion is between the terminals 58 and 78.

Though it is preferred to employ the condenser-charging system just described, it will be understood that any equivalent charging means may be employed, and that the details of the illustrative charging mechanism may be varied, without departing from the scope of the invention. The same result may be attained in many other ways, as, for example, by using two high-voltage transformers instead of one, the primary windings being connected in parallel and the secondary windings in series, or the charging of condenser 20 may be effected by batteries or by any form of so-called "static machines".

The charges are communicated from the condenser system 20 to the cylinders 12 and 14 by connections now to be described. The terminal 64 of the condenser system 20 is connected, by the conductor 62, with one side of the reversing switch 24. The terminal point 70, which as before described, is connected with the terminal 66 of the condenser 20, is connected by a conductor 90 with the opposite terminal of the reversing switch 24. The reversing switch 24 is connected, by a conductor 91, with a terminal 92 of a clamping ring 93 on the cylinder 12, and also, by a conductor 94, with a terminal 95 of a coil 96 of a few turns. The other terminal 97 of coil 96 is connected, by conductor 98, with a terminal 99 of a cap 100 on the cylinder 14.

In the illustrated position of the reversing switch, the terminal 92 of the cylinder 12 is connected, by the conductors 91 and 62, with the terminal 64 of the condenser system 20, and the terminal 99 of the cylinder 14 is connected, by conductors 98, 94, and 90, with the terminal 66 of the condenser system 20. In the other position (not illustrated) of the reversing switch 24, the terminals 92 and 99 are respectively connected with the terminals 66 and 64 of the condenser system 20. By reversing the position of the reversing switch 24, therefore, the polarity of the cylinders 12 and 14 may be reversed. The charges of the conductors 12 and 14 are made very high, in order to subject the sand particles in the space 17 to the action of an intense electric field. The electric field, in fact, should be made as intense as is possible without causing sparking between the electrodes. This does not necessarily mean the use of an excessively high voltage, for the voltage employed will depend upon the size of the air gap 17 between the conductors 12 and 14, and partly upon the nature of the insulating medium 16. If the gap between the conductors 12 and 14 is large, the voltage will be high; but a lower voltage may be used to produce as intense an electric field if the gap is smaller. Using a sufficiently small gap 17, the voltage employed may be as low as 10,000 or 20,000, though preferably in excess of 8,000 volts. A voltage as high as 50,000 is probably unnecessary with proper design. Whatever the voltage employed, the intensity of the electric field is necessarily limited by the fact that a more intense field will cause sparking between the conductors 12 and 14 particularly if no insulating cylinder 16 is used. Higher voltages cannot be utilized to produce a more intense field than this maximum, because they will be attended by sparking.

The circuits and apparatus above described have been found to operate well in practice, and it is therefore unnecessary, in order to comply with the statutes, to hazard any theory as to the operation of the invention. Theoretical considerations sometimes make an invention of this character better understood by persons skilled in the art. For this reason, and for this reason only, the following theory of the operation is expounded.

It may be assumed that the conductor 12 is positively charged, and the conductor 14 negatively charged. If the charges are opposite to those assumed, the following explanation will apply with a change of sign. In consequence of the intense electric field to which the sand particles are subjected while in contact with the conductor 12, an electrical separation of charges will take place on each sand particle, the direction of polarization being in the direction of the field. A negative charge will be produced on the side of the sand particle next to the positively charged conductor 12 (or a negative charge, if the conductor 12 is positively charged), and a positive charge on the side of the sand particle towards the negatively charged conductor 14, as is diagrammatically illustrated in Fig. 3. As the sand particle is in contact with the positively charged conductor 12, the negative charge upon the sand particle will flow from the sand particle to the conductor 12, and become neutralized by some of the positive charge upon the positively charged conductor 12. The positive charge on the other side of the sand particle will remain as a charge on the particle, and will be retained by the particle so long as it remains in contact with the charging conductor 12 and in the electric field produced by the two conductors 12 and 14. The resulting charge is the combined result of both contact and induction. The intensity with which the sand particle becomes positively charged depends upon the strength of this field. If, for any reason, the strength of the electric field becomes reduced while the particle is still in contact with the conductor 12, a part of this positive charge will become lost by the flow of some of the positive charge on the sand particle back to the positively charged conductor 12. It is therefore necessary that the particle be subjected to the same intensity of electric field until it leaves the conductor 12 at 18. For this reason, the inducing conductor 14 is caused to extend beyond the conductor 12 in the direction of longitudinal travel of the sand particles, as is indicated at 19 in Figs. 1 and 3, and as is shown also in the modifications of Fig. 1, illustrated in Figs. 5 to 8, inclusive.

The sand particles, when in contact with a positively charged electrode 12, will therefore take up a positive charge, and when in contact with a negatively charged electrode 12 will take up a negative charge, the charge being of the same polarity as the polarity of the charging electrode.

It is desirable to charge the sand particles with charges of one sign or the other, the sign being opposite to the sign of the charge upon the cloud particles. A charge opposite to the charge acquired by the sand particles is imparted to the frame of the airplane by suitable grounding, and may be dissipated in any well known way, as by the ionized exhaust gases of the engine.

The importance of having the electric field between the conductors 12 and 14 sufficiently high, yet not so high as to cause sparking, has been above alluded to. The location of the apparatus is such that the sparks cannot be seen by the aviator; and owing to the deafening noise, the sounds of the sparking cannot be heard. The present invention therefore contemplates the use of an indicator for informing the aviator when the apparatus is sparking. This indicator comprises a Geissler or other discharge tube 101, arranged in parallel to the inductance coil 96, previously referred to. A neon tube has been found satisfactory for this purpose. When there is an electric discharge between the conductors 12 and 14, the potential difference across the terminals of the induction coil caused by the resulting electric oscillations will cause a discharge in the discharge tube 101. The discharge tube may be positioned so as to be readily visible by the aviator, who will adjust the voltage of the high-voltage transformer 30 in accordance with the indications of the discharge tube.

It is not essential that the cylinders 12 and 14 be vertically disposed, as illustrated. They may be inclined at any angle, or held horizontally. If mounted vertically, the particles may be permitted to travel through the air space 17, by being pulled downward under the action of gravity. Such a method would not be very effective unless some means were provided for insuring contact between the charging electrode 12 and the sand particles. As the electric charge of the conductor 12 resides entirely in the surface of the conductor, contact of the sand particles with the surface is essential. The use of a blast of air or other gas, in the manner before described, effectively insures such contact and causes the sand particles to adhere closely to the charging conductor 12. The compressed air or other gas necessary for this purpose may be obtained from previously filled tanks, or from a pump driven by the airplane engine, or in many other ways that will readily occur to persons skilled in the art.

A modification of the invention is illustrated in Fig. 5. One of the electrodes 12 or 14 is replaced by a cylindrical conductor 102, and the other by a ring conductor 104. The ring 104 may be grounded to the airplane. The conductors 102 and 104 are axially disposed, as illustrated. One of the conductors 102, is connected by the conductor 98 with one terminal 66 of the condenser system 20, and the other conductor 104 by the conductor 91 with the terminal 64 of the condenser system 20. The sand particles are blown by an air blast, or caused in any other way to travel, in the direction of the arrow in Fig. 5, through the conductor 102. The air blast need not be very strong, but must have sufficient force to drive the sand particles through the ring conductor, notwithstanding the electrostatic attraction of the latter. The portions of the conductor 102 forward of the line of travel are restricted, as shown at 106. The forward portion 106 of the conductor 102 is provided with a pointed member 108, extending toward the conductor 104, preferably along the axis of the ring conductor 104. Sand particles are caused to engage this member 108 while in the electric field between the charged electrodes 108 and 104, and to travel in contact with the member 108, thereby, acquiring a charge. The end of the member 108 should preferably not extend beyond the ring conductor so that the sand particles will be maintained under the influence of the electric field at the time of leaving the member 108. If the end of the member 108 is disposed in the medial plane of the ring conductor 104, the sand particles will be subjected to the maximum intensity of the electric field at the time of leaving the member 108. The pointed member 108 aids the charging of the sand because the surface density of an electric charge is greater at a point. The sand particles are caused to travel through the ring 104 along a bundle of diverging paths, several of which are illustrated in dotted lines at 114.

In the modification of Fig. 6, the ring conductor 104 is retained, but the cylindrical conductor 102 is replaced by a cylindrical conductor 116. The electrodes 116 and 104 are connected with the condenser system 20 in the same manner as before described. A second conducting cylinder 118 is disposed within the conducting cylinder 116 and is electrically connected therewith, as by means of conductors 120. The rear portion of the cylinder 118 is cone shaped, as shown at 122. The forward portion of the cylinder 118 extends beyond the cylinder 116 and into and just beyond the ring 104, and its forward end tapers outwardly as shown at 124.

The sand particles that are blown or otherwise forced to travel through the cylinder 116, and between the cylinder 116 and the cylinder 118, are caused to engage the tapering portion 124 of the cylinder 118, and are thus forced outward from the axis of the cylinder along the dotted-line paths 126. This ensures contact between the sand particles and the charging electrode 124 while in the intense electric field existing between the electrodes 104 and 124. The operation is otherwise the same as heretofore described. It will be noted that the paths 126 diverge at a considerably larger angle than in the modification of Fig. 5. The contact of the sand particles with the tapering portion 124 thus effects a double result: first, it causes the sand particles to become more efficiently charged at the contact that is thus ensured; and secondly, it causes the paths 126 to become diverged.

In the modification illustrated in Fig. 7, one conducting cylinder 128 is connected with one side of the condenser system 20, and a conducting member 130, disposed within the cylinder 128, is connected with the other side of the condenser system. The sand particles are caused to travel between the conductors 128 and 130. In order that these sand particles may be prevented from engaging both cylinders at once, an insulating cylinder 132, similar to the insulating cylinder 16 of Fig. 1, is disposed between the conductors 128 and 130. The sand particles are caused to travel between the insulating cylinder 132 and the charging conductor 130. To increase the points of contact between the sand and the charging electrode 130, the electrode 130 is provided with a number of needles or other pointed, projecting-metal members 134, that project from the conductor 130 toward the cylinder 128. The sand particles travel outward, beyond the cylinder 132, as shown by the dotted lines 140. The inducing conductor 128 extends beyond the conductor 130 in order to maintain the intensity of the electric field until after the sand particles have left the charging electrode 130, as was before described in connection with the conductor 14 extending beyond the conductor 12, in Fig. 1.

The apparatus will work satisfactorily without the needles 134.

A very simple form of apparatus is illustrated in Figs. 8 and 9. One of the conductors is shown as an ordinary glass bottle 142. The inner surface of the bottle may be silvered, or in any other way rendered conducting, as, for example, by filling the bottle with water. The conductor within the bottle 142 is connected by the conductor 91, shown extending through the cork stopper 146, with one side of the condenser system 20. The other side of the condenser system 20 is connected in any suitable manner with a conductor 148. The glass of the bottle 142 constitutes the equivalent of the insulating cylinder 16 of Fig. 1, and 132 of Fig. 7. The conductor 148 is shown as constituted of a portion of a cylindrical surface, so as to be more or less parallel to the glass of the bottle 142. The conductor 148 is separated from the bottle 142 by an insulating member, shown as rubber strips 150. The sand particles may be forced through an opening 152 in the conductor 148, and between the conductor 148 and the bottle 142, transversely to the axis of the bottle 142. The sand particles will be forced out of an opening 154 at the forward portion of the conductor 148 and into the atmosphere. Because of the curved form of the path between the conductor 148 and the bottle, the sand particles will be forced into intimate contact with the charging electrode 148, while in the intense electric field existing between the conductors 142 and 148. In the cases unlike the construction shown in Fig. 6, intimate contact is assured between the sand particles and the charging conductor but without causing a divergence in path.

Many other modifications will occur to persons skilled in the art. It is therefore desired that the appended claims be broadly construed, except in so far as limitations may be necessary to be imposed by the state of the prior art.

What is claimed is:

1. The process of changing atmospheric conditions consisting in traversing an atmospheric zone where it is desired to change the conditions with an aeroplane or other dirigible aircraft and scattering from said aeroplane substances which will produce the desired change of atmospheric conditions, as for example, electrically charged sand, dust or other finely divided particles, adapted to produce condensation or coalescence of water vapor or water particles to produce rain-fall or fog dispersion.

2. The process of producing rain-fall or dispersal of cloud or fog, according to claim 1, in which the cloud or fog is scattered with particles having an electrical charge of opposite sign to that of the cloud or fog, to produce coalescence of the water particles.

3. A method of dissolving clouds that comprises charging extraneous particles and directing the charged particles into a cloud.

4. A method of dissolving clouds that comprises encasing sand particles in thin films of moisture, charging the sand particles, and directing the charged sand particles into a cloud.

5. A method of dissolving clouds that comprises causing particles to travel in an electric field, charging the particles, and directing the charged particles out of the electric field and into a cloud.

6. A method of dissolving clouds that comprises causing particles to travel between two conductors charged with charges of opposite sign, directing the particles into contact with one of the conductors during their travel between the conductors, and directing the charged particles into a cloud.

7. An electrical machine having, in combination, a hollow conductor, a conductor disposed in the hollow conductor, an insulating barrier disposed between the conductors, means for charging the conductors with charges of different sign, and means for causing particles to travel between the first-named conductor and the insulating barrier.

8. An electrical machine, having, in combination, two conductors, one disposed substantially along the axis of the other, means for charging the conductors with charges of different sign, means for causing particles to travel between the conductors in a direction substantially parallel to the said axis, and means for causing the particles to travel along diverging paths after leaving the conductors.

9. An electrical machine having, in combination, a cylindrical conductor, a conductor disposed in the cylindrical conductor, an insulating barrier disposed between the conductors, and means for causing particles to travel between the insulating barrier and the second-named conductor in a direction substantially parallel to the axis of the cylinder.

10. An electrical machine having, in combination, two cylindrical conductors disposed one in the other, an insulating cylinder disposed between the conductors, means for charging the conductors with charges of different sign, and means for causing particles to travel between the insulating cylinder and one of the conductors.

11. An electrical machine having, in combination, two cylindrical conductors disposed one in the other, an insulating cylinder disposed between the cylinders, means for charging the con-

ductors with charges of different sign, means for causing particles to travel between the insulating cylinder and one of the conductors in a direction substantially parallel to the axis of the said one conductor, and means for causing the particles to spiral in a cylindrical path during their travel.

12. An electrical machine having, in combination, two substantially vertically disposed cylindrical conductors disposed one in the other, an insulating cylinder vertically disposed between the conductors, means for charging the conductors with charges of different sign, means for introducing particles between the insulating cylinder and one of the conductors, the particles being adapted to travel downward between the insulating cylinder and the said one conductor, and means for causing the particles to spiral along a cylindrical path during their downward travel.

13. An electrical machine having, in combination, two cylindrical conductors disposed one in the other, an insulating cylinder disposed between the conductors, means for charging the conductors with charges of different sign, means for causing particles to travel between the insulating cylinder and the exteriorly disposed conductor in a direction substantially parallel to the axis of the said exteriorly disposed conductor, and means for imparting a spiral movement to the particles during their axial travel to cause the particles to engage the exteriorly disposed conductor.

14. A machine for condensing moisture or vapor having, in combination, means for charging extraneous particles and means for directing the charged particles into the moisture or vapor.

15. A machine for dissolving clouds having, in combination, means for causing extraneous particles to travel in an electric field to charge the particles, and means for directing the charged particles into a cloud.

16. A machine for dissolving clouds having, in combination, means for causing particles to travel along a predetermined path in an electric field to charge the particles, and means for directing the charged particles out of the predetermined path along a bundle of diverging paths into a cloud.

17. A machine for dissolving clouds having, in combination, a hollow conductor, a second conductor, means for charging the conductors with charges of different sign, means for causing particles to travel through the hollow conductor to charge the particles, and means for directing the charged particles along diverging paths into a cloud.

18. An electrical machine having, in combination, two conductors, a source of alternating current, a vacuum tube, means for supplying energy to the vacuum tube from the source, a condenser in circuit with the vacuum tube, means connecting the conductors with opposite terminals of the condenser, means for supplying energy from the source to the circuit comprising the condenser and the vacuum tube, and means for causing particles to travel between the conductors and in contact with one of the conductors.

19. An electrical machine having, in combination, two conductors, a generator, a filament transformer and a high-voltage transformer, each having a primary winding and a secondary winding, means connecting the primary windings with the generator, two vacuum tubes each having a filament and a plate, means connecting the filaments with the secondary winding of the filament transformer, means connecting the terminals of the secondary winding of the high-voltage transformer each with one of the plates, a condenser system, means connecting one terminal of the condenser system with an intermediate point of the secondary winding of the high-voltage transformer, means connecting the other side of the condenser system with the filaments in parallel, means connecting the conductors with opposite terminals of the condenser and means for causing particles to travel between the conductors, and in contact with one of the conductors.

20. An electrical machine having, in combination, two conductors, a condenser system, means connecting the conductors with opposite terminals of the condenser system, means for charging the condenser system, and means for causing particles to travel between the conductors and in contact with one of the conductors.

21. An electrical machine having, in combination, two conductors disposed near each other, a condenser system, means connecting the conductors with opposite terminals of the condenser system, a high-voltage transformer connected with the condenser system, a vacuum tube in circuit with the condenser system and the high-voltage transformer, means for energizing the vacuum tube and supplying energy to the high-voltage transformer to charge the condenser system, and means for causing particles to travel along a path closer to one of the conductors than to the other conductor.

22. The process of changing atmospheric conditions consisting in traversing the atmospheric zone where it is desired to change the conditions with an aeroplane or other dirigible aircraft and scattering from said aeroplane through a substantial area containing water vapor, finely divided particles such as dust, sand or the like, charged with electricity, and thereafter, if desired, producing coalescence of these water particles, for example, by scattering the cloud or fog with finely divided particles having an electrical charge of opposite sign to that of the first-named particles.

23. Method in accordance with claim 1, in which, when the cloud or fog is neutral, it is first charged with electricity of one polarity, and is thereafter treated by scattering therethrough the finely divided particles having an electrical charge of opposite polarity to that previously imparted to the cloud or fog.

24. The process of condensation in free air according to claim 1, in which the aeroplane or other dirigible aircraft scatters simultaneously electrical charges of both polarities, and if desired, the charges of opposite sign being scattered in separate strata.

25. Apparatus for effecting coalescence of atmospheric moisture, which comprises an aeroplane or other dirigible aircraft containing mechanism for discharging minute particles of a medium adapted to react upon the surrounding atmosphere to effect the said coalescence.

26. Apparatus according to claim 1, in which the aeroplane or other dirigible aircraft is provided with a discharging mechanism comprising a discharge nozzle adapted to have a source of high potential connected therewith, whereby the nuclei or small particles of matter passing therethrough are adapted to have imparted thereto a high potential charge of either sign.

27. Apparatus according to claim 1, in which the aeroplane or other dirigible aircraft is provided with a receiving hopper for the neclei or

small particles of matter to be scattered cooperating with a discharge nozzle having a pair of terminals adapted to be connected across the secondary of a high potential transformer through the intervention of a rectifying device and thereby to impart a high potential charge of either sign to the particles of matter discharged from said nozzle.

28. A method of condensing moisture that comprises charging particles from a source extraneous to the moisture and directing the charged particles into the moisture.

29. The process of precipitating moisture from a cloud, comprising scattering widely in the upper portion of the cloud finely divided particles of extraneous matter having opposite electrical charges from that of the cloud.

30. The process of precipitating clouds in free air by scattering above said cloud particles of extraneous matter electrically charged opposite to the charge on the cloud particles.

31. The process of dispersing a cloud having electrically-charged cloud particles that comprises causing sand particles to travel in the form of a continuous stream, simultaneously imparting to the sand particles an electric charge of opposite polarity to the polarity of the cloud particles, and scattering the stream of charged sand particles widely into the upper portion of the cloud.

32. The process of dispersing a cloud having electrically-charged cloud particles that comprises charging two oppositely disposed, insulated conductors with charges of opposite polarity to produce an electrostatic field between them, causing sand particles to travel in the form of a continuous stream in the electrostatic field between the conductors and in contact with that one of the conductors the polarity of which is opposite to the polarity of the cloud particles to impart to the sand particles an electric charge of opposite polarity to the polarity of the cloud particles, directing the stream of sand particles in charged condition out of contact with the said one conductor, and scattering the stream of charged sand particles widely into the upper portion of the cloud.

33. A machine for electrically charging sand particles having, in combination, two cylindrical conductors disposed one in the other and insulated from each other, a condenser system, means connecting the conductors with opposite terminals of the condenser system, means for charging the condenser system to charge the conductors with charges of opposite polarity to produce an electrostatic field between them, means for reversing the polarity of the conductors, and means for causing the sand particles to travel in the form of a continuous stream in the electrostatic field between the conductors and in contact with one of the conductors to impart to the sand particles an electric charge of the same polarity as the polarity of the said one conductor, and for directing the stream of sand partitcles in charged condition out of contact with the said one conductor.

34. A machine for dispersing clouds having electrically-charged cloud particles having, in combination, an aeroplane, two cylindrical conductors carried thereby, the conductors being disposed one in the other and insulated from each other, means carried by the aeroplane for charging the conductors with charges of opposite polarity to produce an electrostatic field between them, a sand-containing hopper carried by the aeroplane, and means for causing the sand particles to travel in the form of a continuous stream in the electrostatic field between the conductors and in contact with that one of the conductors the polarity of which is opposite to the polarity of the cloud particles to impart to the sand particles an electric charge of opposite polarity to the polarity of the cloud particles and for directing the stream of sand particles in charged condition out of contact with the said one conductor and scattering them widely into the upper portion of a cloud.

35. An electric machine having, in combination, two cylindrical conductors disposed one in the other and insulated from each other, one of the conductors having a surface of relatively large distance disposed toward the other conductor, means for charging the conductors with charges of opposite polarity to produce an electrostatic field between them and to produce a charge on the said one surface throughout the said relatively large distance, and means for causing particles to travel in the form of a continuous stream in the electrostatic field between the conductors and in intimate contact with the said charged surface throughout the said relatively large distance to impart to the particles an electric charge of the same polarity as the polarity of the said charged surface, and for directing the stream of particles in charged condition out of contact with the said one conductor.

36. An electrical machine having, in combination, a hollow conductor, a second conductor disposed in the hollow conductor, one of the conductors having a surface of relatively large distance disposed toward the other conductor, means for charging the conductors with charges of opposite polarity to produce an electrostatic field between the conductors and to produce a charge on the said one surface throughout the said relatively large distance, and means for causing particles to travel in the electrostatic field in intimate contact with the said charged surface throughout the said relatively large distance to cause the particles to take up the charge of the said charged surface.

37. An electrical machine having, in combination, two conductors at least one of which has a surface of relatively large distance disposed toward the other conductor, an insulating barrier between the conductors, means for charging the conductors with charges of opposite polarity to produce an electrostatic field between the conductors and to produce a charge on the said one surface throughout the said relatively large distance, and means for causing particles to travel in the electrostatic field in inimate contact with the said charged surface throughout the said relatively large distance to cause the particles to take up the charge of the said charged surface.

38. An electrical machine having, in combination, a hollow open-ended conductors, a second conductor disposed axially of the open-ended conductor, one of the conductors having a surface of relatively large distance disposed toward the other conductor, means for charging the conductors with charges of opposite polarity to produce an electrostatic field between the conductors and to produce a charge on the said one surface throughout the said relatively large distance, and means for causing particles to travel in the electrostatic field in intimate contact with the said charged surface throughout the said relatively large distance to cause the particles to take up the charge of the said charged surface.

39. An electrical machine having, in combination, two conductors having electrically conforming surfaces that are opposed to each other throughout a relatively large distance, means for charging the conductors with charges of opposite polarity to produce an electrostatic field between them, a sand containing hopper, and means for causing the sand particles to travel in the form of a continuous stream in the electrostatic field between the conductors and in intimate contact with one of the conductors throughout the said relatively large distance and thereby to take up the charge of the said one conductor and for directing the stream of sand particles in charged condition out of contact with the said one conductor.

40. An electrical machine having, in combination, two conductors having electrically conforming surfaces that are opposed to each other throughout a relatively large distance, means for relatively highly charging the conductors with charges of different sign to produce a relatively strong electrostatic field between the conductors throughout the relatively large distance, and means for causing particles disposed between the conductors to travel in intimate contact with one of the conductors throughout the said relatively large distance and thereby to take up the charge of the said one conductor.

41. The process of precipitating moisture from a cloud, comprising traversing rapidly the strata above the cloud while charging finely divided particles of extraneous matter with an electric charge opposite to that of the cloud and widely scattering them above the cloud.

42. The process of condensing, coalescing and precipitating moisture from supersaturated atmospheric strata, comprising traversing the strata while charging and scattering in such strata, nuclei carrying an electric charge, thereby causing the formation of a cloud and then precipitating such cloud by traversing the strata above such cloud while charging and scattering through such cloud particles of extraneous matter carrying a charge opposite to that of said cloud.

43. The process of condensing and precipitating moisture from supersaturated atmospheric strata comprising scattering in such strata nuclei adapted to facilitate condensation, thereby causing the formation of clouds, and then precipitating such cloud by scattering upon the upper portion thereof particles of extraneous matter carrying an electrical charge opposite to that of said cloud.

44. The process of condensing and precipitating moisture from supersaturated atmospheric strata comprising scattering in such strata nuclei adapted to increase condensation in clouds, and then precipitating such cloud by scattering through the cloud particles of extraneous matter carrying an electrical charge opposite to that of said cloud.

45. The process of dispersing a cloud comprising scattering widely in the upper portion of said cloud finely divided particles of extraneous matter, while imparting to them a charge of opposite polarity to that of the cloud.

46. The process of dispersing a cloud comprising scattering widely through the cloud finely divided particles of extraneous matter, while imparting to them a charge in excess of 8000 electrostatic volts and of opposite polarity to that of the cloud.

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