Nov. 17, 1931. E. L. CHAFFEE ET AL 1,832,096

ELECTRICAL SYSTEM

Filed April 11, 1925 2 Sheets-Sheet 1

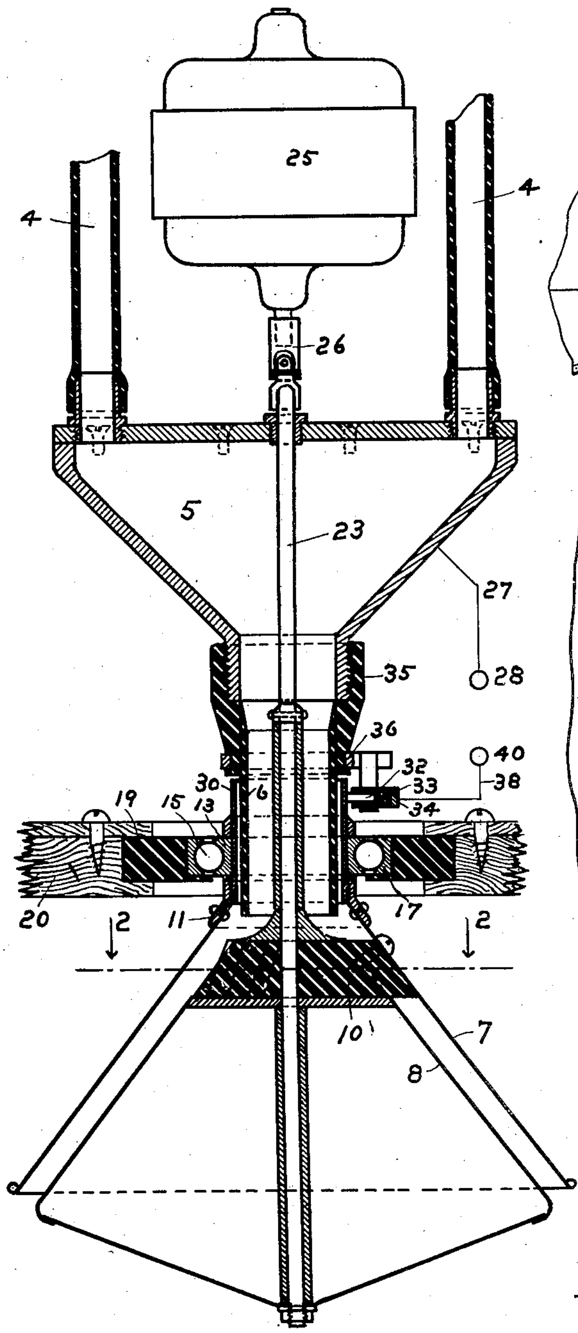

Fig. 1.

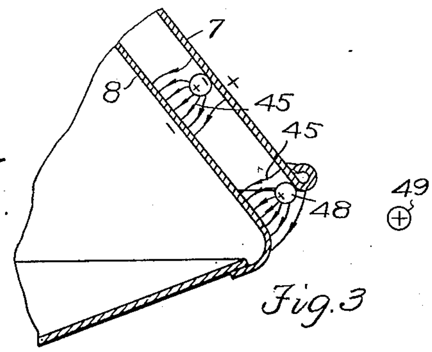

Fig. 3

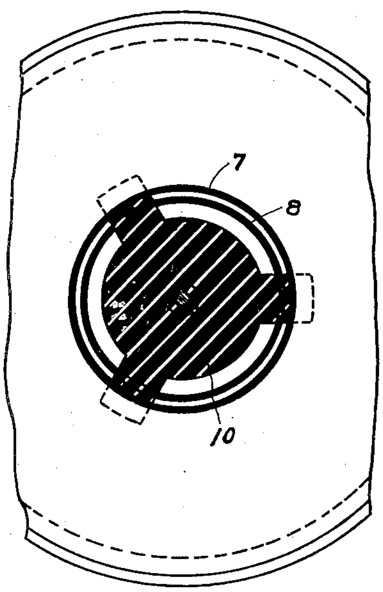

Fig. 2.

Inventors
E. L. Chaffee
R. O. Chaffee
by David Rines
Attorney

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2 Sheets-Sheet 2

Fig. 5

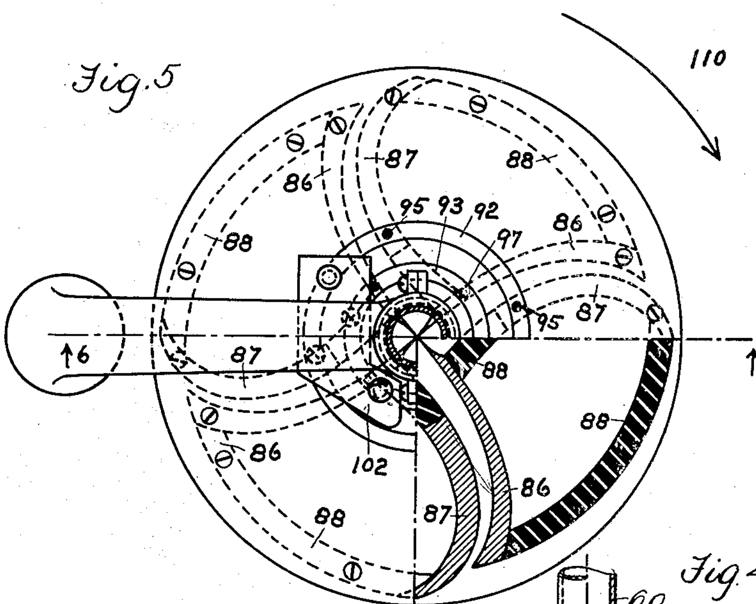


Fig. 4

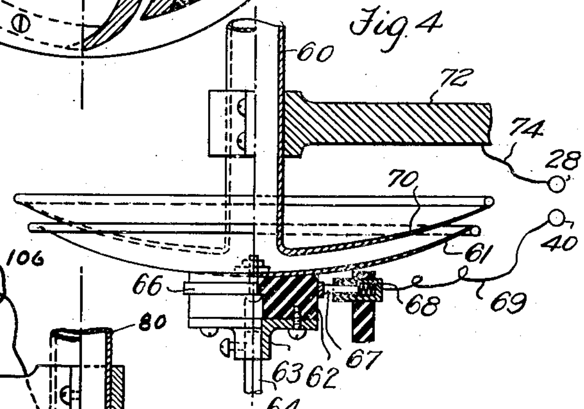
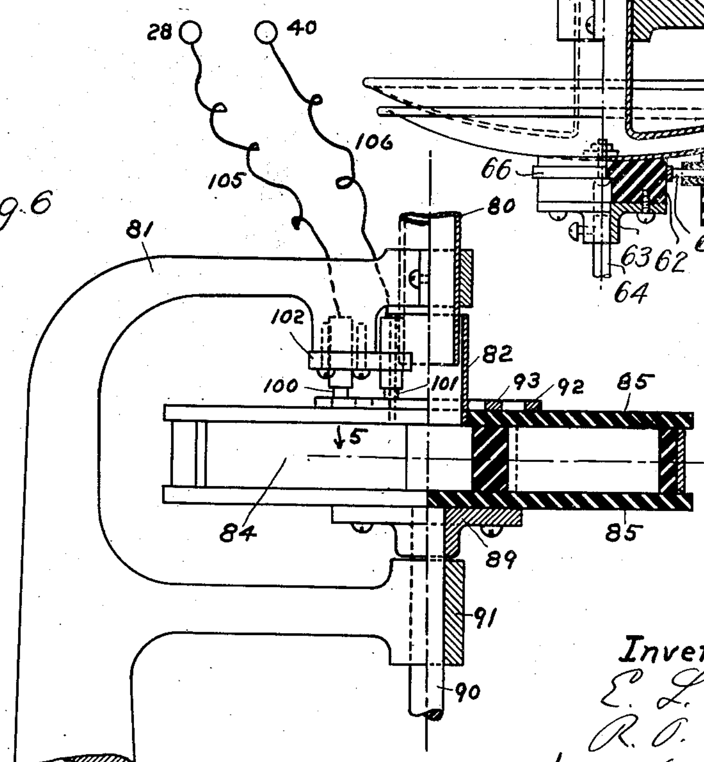


Fig. 6



Inventors
E. L. Chaffee
R. O. Chaffee
by David Rines
Attorney

Patented Nov. 17, 1931 1,832,096

UNITED STATES PATENT OFFICE

EMORY LEON CHAFFEE, OF CAMBRIDGE, AND RAYMOND OSGOOD CHAFFEE, OF BELMONT, MASSACHUSETTS

ELECTRICAL SYSTEM

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The present invention relates to electrical systems, particularly to systems for producing electrical charges, and more specifically to the production of electrical charges on discrete particles of matter. From a more limited aspect, the invention aims to dissolve clouds and fogs, and to produce rain.

It is generally believed that moisture 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 particles, like sand, clay, marble dust, cement dust, and the like, and even finely divided liquid particles, are charged with charges opposite in sign to the charges of the moisture particles, and are then scattered into the cloud. 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 such charged sand or other particle 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 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.

Similar results may be produced in vapor-laden atmospheres other than clouds or fogs. Assuming the vapor-laden atmosphere to be properly super-cooled, the use of charged particles, according to the present invention, will hasten the formation 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".

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 accompanying drawings, in which Fig. 1 is a vertical section, partly in elevation, of a preferred embodiment of the present invention; Fig. 2 is a horizontal section taken on the line 2—2 of Fig. 1, looking in the direction of the arrows; Fig. 3 is an enlarged, vertical section corresponding to the lower right-hand portion of Fig. 1, showing two sand particles in the process of becoming charged and one sand particle already charged and leaving the charging nozzle; Fig. 4 is a side elevation, partly in vertical section, of a modification; and Figs. 5 and 6 are respectively a plan and an elevation of a further modification, Fig. 5 being partly in horizontal section along the line 5—5 of Fig. 6, and Fig. 6 being partly in vertical section along the line 6—6 of Fig. 5, looking in the direction of the arrows.

The most convenient method known of reaching the clouds in order to dissolve them is by using airplanes, balloons and the like, but the invention is obviously not restricted to this known method. 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. 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 is caused to flow by gravity from hoppers (not shown) through rubber tubes 4, into a chamber 5. The flow of the sand from the hoppers may be controlled by suitable valves (not shown). From the chamber 5, the sand flows through a rubber or other insulating tube 6, into the space between an outer, conducting, cone-shaped, charging electrode 7 and a parallel inner, conducting, cone-shaped, inducing electrode 8. The two cones 7 and 8 are rigidly held together as a unit in nested, axially disposed relation, by a three-pronged, hard-rubber support 10 to constitute a charging nozzle. The cone 7 is also rigidly riveted to a flange 11 which is, in turn, clamped to the inner race 13 of a ball bearing 15. The outer race 17 of the ball bearing 15 is rigidly clamped in the stationary insulating support 19 which is, in turn, clamped in the main support 20. The two cones 7 and 8 may thus be revolved about a vertical axis by a shaft 23, connected to a motor or some other suitable driving mechanism 25 through a flexible coupling 26. The inducing electrode 8 is in electrical contact with the conducting shaft 23 and hence in electrical contact with the metal chamber 5, which is connected by a wire 27 to a terminal 28. The charging electrode 7 is in electrical contact with the flange 11 and with a cylinder 30 which rotates with the cone 7. Electrical contact is made with the cylinder 30 by means of a brush 32, pressed by a spring 33, and held in a brush holder 34, which is rigidly clamped around a hard-rubber or other insulating bushing 35 by a ring clamp 36. The brush holder 34 is connected by a wire 38 to a terminal 40. The terminals 28 and 40 are connected to any suitable source of high potential giving voltages of the order of 10,000 or 20,000 volts. This high potential may be produced in any well-known way, as by means of a static machine of well-known form, or by means of vacuum-tube rectifiers which charge a condenser by rectifying alternating current of high voltage produced by a generator acting through a step-up transformer, as described in a copending application, Serial No. 1890, filed January 12, 1925. Means are provided, as illustrated in said application, for reversing the sign of the electrical potential of the terminals 28 and 40, so that the terminal 28 may be made positive or negative with respect to the terminal 40 at the will of the operator.

The operation of the apparatus shown in Fig. 1 may be described as follows: Sand, flowing by gravity from the chamber 5, through the tube 6, encounters the top of the rotating support 10. The sand takes on the rotating motion of the terminals 7 and 8 and is thrown out by centrifugal force on to the inner surface of the charging electrode 7. It is preferred to rotate both electrodes 7 and 8, though one only may be rotated, as in Fig. 4. Because of the combined action of centrifugal force and gravity, the sand slides down the inner surface of the electrode 7, always remaining firmly in contact with the electrode 7, and out of contact with the electrode 8, finally emerging at the edge of the electrode 7. The sand particles, during their travel between the electrodes 7 and 8, are subjected to a strong electric field caused by the potential difference between the terminals 7 and 8. The electric field is represented in Fig. 3 by lines 45. This electric field will have a tendency to separate the charges on the sand particles by induction and if the electrodes 7 and 8 are respectively positively and negatively charged, as indicated in Fig. 3, the induced positive charge on the sand particle will be on the side of the sand particle toward the terminal 8 and the negative charge induced on the sand particle will be on the side of the particle toward the terminal 7.

This separation of charges by induction on the sand particle presupposes that the sand particles are partial conductors of electricity. It is well-known that sand,—using the term in the restricted sense,—which is essentially silicon dioxide, is a very good insulator and hence not a conductor. The same is true also of many other sand particles, using the term now in the generic sense. Insulating substances, as is well-known, cannot easily be charged electrically except by friction. Under ordinary atmospheric conditions, however, sufficient moisture is condensed on the sand particle to constitute a conducting layer sufficient to allow the separation of charges as described above. It may be stated, however, that in case the sand is excessively dry, artificial means must be used to moisten the sand particles. It is these moisture films, it is believed, that take up the charge.

Returning now to the description of the charging process, because the sand particles are maintained in firm contact with the electrode 7 during their journey through the charging nozzle, the negative charge induced on the sand particles will flow to the terminal 7 and be neutralized, as illustrated by the sand particle 48 in Fig. 3. The sand particle, on emerging from the charging nozzle into a cloud, will hence be positively charged, as shown by particle 49 of Fig. 3. It is obvious that if the electrode 7 had been negatively charged with respect to the electrode 8, the emerging sand particles would then be negatively charged, instead of positively charged.

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.

In order to impart to the sand particles a maximum charge, it is necessary that the potential between terminals 7 and 8 be made as large as possible without sparking.

A modification of the invention is shown in Fig. 4. The sand fed from a hopper (not shown), passes by gravity through a tube 60 and falls on the rotating dish-shaped electrode 61. The electrode 61 is supported on an insulating cylinder 62 which is screwed to a flange 63 and driven about a vertical axis by some suitable means, such as a motor, through a shaft 64. A metallic ring 66, electrically connected to the metal electrode 61, is supported on the insulating cylinder 62. Electrical connection is made with this ring 66 through the brush 67, pressed by a spring 68 against the ring 66 and connected by a wire 69 to the terminal 40. Above the electrode 61, which performs the same function as the charging electrode 7 of Fig. 1, and hence may also be termed the charging electrode, is supported the inducing dish-shaped electrode 70, which is in electrical connection through the tube 60, with the metallic support 72. Though one only of the electrodes 61 and 70 is rotated, the relation of the portions of the electrodes between which the sand is disposed, is not thereby disturbed. The support 72 is connected by a wire 74 to the terminal 28. The terminals 28 and 40, as described in connection with Fig. 1, are connected to some source of high potential, so that the potential difference between them may be reversed at will. The process of charging of the sand, as it passes through the device shown in Fig. 4, is similar to the process described above for Fig. 1. The dish-shaped electrodes 61 and 70 extend at an angle to the tube 60 less than a right angle instead of, as in Fig. 1, greater than a right angle. The sand striking the rotating electrode 61 will therefore be forced outward by the action of the centrifugal force and, during the journey outward, is subjected to the strong field set up between the inducing electrode 70 and the charging electrode 71. Because of the curvature of electrode 61, the sand is forced into contact with the electrode 61, as it is thrown outward by the action of centrifugal force and is scattered at a much wider angle than in Fig. 1, being caused to travel upwardly instead of, as in Fig. 1, downwardly. The sand emerges charged with the same sign as the charge of electrode 61.

A further modification of the invention is shown in Figs. 5 and 6. Sand is fed from a hopper (not shown) through a tube 80 which is rigidly held in a support 81, into a tube 82, which is rigidly fastened to a rotating member 84. This rotating member is made up of two parallel discs 85 of hard-rubber or other insulating material. Metal charging electrodes 86 and inducing electrodes 87 and hard-rubber fillers 88 are securely fastened by screws between the discs 85. The lower disc 85 is rigidly fastened to a flange 89, which is fastened to the shaft 90. The shaft 90 is driven by any suitable mechanism, such as an electric motor (not shown). The electrodes 86 and 87 are thus rotated as a unit. The shaft 90 rotates in a bearing 91 which is a part of the main support 81. On the upper surface of the disc 85 are fastened two metal slip rings 92 and 93. The ring 92 is connected by conducting pins 95 with the inducing electrodes 87. The ring 93 is connected by conducting pins 97 with the charging electrodes 86. Brushes 100 and 101 rest on the rings 92 and 93, respectively. These brushes 100 and 101 are supported in suitable brush holders which, in turn, are supported in the insulating holder 102. The brush 100 is electrically connected, through its brush holder and a wire 105, to the terminal 28. The brush 101 is electrically connected, through its brush holder and a wire 106, to the terminal 40. The rotating member 84 is caused to revolve by the shaft 90 in the direction shown by the arrow 110 of Fig. 5. Sand, which is fed to this charging nozzle through the tubes 80 and 82, is charged in a manner exactly similar to that described with reference to Fig. 1. The sand enters the central portion between the discs 85 and is thrown outward by centrifugal force and caused to travel through the narrow channels or chambers between the charging electrodes 86 and inducing electrodes 87. It is there subjected to the intense charging field produced by the source of electrical energy connected to the terminals 28 and 40, as before described in connection with Fig. 1. As the sand is forced outward, it is caused to contact continually with the charging electrodes 86 because of the curvature of electrodes 86 and is maintained out of contact with the inducing electrodes 87. The necessity of this intimate contact of the sand particles to the charging electrode during the charging process has been fully described with reference to the process of charging outlined above.

One charging electrode 86 and one inducing electrode 87 are sufficient, in theory, to produce the described result, but a plurality of pairs of such electrodes, of course, multiplies the effect produced.

The electrodes 7 and 8 are shown substantially parallel to each other, a conforming relation that is maintained throughout during the operation of the machine. Similar considerations apply to the electrodes 61 and 70 of Fig. 4 and 86 and 87 of Figs. 5 and 6. This conforming relation is requisite in order to create an electrostatic field over a relatively large area or distance,—large enough to afford the particles sufficient contact to become charged, as above described. It will be understood, therefore, that the term "conforming", as used in the claims, is not to be restricted to geometrical parallelism, as illustrated in the drawings, but is to be construed broadly, in an electrical rather than a geometrical sense, so as to bring about the above-described result of creating an electrostatic field over the said relatively large area or distance.

Other modifications, too, will readily occur to persons skilled in the art, and are considered to lie within the spirit and scope of the present invention, as defined in the appended claims.

What is claimed is:

1. An electrical machine having, in combination, two conductors having opposed surfaces extending throughout a relatively large distance, one of the surfaces conforming substantially to the shape of the other, means for charging the conductors with charges of different sign, means for moving one of the conductors in the neighborhood of the other conductor in such fashion as to maintain the conforming relation of the surfaces unchanged, and means for supplying particles between the conforming surfaces, whereby the particles will be caused to travel by centrifugal action in contact with the moving conductor and will become charged during their travel.

2. An electrical machine having, in combination, two conductors having surfaces disposed in parallel relation throughout a relatively large distance, means for charging the conductors with charges of different sign, means for rotating one of the conductors without disturbing the parallel relation of the conductors, and means for supplying particles between the conductors, whereby the particles will be caused to travel by centrifugal action in contact with the rotating conductor and will become charged during their travel.

3. An electrical machine having, in combination, two cone-shaped conductors nested in axial relation with a space between them, means for charging the conductors with charges of different sign, and means for rotating one of the conductors, whereby particles disposed in the said space will be caused to travel by centrifugal action along one of the conductors and become charged during their travel.

4. An electrical machine having, in combination, two cone-shaped conductors nested in axial relation with a space between them, a passage to the space through which particles may be supplied to the space, the direction of extension of the space making an angle greater than a right angle with the passage, means for charging the conductors with charges of different sign, and means for rotating one of the conductors, whereby the particles will be caused to travel by centrifugal action along one of the conductors in the said space, and become charged during their travel.

5. An electrical machine having, in combination, two cone-shaped conductors nested in axial relation with a space between them, the axis of the conductors being disposed substantially vertical with the surfaces of the cones diverging outward downward, a vertically disposed passage communicating with the said space through which particles may fall by gravity into the space, means for

charging the conductors with charges of different sign, and means for rotating one of the conductors about the axis, whereby the particles will be caused to travel by centrifugal action along one of the conductors in the said space and become charged during their travel.

6. An electrical machine having, in combination, two conductors having surfaces disposed in parallel relation throughout a relatively large distance, means for charging the conductors with charges of different sign, means for rotating the conductors as a unit, and means for supplying particles between the conductors.

7. An electrical machine having, in combination, two conductors, insulating members connecting the conductors to form a chamber, means for charging the conductors with charges of different sign, means for rotating the conductors and the insulating members as a unit, and means for supplying particles in the chamber.

8. An electrical machine having, in combination, two conductors having 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, means for causing the sand particles to travel in the form of a continuous stream in the electrostatic field between the conductors, and means for rotating one of the conductors while maintaining the conforming relation of the said opposed surfaces to cause the particles to contact by centrifugal action with the said one conductor 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.

9. An electrical machine having, in combination, two conductors having surfaces of revolution disposed in parallel relation, means for charging the conductors with charges of different sign, means for rotating the conductors about the axis of revolution, and means for supplying particles between the conductors.

10. An electrical machine having, in combination, two conductors having 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 moving one of the conductors while maintaining the conforming relation of said opposed surfaces, whereby particles disposed between the conductors will be caused to travel by centrifugal action in contact with one of the conductors throughout the said relatively large distance and will thereby become charged during their travel, by intimate contact with the said one surface, with the charge of the said one surface.

11. An electrical machine having, in combination, two conductors having 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, means for supplying particles of relatively very low conductivity between the conductors, the conductors being so disposed and the electrostatic field being so strong that the particles would have a tendency to be attracted by the field to and contact with one of the conductors, and means for rotating the other conductor about the said one conductor while maintaining the conforming relation of said opposed surfaces, whereby the particles will be caused to travel by centrifugal action in contact with the said other conductor in opposition to the attraction of the field, and will be maintained in contact with the said other conductor throughout the said relatively large distance and will thereby become charged during their travel, by intimate contact with the said other conductor, with the charge of the said other conductor.

In testimony whereof, we have hereunto subscribed our names this 10th day of April, 1925.

E. LEON CHAFFEE.
RAYMOND O. CHAFFEE.