

Oct. 10, 1950

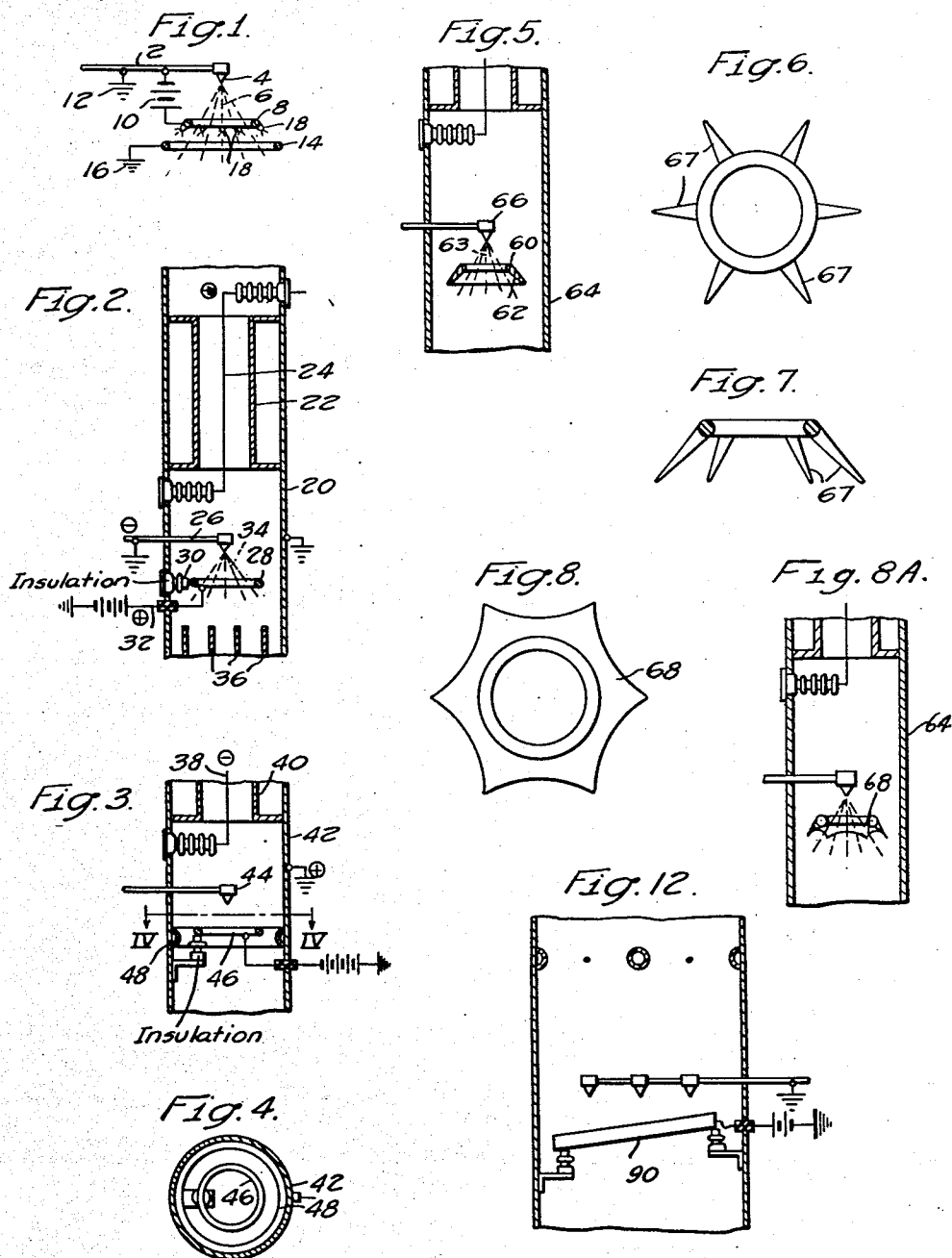
S. GILMAN

2,525,347

ELECTROSTATIC APPARATUS

Filed Feb. 9, 1945

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 10.

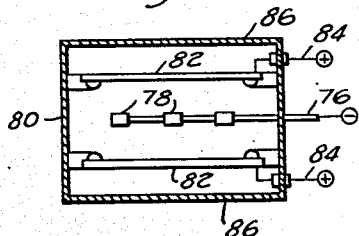


Fig. 11.

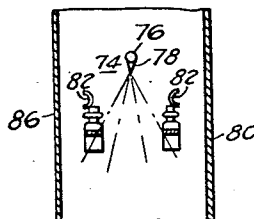


Fig. 9.

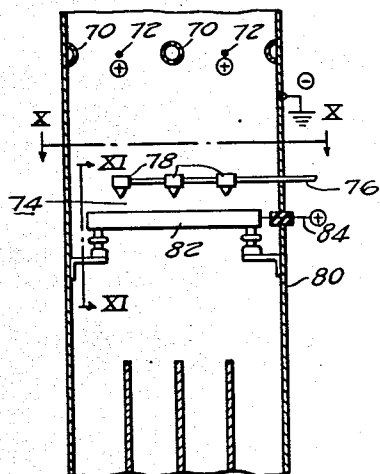


Fig. 13.

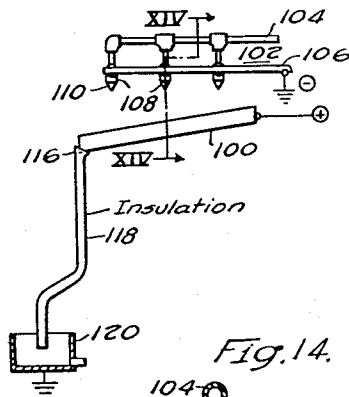


Fig. 14.

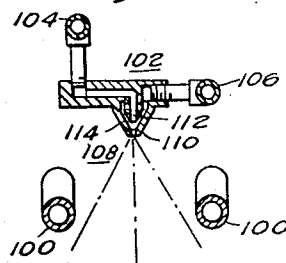
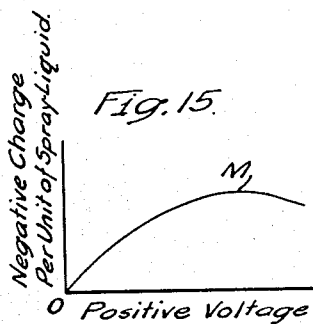


Fig. 15.



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2,525,347

ELECTROSTATIC APPARATUS

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Application February 9, 1945, Serial No. 577,021

22 Claims. (Cl. 183—7)

1 This invention relates broadly to apparatus for providing a charged spray of discrete non-gaseous particles; and, specifically, to a nozzle-device, having an electrode associated with it, for producing a spray which is electrically charged. In another sense, the invention is directed to improvements in electrical dust-precipitators of a type shown in the Gaylord W. Penney Patent No. 2,357,354 of September 5, 1944, which uses a means for producing a charged spray. Such an improved dust-precipitator, in accordance with my invention, has a modified operation with an improved efficiency.

In the removal of dust-particles from a flowing gas-stream, in accordance with the aforesaid patent, the gas-borne dust-particles are first given an electrical charge of a predetermined potential-polarity, and then are precipitated by means of an electrically-charged spray of very fine drops through which the dust-carrying gas is passed. The spray-drops are charged with a potential-polarity opposite to that given to the dust-particles so as to attract and combine with them. The gas is cleaned by subsequently separating the spray with the attached dust-particles from the gas-stream.

My invention seeks to improve upon such electrical dust-precipitators. The aforesaid patent, while not limited thereto, shows several forms of equipment with which a spray can be produced and electrically charged. The spray is obtained by providing a spraying-device having a liquid discharge or liquid emitting opening at the end of a single tapered member, or a plurality of such openings associated with a single pipe-member. The spray-drops are charged inductively by having such member, at which the spray originates, serve as an electrode-means of opposite potential-polarity with respect to another electrode-means relatively insulated therefrom so that an electrostatic field exists at the point at which the spray leaves the member. The spray-drops are electrically charged with a polarity which is opposite to that of the insulated electrode-means and to that on the gas-borne dust-particles.

In apparatus of this kind, it is desirable to provide as large a net or total charge as possible on the spray; but if the voltage or electromotive force between the oppositely charged electrode-means is continuously increased, a point is reached in which this net total charge no longer increases but, on the contrary, may actually decrease. This can be explained. The relatively insulated electrode-means is close to the path of the main part of the spray so that mist-particles

2 bordering the spray actually impinge on, and some spray-drops are electrically attracted to, the relatively insulated electrode-means. The liquid collects on an electrode means and soon there is enough to form a plurality of large drops on this electrode-means, the drops becoming charged to the potential of the latter. If the electric field at this electrode-means exerts a sufficient force, the drop will be pulled out of shape into a point and will discharge an ionizing current of charged matter which is of the same sign or potential-polarity as that of the relatively insulated electrode-means. This charged matter tends to neutralize the opposite charge on the spray to an extent depending upon the intensity of the total ionizing current coming from the drops. In extreme cases, the number of discharging drops and the intensity of their discharges may be sufficient to actually reverse the polarity of the charge on the spray, practically nullifying any electrostatic dust-precipitating effect it might otherwise have.

It is a further object of my invention to improve an electrical dust-precipitator of a type described, by improving its means for producing a charged spray and also by arranging this means so as to aid dust-precipitation.

Hereinafter in the description, in order to readily distinguish the drops collected on the electrode-means from those of the spray, the former are referred to as drops and the latter as droplets, or particles. It should be understood that the drops are generally considerably larger than the droplets in the spray, and can be readily seen on an electrode.

For producing a charged spray, any suitable means may be used. Several examples comprise a nozzle which directly emits the spray, as shown in Figures 1 and 2 of the aforesaid patent, and a pneumatic nozzle-device in which a gas, usually air, is used to break up a liquid into fine particles which the gas carries along in the form of a spray, as shown, for example, in Fig. 3 of the aforesaid patent.

In order to charge the spray-droplets, an intense electrostatic field is provided at the point or opening at which the spray originates that is, a high field-gradient is provided at such point. The relatively insulated electrode-means, which aids in providing this electrostatic field, is preferably close to the point and along the main path of the spray which flows past it, so that liquid necessarily collects on it. The liquid gives up its original charge to this electrode-means and is inductively charged thereby to the potential

of the electrode-means so that the liquid becomes charged to a polarity opposite to that which this liquid originally had as part of the spray. Since the liquid is mobile, it can be moved about on this electrode-means by forces acting on it which result from gravity and from any electrostatic field established between the electrode-means and a region or surface of opposite polarity. Without the improvement of my invention, the spray-charging electrostatic field is mainly that provided between the nozzle-tip from which the spray emits and the relatively insulated electrode-means. If this field provides a field-gradient at the electrode-means which is sufficiently high, the collected drops will be distorted and discharge an objectionable ionizing current, as described above in connection with the electrostatic dust-precipitator, thereby limiting the intensity to which the field can be raised under a given set of conditions.

My invention seeks to improve upon the producing of a charged spray.

It is an object of my invention to increase the charge that can be imparted to a spray of discrete particles.

It is a further object of my invention to provide apparatus for producing a charged liquid-spray in which the spray-droplets are highly charged substantially at the source of the spray, and the net spray charge is not thereafter decreased.

In accordance with preferred forms of my invention, I provide a construction which will introduce forces which will permit the spray-charging electrostatic field to be increased without introducing the objectionable discharge from the collected drops. In some forms of my invention, I arrange the electrode-means so that the collected drops face away from the oppositely-charged nozzle-device and spray. In still another form of my invention I drain off the collected liquid through a high-resistance piping.

Other objects, features, innovations, elements and combinations of my invention will be discernible from the following description which is to be taken in conjunction with the accompanying schematic drawings.

In the drawings, which are not to scale:

Figure 1 is a vertical sectional view of an embodiment of my invention;

Fig. 2 is a vertical sectional view of part of an electrical dust-precipitator embodying another form of my invention;

Fig. 3 is a view similar to Fig. 2, but of still another form of my invention;

Fig. 4 is a horizontal sectional view, taken substantially on the line IV—IV of Fig. 3;

Fig. 5 is a vertical sectional view of an electrical dust-precipitator embodying a further form of my invention;

Figs. 6 and 7 are a plan and a vertical sectional view, respectively, of an electrode utilizable in an application of my invention;

Fig. 8 is a plan view of another form of electrode;

Fig. 8A is a vertical sectional view of an electrical dust-precipitator embodying the electrode of Fig. 8;

Fig. 9 is a vertical sectional view of an electrical dust-precipitator embodying still another form of my invention;

Figs. 10 and 11 are sectional views, taken substantially on the lines X—X and XI—XI, respectively, of Fig. 9;

Fig. 12 is a vertical sectional view of a further form of my invention;

Fig. 13 is a view showing an apparatus, in accordance with my invention, for producing a charged spray;

Fig. 14 is an enlarged sectional view, taken substantially on the line XIV—XIV of Fig. 13; and

Fig. 15 is a curve showing the relationship of the charge put on a spray-liquid as a function of the voltage between a nozzle and associated insulated electrode.

A device for producing a highly-charged liquid-spray operating in accordance with the principles of my invention is shown in Figure 1. For convenience, the spray-producing nozzle-device has been shown as a metal pipe 2 having a conical metallic spray-discharge nozzle 4 which converts a liquid supplied under pressure to the pipe 2 into a conical spray 6 which so passes through a toroidal or ring-shaped electrode 8 that the visible outline of the spray clears the inner periphery of the electrode. The electrode 8 is relatively insulated from the spray-discharge nozzle 4 but arranged as closely as convenient to the extreme opening or point of the spray-discharge nozzle 4 from which the spray comes. The separation is usually determined by the magnitude of the voltage applied between the spray-discharge nozzle 4 and the electrode 8, and should be such that there is no danger of objectionable breakdown or arc-over. A source of electric power, indicated as a direct-current battery 10, has one end connected to the pipe 2 and the other to the electrode 8 for maintaining the nozzle-tip and the electrode 8 at opposite potential-polarities. Accordingly, the nozzle-tip is, in effect, an electrode which is charged oppositely from the electrode 8. Preferably, the whole spray-producing device, which includes the pipe 2 and nozzle 4, is grounded, as indicated at 12.

In the operation of equipment having only the parts thus far particularly described, there usually is an extremely fine mist along the outside of the spray, or other spray-liquid which reaches the electrode 8. Such liquid can accumulate on the electrode, forming large distinct drops thereon. If the electrostatic field between the spray-discharge nozzle 4 and electrode 8 is sufficiently great, the drops will be attracted to the inner side of the electrode and be deformed so as to point toward the charged spray 6. Since the drops are in contact with the electrode 8, they become charged with the same sign and consequently discharge in a manner for introducing charged matter of the same potential-polarity into the spray region, this potential-polarity being opposite to that originally imparted to the spray-droplets. Such an effect limits the charging potential to which the electrode 8 may be raised with respect to the nozzle or electrode 4.

This is illustrated in Fig. 15 in which the ordinates represent the net charge per cubic centimeter of spray-liquid and the abscissae the voltage or electromotive force between a nozzle-tip and a relatively insulated spray-charging electrode of a device along the lines of Fig. 1 having only such parts as electrodes. At first, the total charge on the spray after leaving the nozzle-tip increases as the voltage is increased. The voltage can be increased for increasing the space-charge of the spray, that is, the net spray charge, but a range is reached where the drops on the insulated electrode face toward the spray and are drawn into points discharging into the spray-

region. The net spray charge then levels off with greater voltages. A condition is ultimately reached, indicated at M, beyond which any further increase in the voltage increases the discharge from the drops more than it adds to the charge of the liquid coming from the nozzle-tip. The result is that the net or total charge in the spray is lowered with further increases in voltage beyond M. The maximum point, corresponding to M, is determined by the physical set-up of a particular apparatus, but, in general, the curve of Fig. 15 is found to be followed where a nozzle-tip and an electrode-means, or the equivalent, constitute the charged-spray-producing means. In accordance with my invention, means is provided which opposes or overcomes such drop-discharge effect, altering the curve of Fig. 15 so that the net spray charge still increases with increases in voltage beyond M.

To this end, in Fig. 1 I provide another ring-shaped electrode 14 which is closer to the electrode 8 than it is to the spray-discharge nozzle 4. By grounding the electrode 14, as indicated at 16, an electrostatic field is established between the electrodes 8 and 14, which also acts on the collected drops. The electrostatic forces which result from the reaction of a charged drop and the field between the electrodes 8 and 14 act on the drops but those forces are opposed by the forces which result from the reaction of the charged drop and the field between the electrode 8, on the one hand, and the combined nozzle 4 and spray 6 on the other hand. By creating an adequate field gradient at the electrode 8 directed toward the electrode 14, the drops are pulled to the outside of the electrode 8, become distorted into points, and electrically discharge toward the electrode 14 instead of toward the spray. Such drops are indicated at 18, five of them being arbitrarily shown in Fig. 1. With the connections shown, increasing the voltage between the spray-producing means, as one electrode, and the relatively insulated electrode 8 also increases that between the electrode 14 and the electrode 8. By making the electrode 14 larger than the electrode 8 and arranging it below the electrode 8, the discharge is in a direction away from the spray, so that it can not adversely affect the net charge on the spray.

In Fig. 2, I show the adaptation of my invention to an electrical dust-precipitator such as shown in the aforesaid Penney patent. A grounded circular metal gas-duct 20 includes therein an upstream dust-charging means or ionizer comprising a metal cylinder 22 concentric with the duct 20 and an insulated positively-charged ionizing wire 24 along its axis for producing ions. On the downstream side of this zone, any suitable metallic spray-producing means 25 is provided which is conductively connected to the duct 20 or to a negative terminal of a source of direct current. Associated with the spray-producing means 26 is an electrode-means comprising a ring-electrode 28 insulatedly supported within the duct 20 by an insulator 30 in suitable relation to the tip of the spray-producing means 26. The ring-electrode 28 is maintained at a high positive potential-polarity with respect to the spray-producing means 26 through an insulated conductor 32 passing through the gas-duct means, so that the spray 34 is charged. Any drops which collect on the electrode 28, by impingement or by electrostatic attraction, are made to discharge to the grounded duct 20 by

having the ring-electrode 28 of such size as to be closer to the duct than to the spray-producing means 26. Obviously that part of the duct 20 which faces, or is opposite from, the electrode 28 constitutes, in effect, an electrode that is insulated from the electrode 28, and one that functions in the embodiment of Fig. 2 in the same way as the electrode 14 functions in the embodiment of Fig. 1. The spray-charging voltage can be raised because the discharging drops which would otherwise reduce the net charge in the spray now discharge toward the gas-duct 20, away from the spray region.

Causing the drops to discharge toward the duct 20 has the further advantage of aiding the charging of the dust-particles in the part of the gas-stream passing between the duct 20 and the electrode 28, because the charging action of the pointed drops is the same as that of the ionizing wire 24, and such part of the gas-stream has not yet mingled with the charged spray.

Grounded field-affecting electrodes 36 are provided below the ring-electrode 28 for keeping down the space-charge within the spray after the spray has spread across the gas-duct. The nearest electrode 36 may be farther from the electrode 28 than the nearest point of the grounded gas-duct 20.

If desired, the grounded gas-duct of an electrical dust-precipitator, such as shown in Fig. 2, can be provided with a curved section acting as an electrode-means for providing the secondary electrostatic field extending to the insulated electrode. This embodiment is shown in Fig. 3 in which an ionizing wire 38 and associated electrode-means 40, within the metal gas-duct 42, provide a dust-charging means in an upstream zone in which gas-borne dust-particles are charged. The downstream precipitating zone comprises, briefly, any suitable grounded spray-producing means 44 and associated insulated electrode 46. A curved electrode-means 48 is provided as part of the gas-duct 42, the electrode means 48 being coaxial with the insulated electrode 46.

The dust-particles can be charged positively and the spray-drops negatively, or vice versa, as more fully explained in the aforesaid Penney patent. To indicate these alternatives, the apparatus of Fig. 2 shows positive ionization used for charging the gas-borne dust-particles, while the spray, itself, is charged negatively; whereas in Fig. 3 the potential-polarities are reversed so that the gas-borne dust-particles are negatively charged and the spray-droplets positively charged.

Fig. 5 shows a further embodiment in which the relatively insulated electrode 60 is formed with an outwardly flared conical skirt 62. Gravity can pull the mobile collected liquid on the electrode to the bottom of the downwardly extended skirt so that collected drops are farther removed from the electrical center of the spray 63 and the tip of the spray-producing means than they are from the duct 64. Consequently the spray-charging field and the field established between the electrode 60 and the charged spray exert a total force on the drops which is less than that resulting from the field between the bottom of the skirt 62 and the duct 64. Because the drops no longer discharge into the spray, a much greater charge can be given to the spray than would be possible if the relative strength of the forces exerted by the fields were reversed,

as is the case in the aforesaid Penney patent.

The area through which the gas passes between the relatively insulated electrode, such as 62 of Fig. 5, and the gas-duct can be increased by using electrodes such as shown in Figs. 6 through 8. In these embodiments, the relatively insulated electrode is provided with a series of prongs 67 as shown in Figs. 6 and 7, or with a downwardly extending scalloped skirt 63, as indicated in Fig. 8. The liquid collecting on the electrodes travels downwardly to a lowermost point because of gravitational force.

Any suitable construction of insulated electrode-means and any suitable arrangement of associated electrode-means having an opposite charge for producing the auxiliary secondary field can be used so long as the collected drops are allowed to discharge away from or are led away from the region of the spray. This region is that occupied by the spray until after it has mingled and electrically attracted the charged dust-particles. It is not possible to describe a precise boundary for the region of the spray but when the drops point away from this region generally they can discharge harmlessly into some other region so as not to interfere with the attraction between the charged spray-droplets and dust-particles. In the electrical precipitators shown in Figs. 1 to 5, this discharge of the liquid-drops is used to added advantage for increasing the total charge on the duct-particles.

In Fig. 9, I show still another form of electrical dust-precipitator which embodies the foregoing features of my invention, and, in addition, provides a different form of relatively insulated electrode-means for inductively charging the liquid of the spray as it comes from the spray-producing means. It has more special advantages in a laterally large gas-duct or for providing a charged spray in large quantities.

The dust-charging means in Figs. 9 to 11 comprises a plurality of spaced grounded relatively large tubular electrodes 70 between which relatively fine ionizing wires 72 are insulatedly supported. On the downstream side of this dust-charging zone, a dust-precipitating means is provided comprising a means for producing a charged-spray, the last means being indicated in its entirety by the reference numeral 74. The charged-spray-producing means 74 comprises any suitable equipment which emits a liquid-spray, and is shown as a metal pipe-member 76 provided with a plurality of spray-discharging metal nozzles 78 spaced along its length. The tips of the nozzles are kept at ground-potential by grounding the pipe 76 or conductively associating it with the grounded metal gas-duct 80. The spray from the nozzles 78 passes between a pair of spaced straight semicylindrical insulated electrodes 82 which are given a relatively high potential through insulated conductors 84 and any suitable electrical power source. The potential-polarity of the electrodes 82 and the ionizing wires 72 is the same, and is opposite to that of the electrodes 70 and nozzles 78.

Liquid drops collecting on the electrodes 82 are caused to discharge toward the grounded gas-duct 80 by having a lengthwise side of each electrode 82 sufficiently close to a side 86 of the gas-duct.

In Fig. 12, I have shown an embodiment similar to that of Figs. 9 to 11, except that the action of gravity in removing the discharging drops farther from the spray-charging region is increased. This is done by sloping the spaced elec-

trodes 99 which are equivalent to the electrodes 82 of Figs. 9 through 11. Such sloping permits the spacing between the lengthwise side of the electrodes and the corresponding sides of the gas-duct to be increased because the drops flow to the lowermost ends of the electrodes.

Figs. 13 and 14 show a further form of my invention, using spaced cylindrical elongated relatively insulated electrodes 100 between which a metal spray-producing means 102 establishes a spray. In this embodiment, the spray-producing means has been shown as pneumatic, comprising a grounded liquid-supply pipe-member 104 and an air-supply pipe-member 106 connected to a plurality of spray-nozzles 108, having outlet tips 110. Liquid flows centrally through each spray-nozzle through a passage 112. Air under pressure flows in a conical passage 114 which is around the passage 112 and is tapered to the outlet tip 110 for providing a spray which passes between the insulated electrodes 100.

The electrodes 100 are sloped and the lowermost end of each is provided with a small catch-basin 116 having a drain-opening to which a drain-pipe 118 is connected for draining off liquid collected on the electrode. The drain-pipe 118 is of some insulating material so as to provide a high-resistance path for the draining liquid which flows into a grounded container 120.

In embodiments utilizing a high-resistance drain, the collected liquid loses its charge by leakage, so that electrical discharges from distorted liquid drops on the electrodes are greatly minimized, or entirely eliminated. In embodiments which do not use a drain, collected liquid can fall from the relatively insulated electrode after they form large enough drops. This loss of collected liquid, which is desirable, is augmented in cases where the electrode, which provides the spray-charging electrostatic field, has a portion which slopes downwardly, as, for example, the skirted embodiments shown in Figs. 5 through 8, or the straight sloped electrode embodiments shown in Figs. 9 through 14; the latter, however, being the subject matter of my divisional application Serial No. 705,332, filed October 24, 1946.

The application of my invention to a vertical spray-charging electrode in a horizontal enclosure is obviously much more simple since all the collected liquid will usually drain to the bottom of the electrode. A discharging region or draining means can be provided for the drops just at that place.

Making certain assumptions, it can be shown that the minimum field gradient in volts per centimeter required for distorting a collected spherical drop, so that it becomes a point discharge, is given by the formula:

$$447 \sqrt{\frac{T}{a}}$$

where T is the surface tension of the liquid in dynes per centimeter and a the radius of the drop in centimeters. However, this formula is subject to wide variation because of the difficulty of accurately setting up the phenomena of charging a spray.

I have found that the use of substantially straight electrodes, either cylindrical or semicylindrical, such as shown in Figs. 9 through 14, or other cross section, in equipment for charging a spray, is a considerable improvement over ring-type electrodes, particularly if used with spray-nozzles of a pneumatic type along the lines shown, for example, in Fig. 14.

Using a pneumatic nozzle, identified as type JPNF, set-up No. 12, described in a catalogue identified as "Spraying System Nozzles and Related Products," catalogue No. 22 of the Spraying System Company, Chicago, Illinois, an improvement of as much as 200% and above in the charge given to the spray was obtained over that obtained with the specific non-pneumatic type of spray-nozzle and ring electrode specifically described in the aforesaid Penney patent. In one embodiment of my invention, the top surfaces of the straight electrodes were substantially on the same level as the extreme tip of a spray-discharge nozzle, being not more than $\frac{1}{4}$ " below it. The pair of electrodes were parallel and spaced about $1\frac{1}{4}$ " apart, with a spray-tip mid-way between them. By sloping the electrodes about 20° to the horizontal, instead of keeping them horizontal, very effective draining of collected liquid was provided, permitting a much higher voltage between the spray-nozzle and the electrodes before objectionable drop discharges occurred.

The diameter of the straight electrodes and their spacing affect the size of the collected drops and the amount of charge that can be given to the spray. With a constant voltage across the tubular electrodes and the spray-discharge nozzle, increasing the separation of the electrodes affects the field-gradient at the nozzle tip and at the surface of the electrodes. The factors affecting the field-distribution are, however, so varied and complex that an exact analysis is hardly practical. Various grounded surfaces around the nozzle and the relatively insulated electrodes, as separate electrode means, obviously will change the field lines. Even the character and angle of the spray have their effect. However, experiments indicated that for a particular apparatus there appears to be an optimum spacing for straight electrodes at which a maximum charge is imparted to the spray.

While I have described my invention in forms which are now preferred and have shown the novel spray-charging equipment portion of my invention applied to an electrical dust-precipitator, using water as the spray-liquid, my invention is not so limited either to use with water or in an electrical dust-precipitator. Any liquid or substance consisting of, or capable of being broken into, discrete particles and which has some electricity-conductive or semi-conductive qualities, so that its drops or particles can be charged, can be used for providing the charged-spray. It is also obvious that the principles of my invention can be embodied in forms and modifications other than those herein described.

I claim as my invention:

1. A precipitator device of a class described comprising, in combination, a duct-means for a gas-stream, charging-means for charging gas-borne dust-particles, a liquid-spraying device on the downstream side of said charging-means, an electrode in said duct-means insulated from said liquid-spraying device and arranged in proximity to the path for the spray from said liquid-spraying device, said electrode-means being spaced from said duct-means so that a portion of the gas-stream can flow therebetween, said electrode having a skirt-part sloping outwardly away from said liquid-spraying device.

2. A precipitator device of a class described comprising, in combination, a duct-means for a vertical gas-stream, charging-means for charging gas-borne dust-particles, means for providing a

charged spray on the downstream side of said charging-means, comprising relatively insulated oppositely-chargeable spray-means and electrode-means, the electrode-means being so constructed and arranged that the spray from said spray-means passes in proximity thereto and then spreads across said duct-means, said electrode-means comprising a ring-shaped member provided with a depending outwardly directed extension which terminates short of said duct-means at a place where the spray is not spread across the duct-means.

3. Apparatus for providing a utilizable charged spray, comprising a nozzle-means, a ring-shaped electrode insulated and spaced from said nozzle-means so that a spray from the nozzle-means passes through it, the space between said electrode and nozzle-means being otherwise substantially free, and an additional electrode insulated from and spaced from said ring-shaped electrode, one of said electrodes having an irregular contour on the side toward the other electrode, said electrodes being separated a lesser distance than the spacing between said nozzle-means and said ring-shaped electrode.

4. A precipitator device of a class described for utilizable gas-cleaning of a gas-stream, comprising the combination with a gas duct for a substantially vertical gas-stream, having therein dust-charging means for charging gas-borne dust-particles; of means for subsequently removing charged dust particles from the gas-stream, comprising charged-spray-producing means including an electrode and a spraying device with a substantially free space vertically therebetween, and potential-applying means for establishing an electrostatic field in said space, with a field-gradient at said electrode and at said spraying device, said charged-spray-producing means providing a charged liquid-spray on the downstream side of said dust-charging means, said electrode being so disposed with respect to the spraying device that the charged liquid-spray can pass near said electrode with spray-liquid collecting thereon, forming liquid-drops, the spacing, configuration and potentials being such that the tendency of the field gradient at said electrode in a direction toward said space to cause liquid-drops on said electrode to be deformed and to discharge toward said space, is overcome, whereby the liquid-drops cannot significantly affect the net charge on the dust-precipitating liquid-spray.

5. A precipitator device of a class described for cleaning a gas-stream, comprising a gas duct for a substantially vertical gas-stream, having therein charging-means for charging gas-borne dust-particles, means including a spraying device for providing a charged liquid-spray in a region of the downstream side of said charging-means, said means including a first electrode relatively insulated from said spraying device, there being a substantially free space in the path for gas flow between said first electrode and spraying device, said gas duct including an electrode-means insulated from and spaced from said first electrode on the side thereof away from said region, and potential-applying means for oppositely charging the first electrode with respect to said spraying device and with respect to said electrode-means, the spacing, configuration and potentials of said spraying device, said first electrode and said electrode-means being such that the tendency of the field gradient at said first electrode in a direction toward said space to cause liquid on said first electrode to be deformed and to discharge toward

said region, is overbalanced by the action on such liquid of the field gradient at said first electrode in a direction toward said electrode-means.

6. Means for producing a charged liquid spray, said means including an electrode and a spraying device spaced therefrom for producing a charged spray in a spray-region associated therewith, the electrode being so disposed with respect to the spraying device that spray liquid can collect on the electrode and form liquid-drops, potential-applying means to provide a field-gradient at said electrode in a direction toward said spray-region and a field-gradient in a direction away from said spray-region, the spacing, configuration and potential of said spray device, electrode and potential-applying means being such that the tendency of the first said field-gradient to cause liquid on said electrode to be deformed and to discharge to said spray-region, is overcome.

7. A precipitator device of a class described for utilizable gas-cleaning of a gas-stream, comprising the combination with a gas duct having therein dust-charging means for charging gas-borne dust-particles, of means for subsequently removing charged dust-particles from the gas-stream in the gas duct, comprising means including a ring-like first electrode and a spraying device having a substantially free space therebetween in the direction for gas flow, the electrode being so disposed with respect to the spraying device that spray liquid can collect on the electrode, forming liquid-drops, and a second electrode between said first electrode and a part of said gas duct, said second electrode being arranged so that said first electrode is closer to said second electrode than said first electrode is to the rest of said gas-duct and to said spraying device, said first electrode being insulated and said spraying device, gas duct and second electrode being grounded.

8. A precipitator device of a class described for utilizable gas-cleaning of a gas-stream, comprising the combination with a gas duct having therein dust-charging means for charging gas-borne dust-particles, of means for subsequently removing charged dust-particles from the gas-stream in the gas duct, comprising electrode means including a ring-like portion and a spraying device having a substantially free space therebetween in the direction for gas flow, the ring-like portion being so disposed with respect to the spraying device that spray liquid can collect on the ring-like portion, forming liquid-drops, and a plurality of distinct field-affecting members at different places in the space between said ring-like portion and gas duct.

9. Means for producing a charged spray, comprising a spraying means for establishing a spray originating at a point, an electrode insulated from said point, said electrode having a ring-like portion about said point and a plurality of spaced distinct portions extending outwardly in directions toward a surface charged oppositely from said electrode and away from said point.

10. Means for producing a charged spray, comprising a spraying means for establishing a spray originating at a point, an electrode insulated from said point, having a ring-like portion about said point, said electrode having a skirt portion extending outwardly in a direction toward a surface charged oppositely from said electrode and away from said point.

11. An invention including that defined in claim 10 but characterized further by the edge of

said skirt portion having a plurality of distinct points.

12. A method of increasing the net charge of a charged spray established between a point from which a spray emits and a pronged electrode entirely below said point for forming an electrostatic field therewith, which method comprises the step of gravitationally outwardly forcing all of the liquid collecting on said electrode to positions removed from the region of the charged spray, the liquid flowing outwardly on said prongs.

13. A method of increasing the net charge of a charged spray established between a point from which a spray emits and an electrode near said point for forming an electrostatic field therewith for charging the spray, which method comprises the step of electrostatically deforming drops collected on said electrode into points discharging in a direction toward a surface charged oppositely from said electrode and away from the region of the charged spray.

14. A method of increasing the net charge of a charged spray established between a point from which a spray emits and an electrode near said point for forming an electrostatic field therewith for charging the spray, which method comprises the step of establishing field gradients at said electrode, with the field gradient at said electrode in a direction toward said spray being less than the field gradient at said electrode in a direction away from said spray and toward a surface charged oppositely from said electrode.

15. A precipitator device of a class described for cleaning a gas-stream, comprising the combination of an upstanding gas duct, and dust-collecting means for providing a dust-collecting charged liquid-spray extending downstream in a region in said gas duct, said means including a spraying device, a first electrode insulatedly spaced downstream from said spraying device, and a voltage source connected between said first electrode and said spraying device; of a second electrode insulatedly spaced from and facing a side of said first electrode, said side facing away from said region, and potential-applying means for oppositely charging said second electrode with respect to said first electrode, the spacings, configuration and potentials in said dust-collecting means providing field gradients along said side of the first electrode which are more intense than the field gradients along the side of the first electrode facing toward said region.

16. Means for producing a charged liquid-spray into a spray-region, comprising a spray-producing device, a pair of relatively insulated electrodes spaced along the spray-region and electrically oppositely chargeable whereby to charge the spray-droplets, and voltage-supplying means to provide a voltage between said electrodes so that a first of them has a potential-polarity opposite to that of the second electrode and to that imparted to the spray-droplets, said first electrode being located so that spray liquid can collect thereon, said voltage-supplying means supplying sufficient voltage to provide a tendency ordinarily to deform a plurality of drops collected on said first electrode into a plurality of points which electrically discharge toward the spray, the points being at different places along said first electrode, in combination with a third electrode insulatedly spaced from said first electrode on the side away from said spray-region, and means comprising voltage supplying means to provide an electric field between said first electrode and the said third elec-

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trode, with said third electrode having the same potential-polarity as said second electrode, the spacings, configurations and potentials of said electrodes and voltage-supplying means being such that the field-gradient at said first electrode in a direction toward said third electrode substantially overcomes the aforesaid tendency to deform said drops.

17. Means for producing a charged spray, comprising a spraying means for establishing a flaring spray in a spray-region, an electrode below and insulatedly spaced from said spraying means, means for electrically charging said electrode so as to provide a potential thereon for an electric field to charge said spray, the field providing a first field gradient along a first side of said electrode which side faces toward the spray, an electrode means comprising a metallic member spaced from a second side of said electrode, the second side facing away from said spray-region, and means for electrically charging said metallic member so as to provide a potential thereon which is opposite from that on said electrode, the spacing, configuration and potentials of said electrode and metallic member being such that the field-gradient at said first side of said electrode is less than that at said second side of said electrode.

18. A method of increasing the net charge of a spray between a point from which spray emits and a lower electrode near said point for forming an electric field therewith for charging the spray, which method comprises the step of establishing a second electric field along a side of said electrode which faces away from the charged spray with the field gradient at the electrode due to the second field being greater than the field gradient at the electrode due to the first said field.

19. Means as defined in claim 17 but characterized by said electrode comprising a ring and a metallic extension extending from said ring in a direction toward said metallic member.

20. Means for producing a charged liquid-spray, comprising a spraying device and an electrode insulated therefrom, said electrode being spaced from said spraying device to provide a spray-space therebetween, said electrode having a first side facing in a direction toward said spray-space and a second side facing in a second direction away from said spray-space, a second electrode spaced from and insulated from the first said electrode, said second electrode facing

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said second side of the first said electrode, the distance between said electrodes being less than that between said spraying device and first said electrode.

21. Means for producing a charged liquid-spray, comprising a spraying device and an electrode insulated therefrom, said electrode being spaced from said spraying device to provide a spray-space therebetween, said electrode having a first side facing in a direction toward said spray-space and a second side facing in a second direction away from said spray-space, voltage-supplying means to provide a voltage between said spraying device and electrode providing a first field-gradient at said first side, a second electrode spaced from and insulated from the first said electrode, and facing said second side of the first said electrode, and voltage-supplying means to provide a voltage between said electrode providing a second field-gradient at said second side, with the second field-gradient being greater than the first field-gradient.

22. Apparatus for providing a utilizable charged spray, comprising a nozzle-means, an electrode-ring insulated and spaced from said nozzle-means so that a spray from said nozzle-means passes through it, the space between said electrode-ring and nozzle-means being otherwise substantially free and providing a spray-region, and an additional electrode insulated from and spaced from said electrode-ring on a side facing away from said spray-region, said electrode and electrode-ring being separated a lesser distance than the spacing between said nozzle-means and said ring-shaped electrode, and means to place said nozzle-means and additional electrode at a common potential, and said electrode-ring at an opposite potential relative thereto.

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