

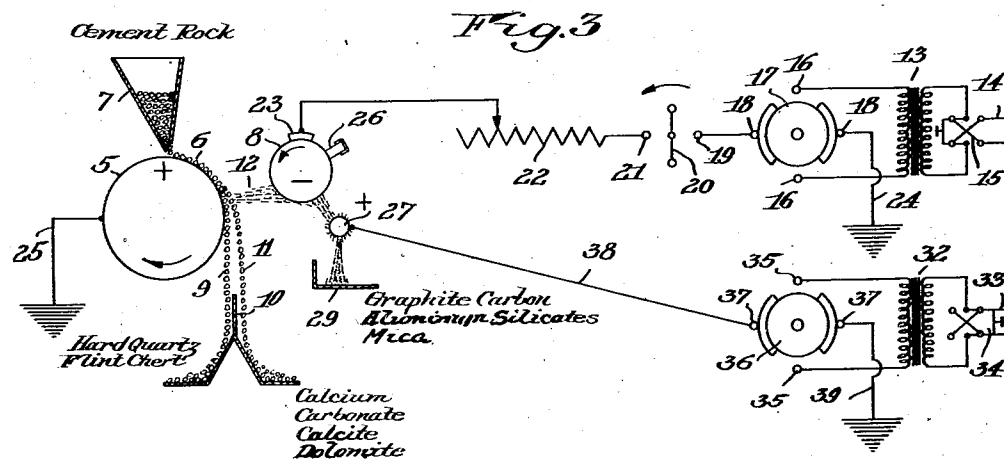
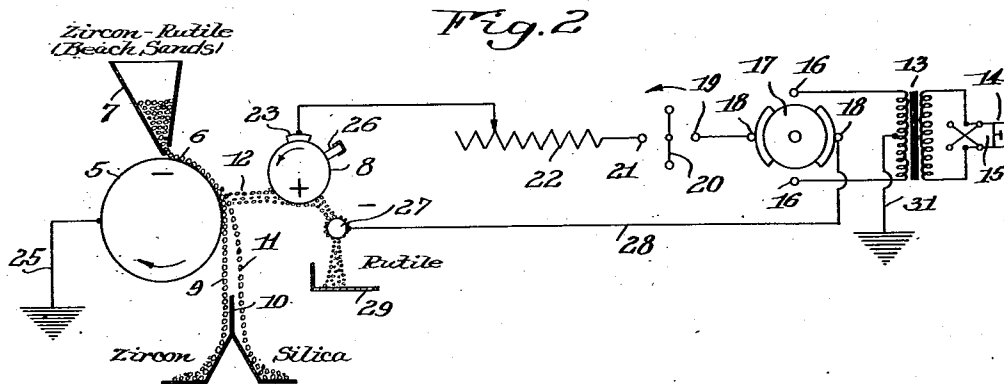
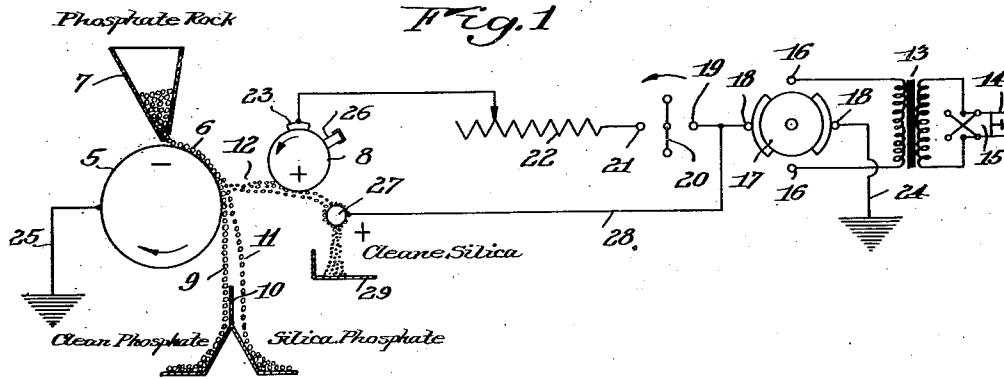
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2,357,658

ELECTROSTATIC SEPARATION PROCESS AND APPARATUS

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ELECTROSTATIC SEPARATION PROCESS
AND APPARATUS

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This invention relates to electrostatic separation processes and apparatus of the type in which a finely divided mixture of materials to be separated is passed through an electrostatic field between a pair of rotary, cylindrical electrodes connected across a high voltage source, the mixture being fed over or close to one of the electrodes, referred to as the conveying electrode, and acted upon by the other or charged electrode. The invention relates, more particularly, to the control and disposition of portions of the mixture by a combination of electrostatic fields and to a combination and arrangement of the several electrodes of such apparatus.

In the use of methods of the above type for separating many ores, salts and other materials, there is a tendency for the particles of finer size to be attracted by and to stick to the surface of the rotating charged electrode. In addition, as in the separation of food products, the mixtures frequently include fine pieces of wire or other metal parts, shells, fibers, wood slivers and the like, which are strongly attracted to the charged electrode, and if all such particles are not continuously wiped or brushed off the revolving electrode surface, to keep it clean and smooth, the particles tend to function as pin point discharge electrodes and discharge an electrostatic spray which tends to stick particles of the mixture, and especially the poorer conductors, to the surface of the other or conveying electrode. These particles accumulate on the electrodes and reduce the space or gap between them so that sparks are discharged from one electrode to the other, thereby lowering their separating efficiency.

Furthermore, such finer particles of the materials to be separated, and of such foreign matter, get under the wiper or brush elements, commonly provided for brushing the electrodes, and cause abrasion and rapid wear.

One object of the invention is to provide an improved and more efficient process for accomplishing the electrostatic separation of particles of different kinds from a finely divided mixture thereof and, more specifically, to provide such a process through improvement in the cleaning and operating efficiency of the separating electrodes.

Another object of the invention is to supply such a process with provision for deflecting or removing the stream of fine particles from the revolving charged electrode before they can bring about any of the disadvantageous results described above.

Another object is the provision of an improved method of the character described, by which such particles are eliminated from the surface of the charged electrode before it engages the cleaning wiper or brush, so as to reduce the abrasion and wear of the wiper and the labor and expense of its frequent replacement.

Another object is to provide an improved and more efficient combination and arrangement of electrode means and energizing circuits for carrying out and accomplishing the foregoing methods and purposes.

To these and other ends the invention resides in certain improvements and combinations of method steps and parts, all as will be hereinafter more fully described, the novel features being pointed out in the claims at the end of the specification.

In the drawing:

Fig. 1 is a diagrammatic view of an apparatus for carrying out and embodying the present invention;

Fig. 2 is a similar view but with a modified arrangement of the electrostatic charges, and

Fig. 3 is a similar view showing a further modification.

The prior type of electrostatic separation method and apparatus referred to, as above, are disclosed, for example, in the patents to H. B. Johnson, No. 2,135,716, dated Nov. 8, 1938, and 2,258,767, dated October 14, 1941, both comprising a rotary, cylindrical electrode by which the mixture to be separated is received and conveyed through the electrostatic field existing in the gap between such conveying electrode and charged electrode located at a suitable distance from it. The charged electrodes of these patents are provided with scraper or wiper elements for removing the fine particles of separated ingredient or foreign materials attracted and adhering to their charged revolving surfaces. In the patented constructions, these wiper elements provide the sole means for maintaining the electrode surfaces in the desired clean, smooth and polished condition, and in such arrangements the wiper elements are subject to considerable abrasion and wear by the adhering particles, and require frequent replacement.

Many attempts have been made with various designs of chutes, skirts, shields and the like, in an effort to prevent or reduce the accumulation of contaminating particles on the charging electrode, without wholly satisfactory results. We have found, however, that this problem may be satisfactorily solved and the desired purposes suc-

cessfully accomplished by an application of electrostatic principles carried out by a new combination and arrangement of electrode members.

Referring to the drawing for a more particular description of our process, in connection with a preferred apparatus for carrying it out, there is shown at 5 a rotary, cylindrical metal electrode to which the mixture 6 to be separated is supplied through a feed hopper 7. Suitably spaced therefrom is another revolving, cylindrical metal electrode 8, the electrodes 5 and 8 being connected across a suitable high voltage source, to induce an electrostatic field in the gap between them, as well understood in the art. The mixture referred to in this instance, by way of illustration, is finely divided phosphate rock and as this mixture is conveyed through the gap by the electrode 5, the bulk of one of its ingredient materials, clean phosphate, which is least responsive to influence by the electrostatic field, falls substantially vertically by gravity, as indicated at 9, at one side of a partition or divider 10. The other ingredient, silica phosphate, which is repelled by the charged conveying electrode 5, falls mainly on the opposite side of the divider 10, as shown at 11, thus separating the two ingredients. Finer particles of the ingredients (in this instance clean silica) and of any foreign matters in the mixture respond more actively to the attraction of the positively charged electrode 8 and approach or adhere to it, as indicated at 12.

The separating electrodes 5 and 8 are given charges of opposite polarity by connection across any known or suitable source of high voltage current, preferably comprising a transformer 13, the primary of which is connected across the usual power line 14, with an interposed double throw, reversing switch 15. The secondary of the transformer is connected to the opposite terminals 16 of a mechanical rectifier 17, of any known or suitable variety, and one of the other pair of opposite terminals 18 is connected to one terminal 19 of a known or suitable circuit interrupting device, preferably comprising a rotating bar 20, the ends of which are arranged to alternately and intermittently contact with the terminal 19 and an opposite terminal 21, the bar 20 being rotated by a suitable motor means at a speed predetermined to close the circuit, at a desired frequency, this circuit arrangement being substantially as disclosed in the patent to H. B. Johnson, No. 2,197,864, dated April 23, 1940. Terminal 21 is connected through an adjustable resistance 22 with a brush 23 in contact with the electrode 8. The other terminal 18 of the rectifier is connected, as at 24, with the ground, and electrode 5 is also grounded, as at 25.

It is apparent from the above description of the circuit connections that the high voltage alternating current of the transformer secondary is converted by the rectifier to uni-directional current of substantially constant, high voltage which is interrupted and transmitted intermittently through the regulating resistance to electrode 8, while electrode 5 is at ground potential. Reversing switch 15 may be employed, however, to reverse the polarities of these electrodes.

In the above described apparatus, the charged electrode 8 is provided, as usual, with a wiper 26 comprising a strip of felt, or other suitable material, extending longitudinally of and bearing against the electrode surface to wipe or brush from it any particles of material adhering thereto.

It is a known characteristic of the operation of apparatus such as described above that the

finer particles of material 12 tend to be pulled into proximity with and collected upon the surface of electrode 8, where they form points for electrostatic discharge which is sprayed over the particles to be separated, causing them to stick to electrode 5 and thus adversely affect the separating process. The particles adhering to electrode 8, furthermore, tend to work under the wiper 26 and subject it to rapid abrasion and wear.

Our invention comprises an electrical process for deflecting the particles 12 and removing them from the electrode 8, so as to improve the operating efficiency of the separating electrodes and protect the wiper 26. Our process comprises the use of a third or auxiliary electrode 27 of copper or other known suitable electrode material, which may be either stationary, or rotated by any suitable means. Electrode 27 is located preferably below and in spaced relation with electrode 8 but nearer to it than to electrode 5, as shown, so as to lie opposite the portion of the circumference of electrode 8 between the field of separation and the wiper 26. Electrode 27 is connected, as at 28, with the high voltage terminal 18 of the rectifier and between it and the interrupter 20, so that the electrode is supplied with a high potential charge of the same polarity as electrode 8. The charge of electrode 27, however, is substantially constant, relative to the intermittent charge on electrode 8 and is preferably maintained at a potential higher than that of electrode 8 by, say, from 500 to 3000 volts, by suitable adjustment of the resistance 22 for lowering the potential of electrode 8.

The diameter of the auxiliary electrode 27 is preferably from one fourth to one third of the diameter of the charged electrode 8, and electrode 27 is preferably separated from electrode 8 by a space or gap which may range from three-fourths to one and one-half inches. In the adaptation of the invention shown in Fig. 1, the difference in potential between electrodes 5 and 8 may range from 5000 to 25,000 volts, while the voltage impressed upon electrode 27 may be increased over that of electrode 8 by from 500 to 3000 volts, such factors varying, of course, with the particular materials to be separated, their condition as to the presence of surface coatings and temperature, the volume to be handled, the presence of foreign matter, and the like, as well understood in the art.

In the operation of our process in accordance with the arrangement shown in Fig. 1, the substantially constant, high potential charge on electrode 27 deflects and removes from electrode 8 the bulk of the fine particles 12, assisted by the intermittent interruption of the charge of lower potential on electrode 8. This causes such particles to proceed to electrode 27 upon which they collect, eventually falling by gravity into a suitable receptacle, as indicated at 29. In this way, electrode 8 is cleaned by an electrostatic action and relieved of the particles 12, so as to eliminate the discharge spraying and sticking of particles on electrode 5 and the sparking across the gap between the separating electrodes. In addition, the particles are removed from the electrode before reaching wiper 26, so as to largely relieve it of the abrasion and wear to which it would otherwise be subjected.

It has been found that 90 to 95% of all the particles normally adhering to the charged electrode 8 are readily removed to the auxiliary electrode 27 before coming into contact with the

wiper 26 and that the separating efficiency of the electrodes 5 and 8 is increased from 10 to 15% by combination with the electrode 27. Furthermore, the cost of maintenance and replacement of a felt electrode wiper 26 is reduced by 50% or more.

The adaptation of the invention comprising the circuit arrangements and induced voltage charges shown in Fig. 1 is applicable to the separation of various materials, being particularly adapted, for example, for the separation of ores, rock, coal, and materials such as cement, or phosphate rock, or a matrix containing varying amounts of pyroelectric minerals, such as silica which has a tendency, when heated in drying, to hold a static charge much longer than most other materials. Thus the finely divided, clean silica, which tends to collect upon the charged electrode 8, is released therefrom to the auxiliary electrode in a particularly sharp and well defined manner. It will be noted, also, that the polarity of each of the electrodes may be reversed by reversing the position of switch 15, to adapt the invention to the handling of materials such as described in the patents to H. B. Johnson, Nos. 2,246,253, 2,197,864 and 2,197,865.

Our invention is applicable, in fact, to the separation of a wide variety of materials, in connection with some of which it has been found desirable to reverse the polarity of the auxiliary electrode 27 relative to the polarity of the separating electrodes, as shown in Fig. 2. Thus in separating a zircon-rutile mixture found in certain beach sands, the zircon particles are least affected by the electrostatic field and are depressed behind the divider plate 10. The charge on the silica particles is influenced to such an extent that they are repelled from the negative conveyor electrode 5 so as to be separated from the zircon and fall on the opposite side of the divider, while the finer rutile particles are largely pulled to the positively charged electrode 8 and thence to the negatively charged auxiliary electrode 27, so as to clean the electrode 8. The reversal of the polarity of electrode 27, relative to the separating electrodes 5 and 8, is obtained by connecting it with the contact 18 of the rectifier located opposite the contact connected to the electrode 8, the center of the transformer secondary, in this case, being grounded as at 31. In this arrangement the charge on electrode 27 is preferably of the same potential as the charge of opposite polarity on electrode 8 except as the latter may be reduced by the variable resistance 22. In this arrangement also the charges may all be reversed in polarity by reversing the position of the line switch 15.

The provisions included in the above adaptations for independently controlling the potential and polarity of the auxiliary electrode may be carried still further by energizing the auxiliary electrode from a separate source, as indicated in Fig. 3, to increase the range of adjustment for the separation of different materials. In this adaptation the auxiliary electrode is charged by a separate circuit comprising a transformer 32 connected with the power line, as at 33, through a reversing switch 34. The transformer secondary is connected with a pair of opposite contacts 35 of a mechanical rectifier 36, as described above, having its other contacts 37 connected, respectively, with the auxiliary electrode 27, as at 38, and with the ground as at 39. By means of this separate circuit, the auxiliary electrode may be supplied with a charge of any desired

potential and frequency of cycle, relative to the charge on electrode 8, as well as with a charge of either polarity.

The modified arrangement shown in Fig. 3 is adapted in the present instance to the separation of cement rock into hard quartz and flint chert on one side of divider 10, and calcium carbonate, calcite and dolomite on the other side. In this separation the polarities of the separating electrodes 5 and 8 are reversed as referred to in the above patents to H. B. Johnson, as by reversing the switch 15. The contained particles of graphite, carbon, aluminum silicates and mica are pulled over to the negatively charged electrode 8 from which they are removed by a positive charge on the auxiliary electrode 27 and separately collected as in the other modifications above.

While our process and apparatus have been described herein in connection with the details of particular embodiments, it is to be understood that such disclosure is intended by way of illustration and not in any limiting sense, as it is contemplated that various changes in the arrangement and construction of the apparatus parts and process steps will readily occur to those skilled in the art, within the spirit of the invention and the scope of the appended claims.

We claim:

1. The process of separating particles of different kinds from a finely divided mixture thereof comprising the steps of passing said mixture through an electrostatic field produced between a pair of oppositely and intermittently charged electrodes for variably attracting particles of different kinds from one of said electrodes toward the other thereof and effecting separation thereof, producing a second electrostatic field between said other electrode and an auxiliary electrode having a substantially constant charge for attracting and removing from said other electrode particles of one of said kinds tending to collect and form electrostatic discharge points thereon, and separately collecting said different kinds of particles.

2. The process of separating particles of different kinds from a finely divided mixture thereof comprising the steps of passing said mixture through an electrostatic field produced between a pair of oppositely charged electrodes for variably attracting particles of different kinds from one of said electrodes toward the other thereof and effecting separation thereof, producing a second electrostatic field between said other electrode and an auxiliary electrode having a charge of higher potential than said other electrode and thereby attracting and removing from said other electrode particles of one of said kinds tending to collect and form electrostatic discharge points thereon, and separately collecting said different kinds of particles.

3. The process for separating finely divided particles of different kinds from a finely divided mixture thereof comprising the steps of passing said mixture through an electrostatic field produced between a pair of oppositely charged electrodes for variably attracting particles of different kinds from one of said electrodes toward the other thereof and effecting separation thereof, producing a second electrostatic field between said other electrode and an auxiliary electrode having a charge of opposite polarity from that of said other electrode for attracting and removing from said other electrode particles of one of said kinds tending to collect and form electrostatic discharge points thereon, and separately collecting said different kinds of particles.

4. The process of separating particles of different kinds from a finely divided mixture thereof comprising the steps of passing said mixture through an electrostatic field produced between a pair of oppositely and intermittently charged electrodes for variably attracting particles of different kinds from one of said electrodes toward the other thereof and effecting separation thereof, producing a second electrostatic field between said other electrode and an auxiliary electrode having a substantially constant charge of higher potential than said other electrode for attracting and removing from said other electrode particles of one of said kinds tending to collect and form electrostatic discharge points thereon, and separately collecting said different kinds of particles.

5. The process of separating particles of different kinds from a finely divided mixture thereof comprising the steps of passing said mixture through an electrostatic field produced between a pair of oppositely and intermittently charged electrodes for variably attracting particles of different kinds from one of said electrodes toward the other thereof and effecting separation thereof, producing a second electrostatic field between said other electrode and an auxiliary electrode having a substantially constant charge of opposite polarity to that of said other electrode for attracting and removing from said other electrode particles of one of said kinds tending to collect and form electrostatic discharge points thereon, and separately collecting said different kinds of particles.

6. In an electrostatic separator for separating particles of different kinds from a finely divided mixture thereof, the combination of a source of high potential current, a pair of rotatable, cylindrical electrodes disposed in insulated, spaced relation with each other and connected across said current source, one of said electrodes being arranged to receive and convey said mixture through the electrostatic field between said electrodes, an auxiliary electrode disposed in insulated, spaced relation with the electrodes of said pair and nearer to the other electrode of said pair than to said conveying electrode, and means for charging said auxiliary electrode to produce a second electrostatic field between said other electrode and said auxiliary electrode for attracting and removing from said other electrode particles tending to collect and form electrostatic discharge points thereon.

7. In an electrostatic separator for separating particles of different kinds from a finely divided mixture thereof, the combination of a pair of rotatable, cylindrical electrodes disposed in insulated, spaced relation with each other, means for inducing on one of said electrodes an intermittent, high potential charge relative to the other electrode of said pair, said other electrode being arranged to receive and convey said mixture through the electrostatic field between said electrodes, an auxiliary electrode disposed in insulated, spaced relation with the electrodes of said pair and nearer the first mentioned electrode of said pair than to said conveying electrode, and means for inducing on said auxiliary electrode a substantially constant charge for producing a second electrostatic field between the first mentioned electrode of said pair and said auxiliary electrode for attracting and removing from said first mentioned electrode particles tending to collect and form electrostatic discharge points thereon.

8. In an electrostatic separator for separating

particles of different kinds from a finely divided mixture thereof, the combination of a source of high potential current, a pair of rotatable, cylindrical electrodes disposed in insulated, spaced relation with each other and connected across said current source, one of said electrodes being arranged to receive and convey said mixture through the electrostatic field between said electrodes, an auxiliary electrode disposed in insulated, spaced relation with the electrodes of said pair and nearer to the other electrode of said pair than to said conveying electrode, and means for inducing on said auxiliary electrode a charge of higher potential than that of said other electrode of said pair for producing a second electrostatic field between said other electrode for attracting and removing from said other electrode particles tending to collect and form electrostatic discharge points thereon.

9. In an electrostatic separator for separating particles of different kinds from a finely divided mixture thereof, the combination of a pair of rotatable, cylindrical electrodes disposed in insulated, spaced relation with each other, means for inducing on one of said electrodes an intermittent, high potential charge relative to the other electrode of said pair, said other electrode being arranged to receive and convey said mixture through the electrostatic field between said electrodes, an auxiliary electrode disposed in insulated, spaced relation with the electrodes of said pair and nearer the first mentioned electrode of said pair than to said conveying electrode, and means for inducing on said auxiliary electrode a substantially constant charge of higher potential than that of said other electrode for producing a second electrostatic field between the first mentioned electrode of said pair and said auxiliary electrode for attracting and removing from said first mentioned electrode particles tending to collect and form electrostatic discharge points thereon.

10. In an electrostatic separator for separating particles of different kinds from a finely divided mixture thereof, the combination of a pair of rotatable, cylindrical electrodes disposed in insulated, spaced relation with each other, means for inducing on one of said electrodes an intermittent, high potential charge relative to the other electrode of said pair, said other electrode being arranged to receive and convey said mixture through the electrostatic field between said electrodes, an auxiliary electrode disposed in insulated, spaced relation with the electrodes of said pair and nearer the first mentioned electrode of said pair than to said conveying electrode, and means for inducing on said auxiliary electrode a substantially constant charge of the same polarity but higher potential than that of said other electrode for producing a second electrostatic field between the first mentioned electrode of said pair and said auxiliary electrode for attracting and removing from said first mentioned electrode particles tending to collect and form electrostatic discharge points thereon.

11. In an electrostatic separator for separating particles of different kinds from a finely divided mixture thereof, the combination of a source of high potential current, a pair of rotatable, cylindrical electrodes disposed in insulated, spaced relation with each other and connected across said current source, one of said electrodes being arranged to receive and convey said mixture through the electrostatic field between said electrodes, an auxiliary electrode disposed in insu-

lated, spaced relation with the electrodes of said pair and nearer to the other electrode of said pair than to said conveying electrode, and means for inducing on said auxiliary electrode a charge of opposite polarity from that of said other electrode for producing a second electrostatic field between said other electrode and said auxiliary electrode for attracting and removing from said other electrode particles tending to form electrostatic discharge points thereon.

12. In an electrostatic separator for separating particles of different kinds from a finely divided mixture thereof, the combination of a source of high potential current, a pair of rotatable, cylindrical electrodes disposed in insulated, spaced relation with each other and connected across said current source, one of said electrodes being arranged to receive and convey said mixture through the electrostatic field between said electrodes, means for varying and interrupting the difference of potential between said electrodes, an auxiliary electrode disposed in insulated, spaced relation with the electrodes of said pair and nearer to the other electrode of said pair than to said conveying electrode, and means independent of said source for charging said auxiliary electrode to produce a second and variable electrostatic field between said other electrode and said auxiliary electrode for attracting and

removing from said other electrode particles tending to form electrostatic discharge points thereon.

13. In an electrostatic separator for separating particles of different kinds from a finely divided mixture thereof, the combination of a source of high potential current, a pair of rotatable, cylindrical electrodes disposed in insulated, spaced relation with each other and connected across said current source, means for feeding said mixture to one of said electrodes of said pair for conveyance thereby through the electrostatic field between said electrodes, a wiper arranged to engage and clean the surface of the other of said electrodes, an auxiliary electrode disposed in insulated, spaced relation with the electrodes of said pair and nearer to said other electrode than to said conveying electrode, and means for inducing on said auxiliary electrode a charge of higher potential than that of said other electrode for producing a second electrostatic field between said other electrode and said auxiliary electrode for attracting and removing from said other electrode particles tending to form electrostatic discharge points thereon and abrade said wiper.

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