H. A. WENTWORTH.

APPARATUS FOR ELECTRICAL SEPARATION.

APPLICATION FILED MAY 5, 1909.

960,470. Patented June 7, 1910.

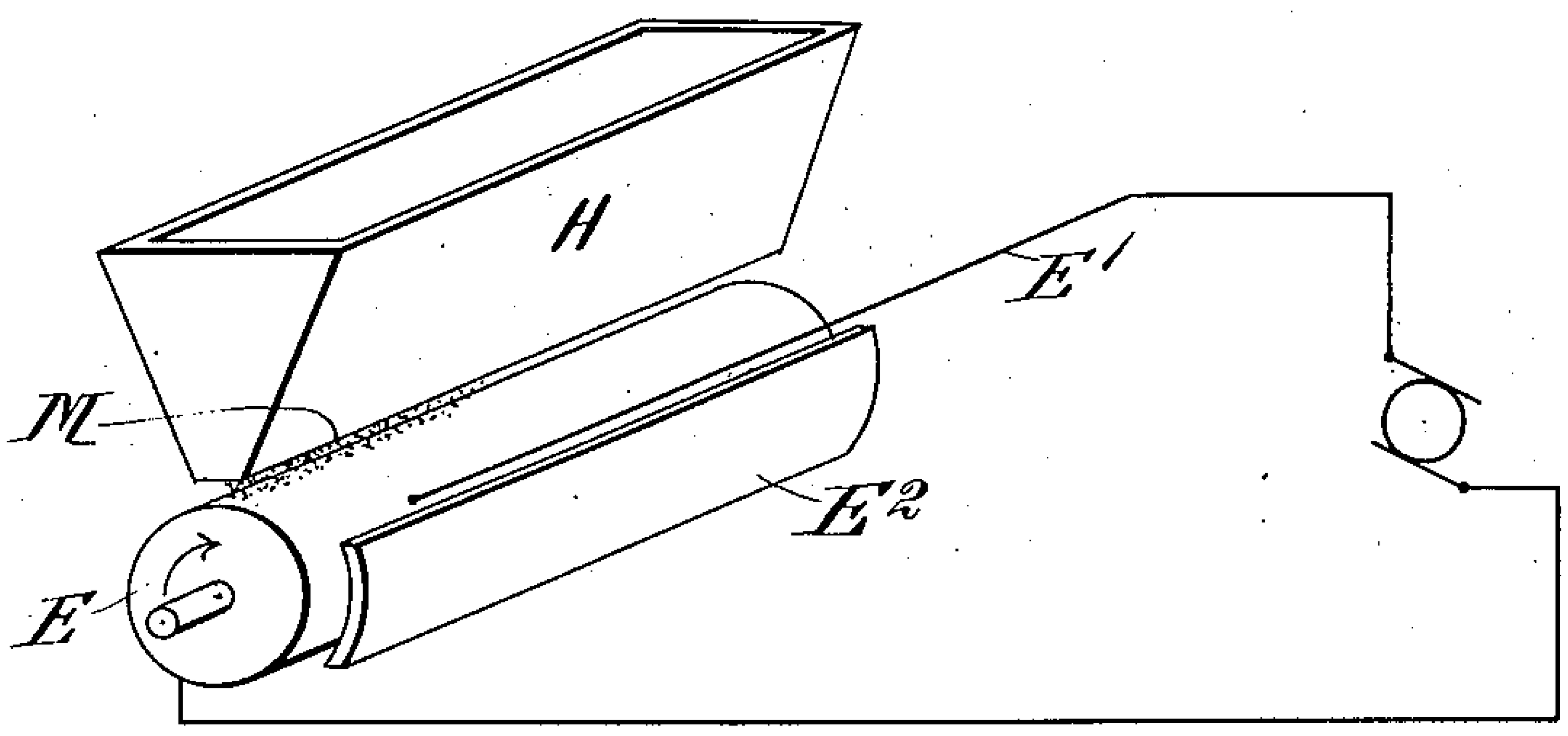

Fig. 1.

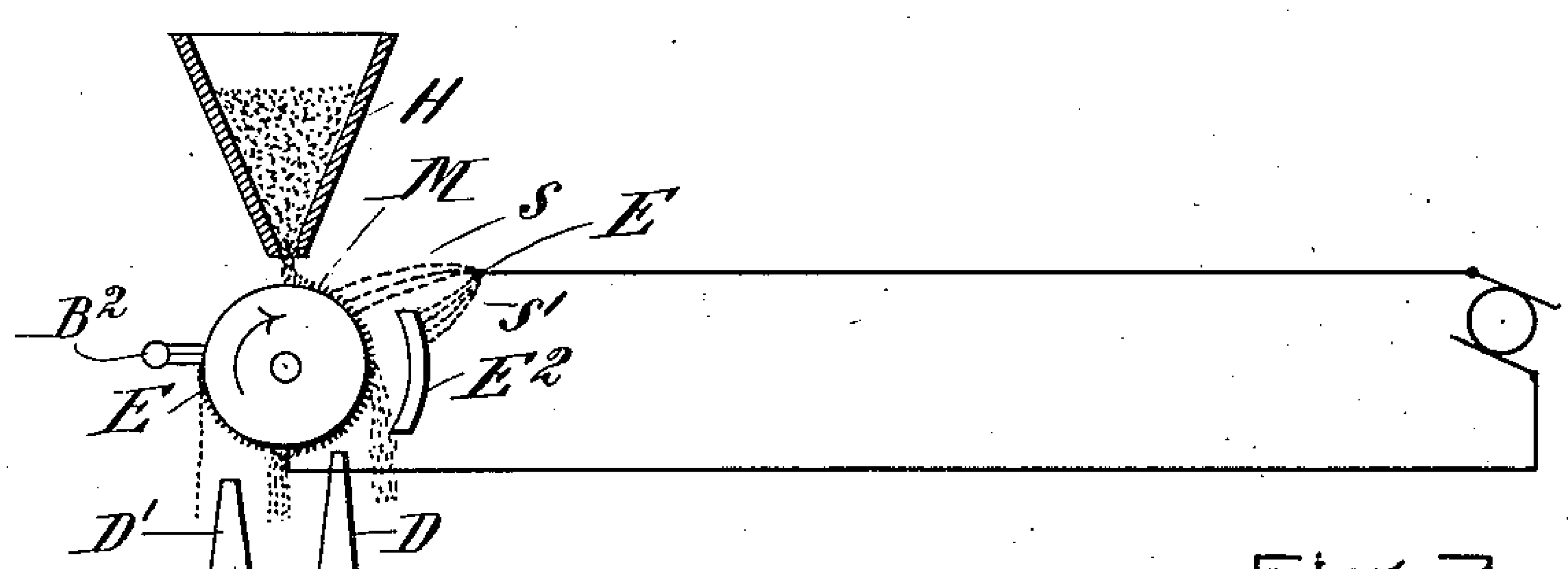

Fig. 2.

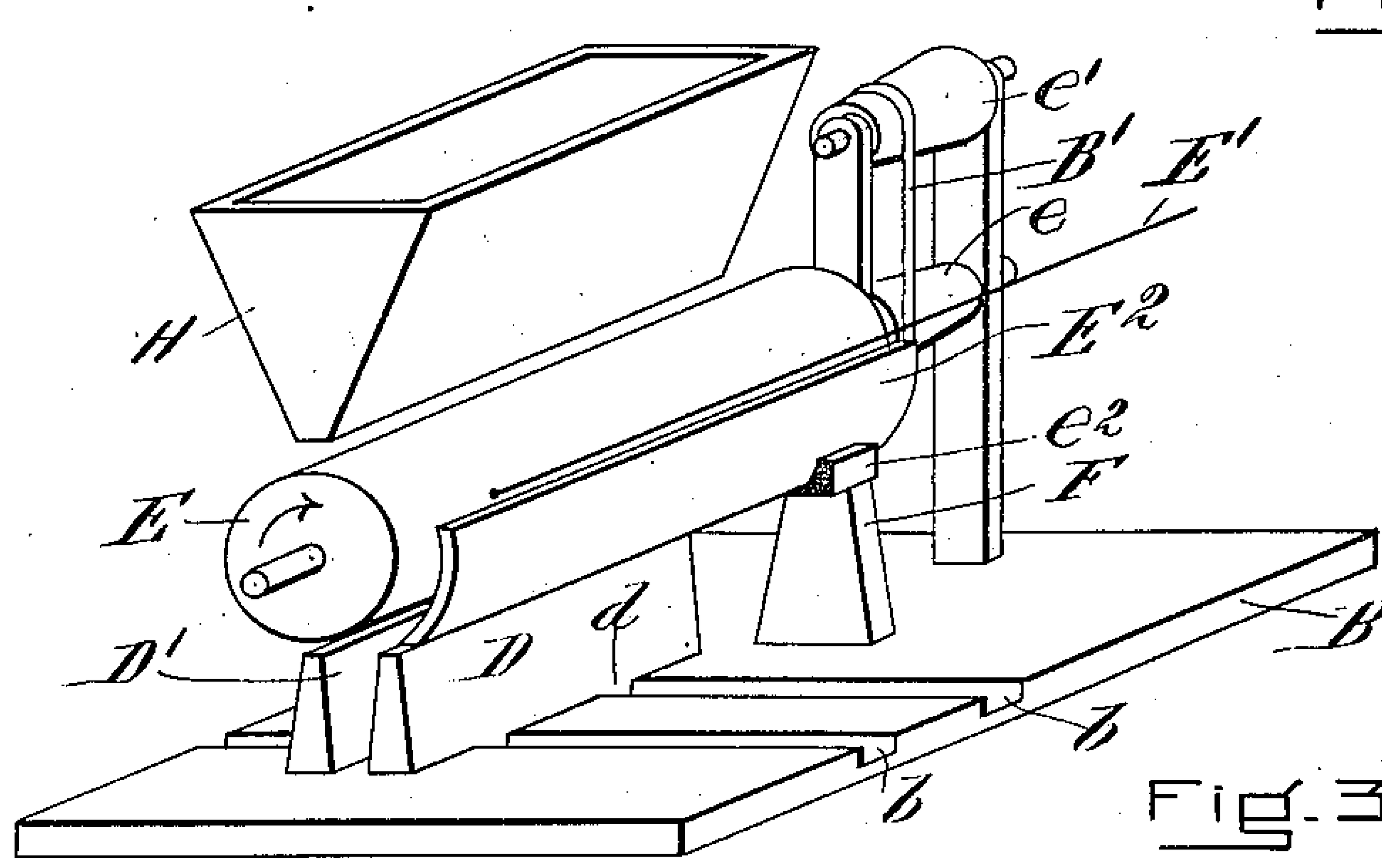

Fig. 3.

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APPARATUS FOR ELECTRICAL SEPARATION.

960,470. Specification of Letters Patent. Patented June 7, 1910.

Application filed May 5, 1909. Serial No. 494,189.

To all whom it may concern:

Be it known that I, HENRY AZOR WENTWORTH, a citizen of the United States, and resident of Newton, in the county of Middlesex and State of Massachusetts, have invented new and useful Improvements in Apparatus for Electrical Separation, of which the following is a specification.

My invention relates to the art of electrical separation, concentration or classification of the ingredients of mixtures of solid comminuted matter, whereof the particles are differentiated as to their electrical conductivity, and consists in an improved apparatus by which the separation of one class of particles from particles of another class may be accomplished.

The method characteristic of the intended operation of the herein described apparatus is set forth and claimed in an application for United States patent heretofore filed by me on December 21, 1907, Serial Number 407,566.

In the patent granted to me July 16, 1907, No. 859,988, there is set forth and described a method of electrical separation wherein the deposition on and retention by certain particles of a mass under treatment, of localized charges conveyed thereto by an ionized jet, performs a distinctly useful function in effecting the separation of one class of particles from another. The conditions described in the said patent are such that the stress of the electrostatic field is sufficiently powerful to cause a repulsion of the more highly conductive particles of the mass from the surface of the electrode on which they rest, in spite of the opposed tendency due to the ionized gaseous jet; the retention of particles of lower conductivity and the repulsion of particles of higher conductivity are nearly coincident in both place and time. The relative conductivity of mixed particles may be due to high surface conductivity, or to conductivity through the body of the particle, or both.

My invention herein described is, at least in the preferred mode of separation, characterized by the production of electrical conditions under which within a portion of the electrostatic field the repellent effect due to electrostatic stress is, with respect to conductive material, counteracted or controlled by an opposed electrical effort due to the maintenance of a spray or jet discharge from one electrode to another, whereas in another portion of the field the qualification of the effect of electrostatic stress by spray discharge is suspended or eliminated leaving the electrostatic repellent effort free to disengage conductive particles from the surface of the electrode in contact with which they rest.

The said method which I have invented is properly described as a specific mode of the more broadly claimed process described in the Blake and Morscher Patent No. 668,791, dated February 26, 1901, wherein the patentees state their object to be, in part at least, to charge all particles of a mixture with electricity of one sign, and then bring them into contact with an electrode surface charged with electricity of the opposite sign, and establishing a static field in opposition to another electrode, there to repel the conductive particles, while the non-conductors (relatively speaking) are not repelled. By the preliminary treatment all the particles are similarly charged, and thus the time required for an inferior conductor to lose this charge and acquire that imparted by the active, or repelling, electrode, is increased over what would be the time required were all the particles in neutral condition when applied to the repelling electrode. My method involves also the application to all particles of a mixture of a charge opposite in sign to the charge of a subsequently operative repelling electrode surface, and, later the subjection of the pre-charged mixture to the repelling action due to a charged electrode in a field of substantially pure static stress, the said field being produced by the pressure of a statically charged electrode opposite to the material-carrying electrode, as in the Blake and Morscher patent; the difference, however, being principally in the mode with which I administer the preliminary charge, and secondarily in the mode with which I apply static charge to the surface of an electrode opposed to that of the material-carrying electrode. By the maintenance of such conditions as these, I have been enabled to make satisfactory separations by virtue of differentiations in conductivity with an electrostatic field of moderate potential as contrasted with the field employed in many instances in the operation of the process described in the Wynne Patent No. 805,694, dated November 20, 1905, and moreover, I have produced good separation under the conditions named as characteristic of this invention, with substantially continuous potential.

In the drawings hereto annexed which illustrate diagrammatically an apparatus suited to the performance of my method,—Figure 1 is a view, partly in perspective, of the elementary members of such an apparatus; Fig. 2 is a cross sectional view diagrammatically illustrating the electrical conditions which exist in the performance of my apparatus; and Fig. 3 shows an apparatus, in perspective, with portions of a suitable frame and accessories.

Referring to the drawings, E is a material-receiving electrode which is preferably a cylinder with a good conducting surface mounted to rotate upon its axis in the direction indicated by the arrow.

H represents a hopper or equivalent apparatus for feeding the material M in a properly distributed stream to the surface of electrode E. The opposed electrode E′ is shown as a fine wire stretched parallel to the surface of the electrode E or to the axis thereof. Other forms of spray discharging electrodes are well known; see for instance Osborne's Patent No. 287,957, dated November 6, 1883. The proportions of the electrode E′ are therefore such that when the two electrodes E, E′ are connected respectively to the terminals of a suitable generator the electrostatic field between the two electrodes is qualified and modified by the formation of a silent spray discharge proceeding from the electrode E′. This spray discharge is convective and consists probably of particles of air electrified by contact with the electrode E′ and in part also of electrical "corpuscles" or, as they are nowadays termed, "ions" which shoot across from one electrode to the other. Probably, also, the air particles or molecules travel from one electrode to the other at a much lower rate than the discharged ions; whatever may be the correct scientific explanation or analysis of the phenomenon, it is sufficiently well known qualitatively as a spray discharge. The effect of a spray discharge is that of a leakage involving a transfer from the electrode E′ to the electrode E of a portion of its electrical charge and this spray modifies the rate of drop in potential from point to point between the electrodes and distributes the drop in potential in varying rates in the region affected. When the particles of mixed material M are carried into this field they are sprayed by the spray discharge and receive electric charges similar in sign to that of the electrode E′ and retain these charges with a persistance which is, roughly speaking, inversely in proportion to the rate of surface leakage or other leakage such as bodily conduction through the particles themselves; these charges and the particles which carry them are attracted to the electrode E. At the same time the electrostatic charge on the electrode E exerts its repellent effort which is responded to by the particles with promptness and emphasis which are, roughly speaking, in proportion to their electro-conductivity. Thus, all the particles in contact with the electrode E are in a region of conflict between two opposed energetic efforts and their behavior under this condition depends upon the varying degrees of their respective conductivities. In the case of good insulators whereon the surface or other leakage is very slow, the deposition of electric charge like in sign to that on the electrode E′, causes such particles to adhere closely to the electrode E in the manner described in my Patent No. 859,998 aforesaid. In the case of a particle of good conductive material, as, for instance, a particle of metal, the charge transferred by the spray is quickly conveyed to and neutralized by the opposite charge of the electrode E and the repellent effort manifests itself; but the instant that such a metallic particle leaves the electrode and is free from its contact influence, the spray recharges the particle which, under the new condition, is surrounded by air and is not in actual contact with the electrode E and consequently the particle is thrust back into contact with the electrode E there to lose its recently acquired charge and go through the same operation again. This behavior of metallic particles under the complex conditions of electrostatic stress, contact with a metallic electrode such as E, and spray discharge from the opposite electrode, is admirably demonstrated by observing the contact of fine particles of copper conveyed through the field qualified by spray discharge. Though the potential difference between the electrodes may be so moderate, that the copper particles do not actually leave the electrode with which they are in contact, they demonstrate the persistent repellent effort by squirming and hopping on the surface; the whole mass of copper particles seems alive. In the case of particles of distinctly non-conductive character as, for instance, fine quartz sand, under the same electrical conditions the particles appear inert or as if glued to the electrode surface. The demonstration may be modified in respect to the conductive character of the particles employed, and as the conductivity diminishes in degree, the activity of the particles themselves becomes less and less manifest to the eye of the observer; the repelling charge, or potential, of the surface remaining the same. As the spray discharge is continuous or substantially so, the effect on the particles in the spray-affected region is to give each particle, whether a good or a poor conductor, a persistent charge opposite in sign to the charge on the electrode E.

In the apparatus shown in the drawings, I first pass the mixed material M through that portion of the electrostatic field which is characterized as above described by directionally opposed tendencies and thus cause the relatively non-conductive particles to adhere closely to the electrode E while the better conductors which repeatedly manifest the repelling tendency but are as repeatedly restrained, are held either in contact with or in close proximity to the same electrode surface. I then convey the mass of material out of the spray-affected region, and preferably into a portion of the electrostatic field which, relatively speaking, is characterized by pure electrostatic stress unqualified by spray discharge, thus leaving the repellent effort (which existed previously, in another region, under restraint) free to manifest itself without restraint upon those particles conductively responsive thereto. I effect this by providing an electrode E^2, which also serves as a shield or screen between the electrodes E and E′. This screen-electrode is charged with electricity of the same sign as that of the spraying electrode E′, and serves not only as a static-stress producer, to effect repulsion of particles by its action in conjunction with the electrode E, but also as a shield to prevent the spray discharge from the electrode E′ from continuing to bathe the surface of E and the particles thereon. The electrode E^2 receives the spray from E′ on its back, and is thus charged, so that no other source of charge need be connected with the electrode E^2, provided it be made of such material, or have such a surface, as will conduct the charge received from E′ over the surface of E^2 and to the face thereof which is presented to the electrode E, and provided also that the electrode E^2 be suitably insulated from the ground and from other parts of the machine. A metal screen will serve the double function of screen to catch the spray discharge and of electrode to produce a static field and assist functionally in effecting a repulsion of particles from the opposite electrode E. A less active conductor than metal may be employed, but a degree of conductivity high as compared with the insulators or dielectrics, is necessary to the effective production and maintenance of the static field between E and E^2. By preference, also, I construct this screen E^2 so that it presents a relatively broad surface (as compared with the electrode E′) in parallelism to the surface of the electrode E immediately opposed thereto. The spray which proceeds from the electrode E′ is interrupted by the screen E^2 which, so to speak, casts an electrical shadow upon the electrode E. The condition of the entire field is illustrated in Fig. 2 where *s* is that portion of the spray which is playing uninterruptedly upon the surface of the electrode E while the portion *s′* is intercepted by the screen E^2. Between the screen E^2 and the electrode E the electrostatic field is characterized by substantially pure stress. Moreover, as the screen E^2 is of conducting material, or at all events, has a conductive surface and is insulated at its supports, the charge transferred by the spray portions *s′* flows over the surface of the screen on all sides thereof and raises the potential of the screen approximately to the potential of the electrode E′. As the screen E^2 is nearer to the electrode E than is the electrode E′, the field between E^2 and E is correspondingly more intense than would be the case if the screen E^2 were as distant from the electrode E as is the electrode E′.

The particles of the material M pass from the region of spray *s* into the screened region. The poor conductors retain the spray-deposited charge and remain therefore in close adherence to the electrode E, while the better conductors, being relieved from the restraining influence of the spray, transfer the spray-applied charge to the electrode surface and respond at once to the repellent effort (previously felt by such particles but counteracted by the spray charge) and fly from the electrode E to be received and collected in some suitable receptacle. The screen electrode E^2 thus, in association with the electrode E, exerts a repellent effort sufficiently powerful to disengage the better conductors from the surface of the electrode E. The operation of that portion of the described apparatus which consists of the opposed faces of electrodes E and E^2, is the same in substance and effect as that of the opposed electrodes shown in the Blake and Morscher patent, aforesaid, or the Dolbear Patent No. 685,508, dated October 29, 1901.

The poor conductors are conveyed out of the electro-static field produced as aforesaid and may thereafter be removed either by mechanical or electrical means and collected in another receptacle.

The gist of the process above described rests in the different rates of leakage of charge from particles on the material-receiving surface to the surface. In the spray-effected region the spray-charge is showered upon all the particles of the mixture, and the conductivity of some of these may be so perfect that they deliver their spray-derived charges to the material-receiving surface instantaneously, so that while in the spray-affected region they repeatedly leave the surface or rise on it, only to be recharged by the spray and thrust back. Such particles, as soon as the conveying surface removes them from the spray-affected region, will respond promptly to the electro-static repellent effort and be emphatically discharged from the mixture. Other particles, less conductive, will require a longer time for surrender of the spray-deposited charge to the conveying surface, and will be carried thereby beyond the region where the high conductors were repelled. Just as soon as this second class of particles loses the spray-deposited charges by leakage to the conveying surface, the attractive force is eliminated, and the counter repelling effort of the electrostatic field asserts itself, and though some of these particles may seem to fall from the electrode as if impelled by gravity alone, yet the presence even of a feeble electrostatic repellent effort provides the initial liberating effect; the particles are freed electrostatically from contact with the surface and association with close-clinging particles of very low conductivity. There is no portion of an electrode such as E whereon there is no charge, while the apparatus is electrically excited. The electrode E may be grounded, but this will not alter the fact that it is charged at all points of its surface, the density of field being greatest at the region nearest the electrode E′ (and E^2) and least on the side away from these opposed electrodes.

The behavior of a mass of differentiated particles is indicated in Fig. 2, where dividers D and D′ are shown to define different regions of liberation or discharge of particles from the electrode E. Very good conductors are repelled from the region affected by the screen E^2 and show a trajectory which visibly demonstrates the electrostatic repulsion, and the coaction of directionally divergent forces, namely, the electrostatic repulsion and gravity. These particles fall between the screen E^2 and divider D.

Less conductive particles, delivering their spray-deposited charges more slowly to the electrode E, cling thereto until their charges are effectually neutralized. When these charges are neutralized, the counter charge creeps from the electrode E to the particles, which are thereupon repelled. These particles are shown as leaving the electrode between the dividers D and D′. As, in the illustration given by the drawings, this second class of conductors happens to leave the electrode E from a region where the surface thereof is nearly horizontal, these particles appear merely to fall by gravity; the liberation of the particles from the surface and from the other ingredients of the mixture is, however, initiated and assisted by electrostatic repulsion, exerted in the direction of gravitational pull, so that the path or trajectory is substantially the same as it would be were the particles liberated by gravity alone.

The persistently clinging particles of poor conductivity will, in practice, be removed from the electrode E by a brush, as B^2, or by other effective means.

The progressive liberation of particles from the electrode surface, in the manner above described, is timed according to the rate at which the spray-deposited charge is delivered by each class of particles to the electrode; therefore, in order to insure the proper physical separation of the several classes, the rate of conveyance through the different portions of the field will properly be adjusted so that the difference in discharge time as between two sets of particles will correspond to the time required to move the conveying surface from one point of particle-liberation to a point well removed therefrom, and yet be not so rapid as to convey particles destined to liberation at one selected region into the next region. Thus, it will be found desirable to rotate the electrode E at different speeds for different material mixtures, or to shift the positions of dividers, as D, D′; or to provide for both these variations in adjustment of the apparatus.

Referring to Fig. 3, the barrier E^2 is shown as provided with insulating blocks, e^2, which should be provided as E^2 is made of conductive material or has a conductive surface. These blocks e^2 rest on the frame F, (which is shown at one end only of the apparatus, in Fig. 3, the frame at the other end being omitted). Variations in rotation of the electrode E may be secured by the cone pulleys e and e' and belt B′. The dividers D, D′, may be mounted, as here shown, on a base B, grooved at b; the lugs d, d' on the dividers fitting and sliding in the grooves b for purposes of adjustment of the dividers.

What I claim and desire to secure by Letters Patent is:—

1. In an electrical separator, a material-receiving electrode, means to deliver comminuted material thereto, an opposite spray-discharging electrode, an insulated electro-conductive shield between the spray-discharging electrode and the surface of the material-receiving electrode, to protect the latter from direct action of the spray, the delivering means being so disposed as to expose the material to the direct action of the spray in the passage of said material to the shielded surface of the material-receiving electrode, and the shield being so disposed as to produce in opposition to the shielded surface of the material-receiving electrode, a material-repelling static field, and means to collect separately the separated material.

2. In an electrical separator, a conveyer electrode, means to deliver comminuted material thereto, an adjacent spray discharging electrode, and an insulated electro-conductive shield, so disposed in relation to the two electrodes as to intercept further lodgment of the spray upon material affected by the spray earlier in the conveyance of the material, and so as to produce, in opposition to the surface of the conveyer electrode, a material-repelling static field, and means to collect separately the separated material.

Signed by me at Boston, Massachusetts this 4th day of May 1909.

HENRY AZOR WENTWORTH.

Witnesses:
ODEN ROBERTS,
CHARLES D. WOODBERRY.