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PROCESS OF ELECTRICAL SEPARATION.

APPLICATION FILED JAN. 11, 1908.

1,116,951. **Patented Nov. 10, 1914.**

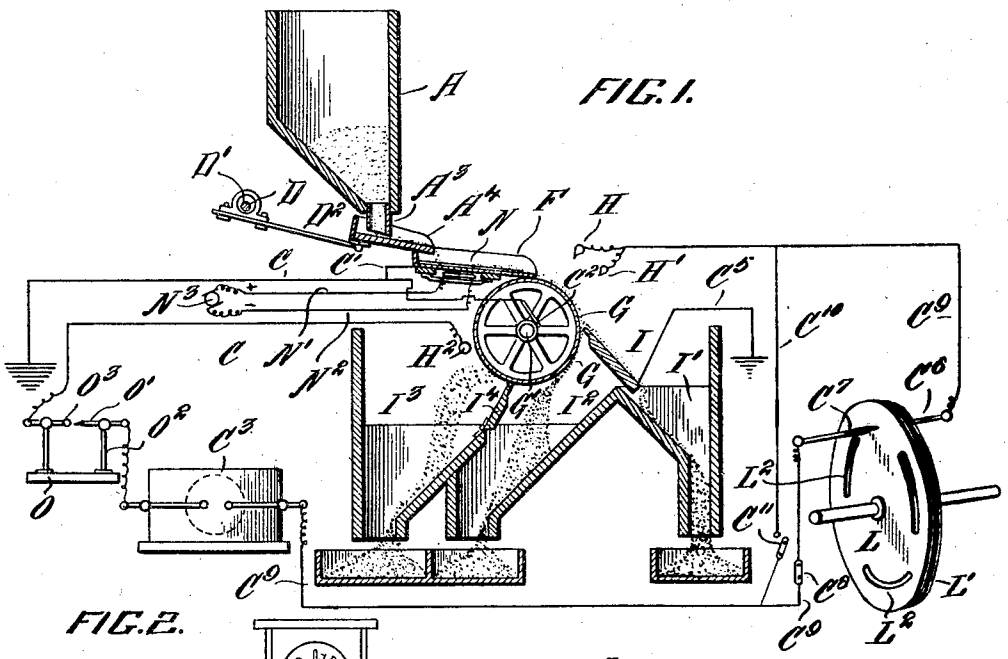


FIG. 1.

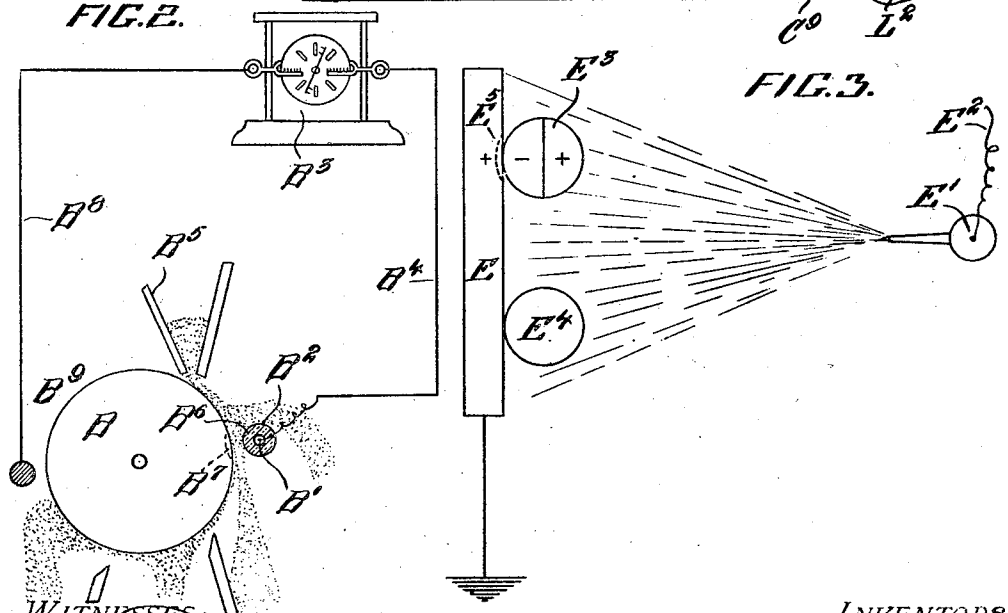


FIG. 2.

FIG. 3.

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PROCESS OF ELECTRICAL SEPARATION.

1,116,951. Specification of Letters Patent. Patented Nov. 10, 1914.

Continuation of application Serial No. 225,852, filed September 24, 1904. This application filed January 11, 1908. Serial No. 410,397.

To all whom it may concern:

Be it known that we, HENRY M. SUTTON, WALTER L. STEELE, and EDWIN G. STEELE, citizens of the United States, residing at Dallas, county of Dallas, and State of Texas, have invented certain new and useful Improvements in Processes of Electrical Separation, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to a process of electrostatic separation, and particularly to the charging of particles electrically to affect their different capacities of receiving such charge.

The invention has for an object to provide an improved process for separating a comminuted mass of particles of different dielectric capacities by exposing them to the action of a convective current or charge of electricity delivered directly upon them, whereby some of the particles become polarized and by which a constant difference of potential is created and maintained between these particles and a separating electrode causing them to adhere to it by reason of such polarization, and for separately collecting those particles that are unaffected, or affected in a different degree by the action of the convectively delivered charge.

Other and further objects and advantages of the invention will be hereinafter set forth and the novel features defined by the appended claims.

In the drawings:—Figure 1 is a diagram illustrating one form of apparatus for carrying out this process; Fig. 2 is a similar view of another form of apparatus for the same purpose; and Fig. 3 is a diagram illustrating the electrical action involved in this process.

Like letters refer to like parts in the several views of the drawing.

The form of apparatus shown in Fig. 1 for carrying out this process is substantially described and claimed in our pending application Serial Number 225,852, filed September 24, 1904, and comprises a continuation thereof embodying the form thereof where a continuous and pulsating convective charge or current is used, but the process can be carried out by other apparatus than that there disclosed, as shown by the accompanying drawings.

In Fig. 1, the letter A designates a hopper which is mounted in any desired manner, for instance, upon a frame constructed in accordance with the requirements of the machine. The material to be separated is fed from the lower portion of the hopper through the spout A^3 to the shaker pan A^4 which is adapted to be vibrated by the eccentric strap D^2 mounted upon the eccentric D′ on the shaft D. The vibratory motion feeds the material upon the spreader tray F from which it is delivered to the separating electrode or roller G. This roller may be constructed of metal or good conducting material, and both it and the spreader tray F are electrically connected to the ground by means of the line C so that they are incapable of retaining a charge of electricity which may be imparted to them. This connection may be any desired means, for instance, the wire C′ from the tray to the wiper C^2 bearing upon the shaft G′ of the roller G. Adjacent to the separating electrode are one or more thin metallic rods H each provided with a series of metallic points H′ directed toward the surface of the separating electrode by which a convective flow of current is maintained from the rods. Any other desired means may be used for producing such a current at the charging point. The charging means is connected to one pole of the electrostatic generator C^3, or to any other source of power capable of supplying static electricity, and the current conducted therefrom either through the line C^{10} to provide a continuous or constant charge of one polarity, or through the line C^9 having an interrupter disposed therein. In order that either of these lines may be used a switch C^{11} is provided in the line C^{10}, and a similar switch C^8 in the line C^9. This line is provided at opposite sides of the interrupter with pointed terminals C^6 adapted to discharge through the slots L^2 in the interrupter when these slots are brought into alinement with said terminals. This interrupter may comprise the disks L and L′ each similarly slotted, and the adjustment of these slots relative to each other will vary their area and the consequent duration of the charge.

The material to be separated is fed upon the roller electrode and in passing the charging points receives therefrom a charge by convection from the opposing electrode, and a dielectric hysteretic impedance or lag

of charge is set up in certain particles of the mass, while others remain unaffected. These latter particles drop upon the division plate I by centrifugal force due to the motion of the roller as it revolves in the direction of said plate from which they are discharged into the chute I'. The particles which have small dielectric hysteretic impedance are drawn closer to the face of the roller and they pass above the division plate and drop into the chute I^2, while those which have the greatest impedance remain adhering to the roller and are carried past the adjustable plate I^4 and discharged into the chute I^3. This disposition of the remaining material adhering to the roller may be facilitated by electrical means, preferably, a charged rod H^2 disposed at the back of the roller and connected by the line C^4 with the opposite side of the generator C^3 to that which supplies the charging means. To effect a continuous or constant charge on the rod H^2 and to regulate the charge, a regulator O is inserted in the line C^4 and provided with a pointed discharge terminal O' adjustable in its post O^2 relative to a rounded terminal O^3 opposite thereto. This regulator determines the amount of charge supplied to the particles and the amount of current flowing therethrough proportionately determines the degree of supply at the point because circuit is established from the points through the separating electrode and releasing rod to the regulator. The necessary amount of current may thus be governed relative to the material to be separated. In order that the division plate I shall not retain the electrical charge it is preferably formed of proper conducting material and grounded by means of the line C^5. This plate forms a shield for determining the extent of the surface of the roller electrode to be exposed to the charge, while the grounded feed tray F performs a similar function at the top of the roller. It has been found desirable to heat the tray for the purpose of supplying heated material to the charging electrode which causes any residual charge thereon to be dissipated and to render such material more susceptible to a charge which is imparted thereto while heated and by conduction heats the separating electrode facilitating the dissipation of the charge therefrom. One means of accomplishing this heating comprises the heater N connected by lines N' and N^2 with any source of power, as at N^3 for that purpose.

In the form of apparatus illustrated in Fig. 2, B designates the roller or separating electrode and B' the charging electrode which is inclosed in a suitable dielectric envelop B^2. The electrode B' is connected to any suitable source of high tension electricity, preferably an electrostatic generator as indicated at B^3 by means of line B^4. A hopper B^5 is provided to feed the comminuted material to the electrode B. When the static charge is delivered to B from B' the density of the charge on B' becomes relatively very great on account of its close proximity to the electrode B resulting in a transfer of electrical action through the dielectric B^2 by induction and causing an accumulation of the charge of relatively very great density on the outer surface of the envelop at the point B^6 thereby producing a corresponding condition on the electrode B' at B^7. The excessive difference of potential raised at this point rapidly undergoes equalization as the surplus charge is continuously passing by convection between the electrodes at the points described. When the particles of the comminuted material pass through this charge they become polarized and stick or adhere to the separating electrode. The opposite side of the generator to that connected to the charging electrode is connected by the line B^8 with a releasing rod B^9 similar to that hereinbefore described. In carrying out this process the use of the usual pointed electrode is preferable except for ores and combinations demanding special treatment for the following reasons: The amount of charge conveyed to the electrodes B and B' by means of the line wires B^4 and B^8 that passes by convection is relatively but a small amount of the total charge retained by them, the density of the charge being only lowered at the point where convection takes place. The electrode B will therefore act repellantly on those particles that are classed as good conductors while the poorer conductors that do not receive their repelling charge by the time they reach the convection stream passing between the electrodes are polarized as hereinbefore described and adhere to the separating electrode.

The process herein disclosed may be readily understood by reference to the diagram in Fig. 3, wherein E represents the separating electrode and E' the charging electrode having the points opposing the electrode E. When a charge of electricity of sufficiently high density is conveyed to the charging electrode E' through the line E^2 such charge passes by convection to E. E^3 designates a particle possessing dielectric capacity, while E^4 is one without such capacity, such, for instance, as a metal. The particle E^3 being a dielectric intercepts the charge which is convectively delivered from E'. Such a charge, as is well known, consists of a stream of electrified molecules of air which on account of the accumulation of the charge at the point of electrode E' is at a very great density and drives off these electrified molecules by repulsion, each molecule carrying a portion of the charge with it. Therefore it

will be seen that the particle E^3 intercepts this stream of electrified molecules of air which impact upon its face directly opposite to electrode E'. The electrified molecules of air therefore deliver all their charges or portions of them to particle E^3 whenever they impact with it and consequently charge that portion of the surface of E^3 with electricity of the same sign as they themselves possess. E^3 being an insulator, and consequently a dielectric therefore becomes polarized, that is, one side of its surface opposite the pointed electrode carries, for instance, a plus charge, while that in contact with the separating electrode carries a minus charge, the latter charge being produced by the conversion of the plus charge acting through the mass of the particle by electrostatic induction, and the effect of this is to hold a small plus charge bound at the point of contact of the particle E^3 with the electrode E at E^5. In the case of particle E^4, which is a metal or good conductor, it remains inert as it parts with as much electricity to the earth where it contacts with the separating electrode, as it receives on its opposite face from the pointed electrode and therefore such particles remains inert and falls by gravity. It is, of course, understood that the electrode as a whole is without an appreciable charge, it being connected to the earth, or to the other side of the source of electrical energy to that of the pointed electrode E'. This causes a dissipation of the charge from E by conducting it to the earth or to the opposite side of the generating means thus completing an electric circuit. In other words, there being a constant discharge across the electrodes by convection, they are depleted of their charge as fast as they are supplied, as such charges are either conveyed to the ground or back to the opposite side of the generator, and therefore the electrodes are without appreciable fixed density of charge as the charges are constantly in motion both across the intervening space and through the conducting lines and the electrodes where they then become current electricity in the true sense of the term. It is the generally accepted theory that moving charges are the exact equivalent of an electrical current. The convective discharge consists in rapidly moving molecules of air carrying minute electrified particles which constantly act to transfer the charge from one electrode to the other where one or both of the electrodes are pointed. With the electrodes as described the intervening air does not act as a dielectric because the electrified molecules of air act to form a path for the electric current to pass between the electrodes, and such an air gap is simply a resistance in the electrical circuit across which the charge or current passes by conduction and not induction. Therefore the action of the convectively delivered charges upon particles of matter is radically different from that of submitting the particles to a statically charged surface of constant potential, as in the latter case, the particles become charged not only with electricity of the same sign as that of the electrode with which they are in contact, but the entire surface of each particle is charged at an equal potential in regard to itself as well as to that of the electrode, and under these conditions there is no double polarity maintained upon those particles susceptible to being polarized as such a polarity is destroyed by the action of a static charge of a fixed density acting upon them which simply charges them with electricity of the same sign as the electrode with which they are in contact and repels them therefrom.

In the case of the dielectric particle E^3, this particle intercepts a portion of the convective current flowing from E' and consequently shields as much of the area of the electrode E as is covered by its diameter. It hence follows that the potential of the particle E^3 is raised at its face away from electrode E and consequently produces an opposite charge on its face in proximity or contact with the electrode E. This illustration is for positive electricity emanating from the points, but it must be understood that the direction of the charge does not alter the conditions except in the direction of the plus or minus polarity of the particles. This explanation is given with a view of differentiating this process over the prior art, but it is not our intention to confine ourselves to the explanation given. Particular stress is laid upon the production and maintaining of a constant difference of potential between some of the particles and the electrode which is produced by the action of a convectively delivered charge upon the comminuted mass of particles that differ in their dielectric capacities. The action explained in our prior process Patent #813,063 dated February 20, 1906, of creating and maintaining a difference of potential between the electrode and some of the particles by dielectric hysteretic impedance is intended to cover any action upon the dielectric particles by varying the density of the charge upon the electrode at a faster ratio than some of the particles could keep pace with the variation thus causing some of them to lag behind in the potential of the charges upon their surface from that of the electrode with the result of the polarization thereby effected on the particles. The present process effects the same polarization but by convective currents of electricity that are continuous in their action during the time of their application, that is, the action of the convective current is to build up potential

upon one side of the dielectric particles while at the same time it is reducing it on the other side which causes the particles to lag behind in potential to that of the convectively applied charges and consequently differ in potential from that of the electrode. A particle that has no dielectric capacity, such as a metallic particle agrees perfectly with the rate of the passing charge as it disposes of as much current to the grounded electrode as it receives from the pointed electrode, consequently dielectric hysteretic impedance is produced in the dielectric particles by a continuous convective current of electricity from a pointed or suitable electrode when the dielectric particles intercept the flow of this convection current. The use of an interrupter in this connection does not produce hysteretic lag, but acts to regulate its development to any desired stage and thus allows the convection current to act selectively upon particles of matter having diverse electrical susceptibilities.

The electrostatic field produced when a series of sharp points or an edge or edges is connected to a source of static or high tension electricity and escapes across an intervening space to a surface of conducting material grounded to the earth or connected to the opposite pole of the electrical source of energy to that connected to the points or edge is that of a very highly concentrated electrostatic field, and when the comminuted mass of particles is fed into such a field, the conducting surface over which they are fed has no power of repulsion and the points or sharp edge no power of attraction. This is the condition where one of the electrodes consists of a row of points or sharp edge and the other cylindrical or smooth. There are conditions where the convection of the charge is only partial and this exists with electrodes one of which is very large and the other very small, the smaller one being surrounded by a dielectric envelop and brought within quite close proximity to the larger one, at a distance from it somewhat approximating the thickness of the dielectric envelop. When such electrodes are connected to a source of electricityof high tension or density, the pressure of the charge becomes relatively very great on the smaller electrode and acts through the dielectric envelop developing on the outside thereof a static charge of considerable density on its face immediately opposite the larger electrode. The density of this charge is so great that it cannot all be retained and a portion of it passes to the opposite electrode by convection. This would not take place with the electrodes at this distance apart were it not for the dielectric envelop which on account of being a nonconductor prevents the sparks from passing in the form of a series of disruptive discharges as would be the case were it omitted, as the charge would break through the air gap separating the electrodes and take the form of a series of sparks known as a disruptive discharge in contradistinction to a convective, silent or brush discharge as it is sometimes called. A disruptive discharge would defeat our above described process.

In the operation of the apparatus shown in Fig. 1 the comminuted material to be separated is delivered from a hopper over the distributing tray and thence to the separating electrode which may be either connected to the earth or to the opposite side of the electrical source of energy to that of which the charging electrode is connected. The separating electrode is rotated by suitable means, and when the charging electrode is connected to a source of electricity of sufficiently high density, the charge passes therefrom to the separating electrode in the form of a convective discharge, and the rotation of the separating electrode causes the material to pass through the path of this discharge, the effect of which is to create and maintain between some of the particles and the separating electrode a constant difference of potential which is accomplished by affecting the polarization of the dielectric particles to a greater or less extent depending upon the strength of the charge delivered from the charging electrode and also the duration of time of its application.

Those particles that are conductors, or have but small dielectric capacity which are not affected by the charge delivered upon them fall inertly from the separating electrode. This electrode being grounded serves to draw the charge from the pointed charging electrode in the form of a silent or convective charge. Therefore those particles in the mass that are good conductors remain inert by reason of the fact that they part with as much electricity to the earth through the grounded separating electrode as they receive from the pointed electrode. The connection of the separating electrode to the opposite side of the generator from that of the charging electrode has the same effect, as by this means as much electricity is taken out of one end of the circuit as is supplied at the other, and this prevents a charge of any appreciable density from being built up on the separating electrode. The effective time of polarizing these particles varies largely by virtue of the nature of the particles as some have a certain time limit in which they can be polarized, and this process contemplates regulating and supplying to the particles upon the electrode charges at predetermined intervals, such predetermination being in succession as well as in duration.

The particles that are polarized to the greatest extent stick tightly to the separat-

ing electrode until they are removed by an extraneous means, such as a wiper or the depolarizing rod shown. This rod is connected to the opposite side of the generator to that of the charging electrode and serves to complete the electric circuit as on account of its close proximity to the separating electrode small disruptive discharges pass continuously from the rod to said electrode. The rod being round and free from points acts to neutralize the polarity of particles and exerts an attractive influence thereon, while the disruptive discharges passing from the rod to the separating electrode cause concussions in the air in the vicinity of the particles and assists in loosening them from the electrode. As before described the amount of current or charge supplied from the generator to the charging and separating electrodes may be controlled by means of the regulator in circuit with this rod and one side of the generator.

If the convective discharge delivered to the particles is uninterrupted, the process acts to separate particles that have the greatest dielectric capacity from those having practically none, while on the other hand, as there is a time limit in which some particles can be polarized, a regulation of the time of the application of the charge conveyed by convection to them enables the process to be used to separate particles that differ but slightly in their dielectric capacity by acting selectively upon the particles of greatest capacity. The interruption of the charge may be effected by any desired means, the disks herein shown being one form capable of accomplishing the object. In this process the production of the lag of charge or dielectric hysteretic impedance by which separation is accomplished is by convective discharges and the interrupter acts merely as a means to govern the development of this lag and not its production.

The feeding of the particles to the separating electrode while heated causes a rapid dissipation of the residual charge upon both the particles and the electrode as the latter is grounded, and this rapid dissipation renders the particles highly susceptible to the convectively delivered charge and at the point of contact of the particles with the electrode produces a more intense electrostatic stress between some of the particles and the electrode than can otherwise be secured, and therefore causes a greater difference of potential between the particles and the electrode. The metallic or conducting particles when heated are rendered more inert to the convective charge than ordinarily and therefore less liable to be affected by such a charge as it is essential that they remain practically inert during the charging of the dielectrics. The feeding of the heated particles heats the separating electrode and therefore facilitates the more rapid discharge thereof so that it may be quickly reduced to an inactive potential when the charge is interrupted. This charge is localized upon some of the particles, that is, the opposite surfaces thereof are inductively charged with opposite potential, and one side of such a particle is of a different potential and polarity from the bound charge upon said electrode in order to cause a temporary adherence of some of the particles thereto. The charges are thus delivered to the grounded electrode without inductively charging the latter. It is advantageous to use a phase or portion of the full charge from the generator when said charge is applied to separating particles that differ but slightly in their lag of charge or dielectric capacity, as if the charge continues for the full phase or period the particles that differ but slightly in such capacity would adhere to the electrode with the other particles of the mass, and therefore but a portion of such charge is used and not the full duration thereof. The term phase is herein used as relating to the duration of charge and not in a specific sense as in some of the electrical arts.

The terms "convection" or "convective charge" as herein used, refer to a flowing charge passing through an air gap between the electrodes. The passage of such a charge produces what is now recognized as ionization of the air and is visibly manifested by a stream of violet light.

Having described our invention and set forth its merits, what we claim and desire to secure by Letters Patent is:—

1. A process of separating comminuted material consisting in subjecting the material to a convectively delivered electrical charge in the path of convection, varying said charge while being delivered in polarity and duration according to the relative characteristics, susceptibilities of different particles of the material, and separately collecting the separated particles.

2. The process of separating comminuted material consisting in subjecting the material to a convectively delivered electrical charge in its path, successively interrupting said charge while subjecting the material thereto, and separately collecting the separated particles.

3. A process of separating comminuted material consisting in subjecting the material to a convectively delivered electrical charge in its path, varying said charge in its phase while being applied, and separately collecting the separated particles.

4. A process of separating comminuted material consisting in subjecting the material to a convectively delivered electrical charge to cause adherence of some of the particles thereof to an opposing electrode,

subsequently subjecting said adhering material to an electrical charge of different polarity for releasing the same, and separately collecting the separated particles.

5. A process of separating comminuted material consisting in subjecting the material to a convectively delivered electrical charge to cause its adherence to an electrode, subsequently subjecting the finally adhering material to an electrical charge of opposite polarity for releasing the same, and separately collecting the separated particles.

6. A process of separating comminuted material consisting in delivering to the material a convectively delivered electrical charge in the path of convection to produce in the particles of said material a lag of charge in accordance with their susceptibilities to receive said charge, and separately collecting the thus separated particles.

7. The process of separating comminuted material consisting in directly delivering charges convectively to the material and contacting said material with a source of opposite potential to reverse the charge upon a part of the particles, and separately collecting the particles separated thereby.

8. A process of separating comminuted material consisting in directly delivering electrostatic charges convectively upon the material and subjecting the particles thereof to maintained contact with a source of opposite potential to that of the convectively delivered charges, and separately collecting the thus separated particles.

9. A process of separating comminuted material consisting in delivering directly to the material a convectively delivered electrical charge for predetermined intervals separated by substantially inactive intervals, and separately collecting the thus separated particles.

10. A process of separating comminuted material consisting in subjecting particles thereof directly to an electrical charge convectively delivered for predetermined intervals regulated in duration, and separately collecting the thus separated particles.

11. A process of separating comminuted material consisting in heating the material to a degree to cause it to be more susceptible to electrical treatment, subjecting said material while heated directly to a convectively delivered electrical charge, and separately collecting the thus separated particles.

12. A process of separating the particles of a mass consisting of conductors and dielectrics which consists in submitting them to a directly and convectively delivered electrical charge and contacting said material with a source of opposite potential to attract the particles and to retain the dielectric particles while not retaining the conducting particles, and separately collecting the thus separated particles.

In testimony whereof we affix our signatures in presence of two witnesses.

HENRY M. SUTTON.
WALTER L. STEELE.
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Witnesses:
E. H. LILLY,
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