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 HAVING DIFFERENT ELECTRICAL SUSCEPTIBILITIES

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2 Sheets-Sheet 1

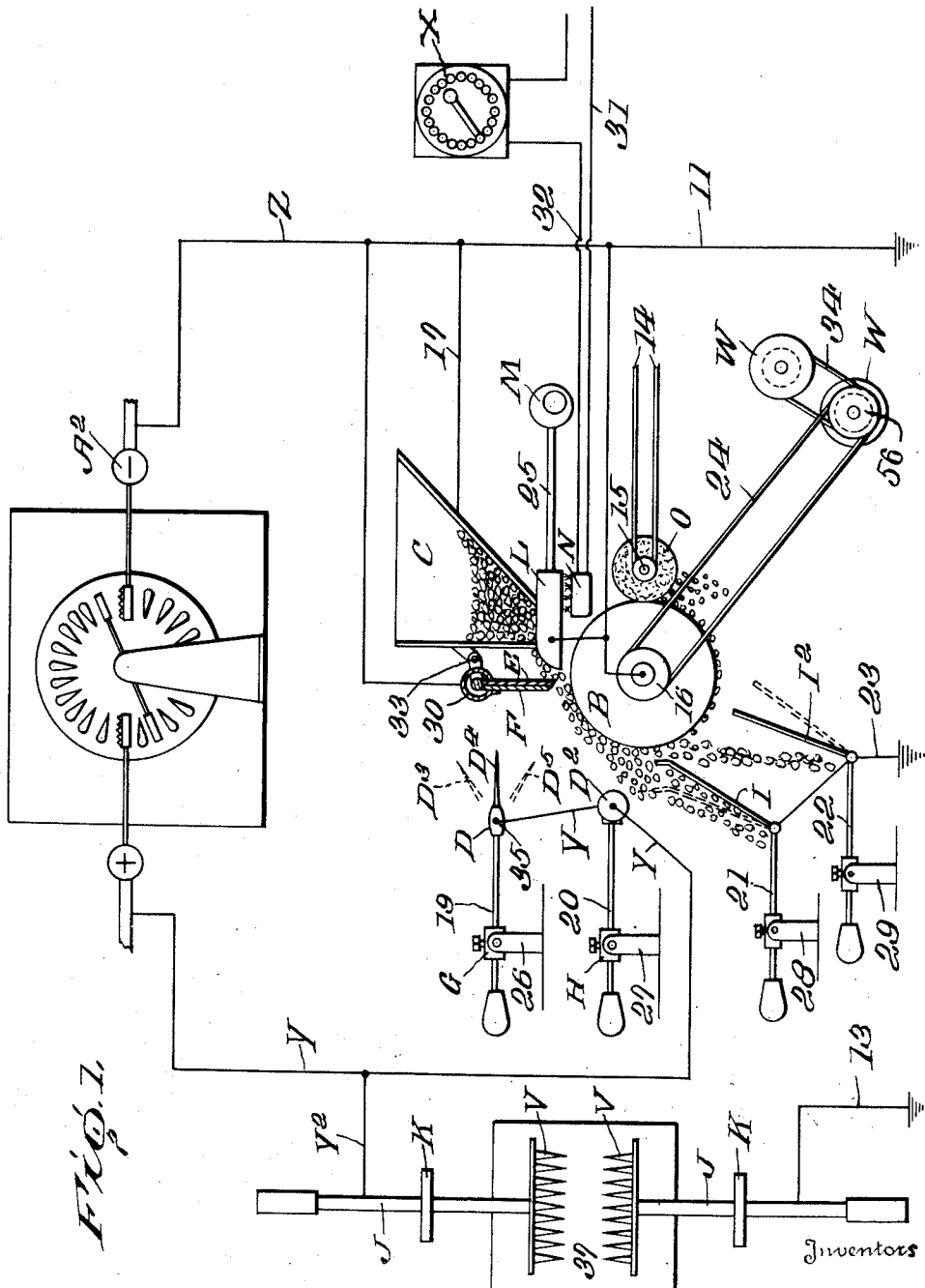


FIG. 1.

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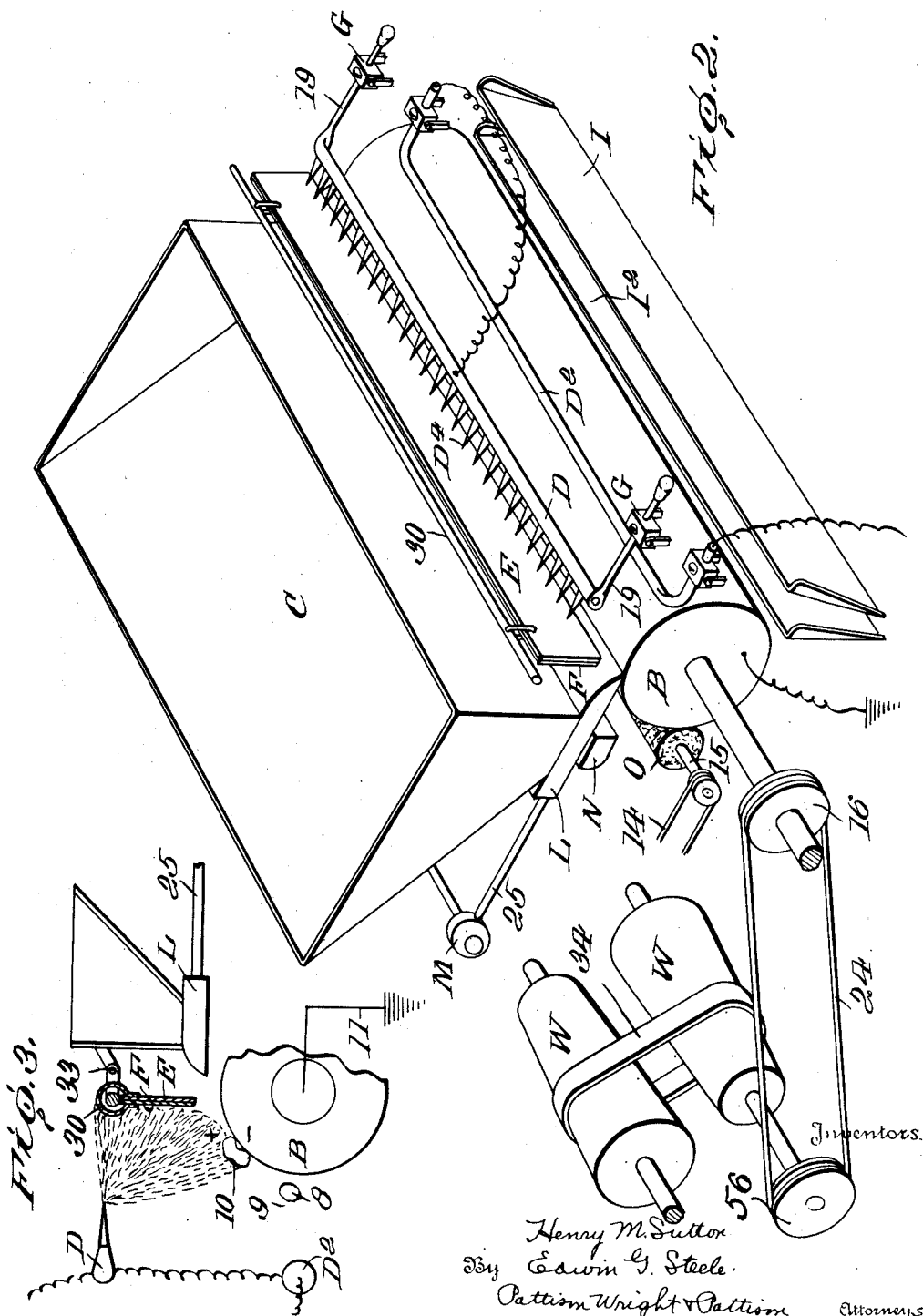
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UNITED STATES PATENT OFFICE

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APPARATUS FOR THE ELECTROSTATIC
SEPARATION OF PARTICLES HAVING DIFFERENT
ELECTRICAL SUSCEPTIBILITIESHenry M. Sutton and Edwin G. Steele,
Dallas, Tex.

Application August 26, 1937, Serial No. 161,152

7 Claims. (Cl. 209-129)

This invention pertains to an improved apparatus for the electrostatic separation of particles having different electrical susceptibilities and has for its objects the separation of masses composed of conductors and non-conductors, and masses composed of non-conductors, and masses composed of particles having different temperatures, as will be specifically pointed out hereinafter.

Referring now to the drawings:

Fig. 1 is a diagrammatic view of an apparatus embodying the invention.

Fig. 2 is an isometric view of the said invention.

Fig. 3 is a diagrammatic view showing the electrostatic fields between the electrodes employed in the practice of the invention.

The invention herein disclosed will be first explained and its different objects pointed out, after which certain reference to the prior art will be made for the purpose of making the invention more fully appreciated.

Referring now to the drawings the mass of particles to be separated are fed to a hopper C and from this hopper they are fed to a separating electrode B and as they are fed over the traveling electrode these particles are treated by electricity in the following manner.

At the outlet end of the hopper C is located a reciprocating feed pan L which is actuated by means of a rod 25 that is connected with an eccentric M that is driven by any suitable power.

The separating electrode B is driven from a suitable source of power by a belt 24 which passes over a pulley 16 attached to the shaft of the said electrode. Said belt 24 is driven by a pulley 56.

The separating electrode B has a curtain E composed of suitable insulating material such as Bakelite, hard rubber, etc. This curtain has a metallic facing F on its front side that reaches down within a short distance of its lower tip.

This curtain swings loosely on a metal rod 30. This rod and curtain are adjustably connected to the front side of the hopper by adjustable links 33. The metal facing F on the curtain E is metallically connected with the metal rod 30. In some

separations, however, the metal facing F may be omitted or it may extend downward on the curtain F covering any desired portion of the width.

Opposite to this metal rod is an electrode D composed of a row of sharp points pivotally mounted on the rod 19, but arranged to be clamped in any position desired. This rod 19 is slidably and adjustably mounted on a support 26 and arranged to slide backward and forward through a sleeve G. Opposite the separating electrode B is placed a second electrode D²

mounted in the same manner as the above electrode D. This electrode D² is composed of a glass tube or one of any suitable insulating material having sufficient strength to prevent collapsing under atmospheric pressure and from which the air has been exhausted and a small amount of gas admitted such as neon or helium, or any gas suitable for the purpose. It is known that neon, helium, argon, krypton and xenon gases are classed as the "rare" gases and display one characteristic in common, they are "chemically inert", that is to say, they will not combine with any other substance. Chemists have never succeeded in making them combine either with each other or with any other chemical substance (book, "Neon Signs" by Miller and Fink, page 33). All of these gases are good conductors of electricity. Krypton and xenon gases are extremely rare and are expensive. Neon, helium and argon are more easily obtained and of these three gases we prefer to use helium because of its more favorable characteristics. We do not wish to be limited to the use of any of these gases, or to any other kind or class of electrically conducting gas, or to any mechanical combination or mixture of them. Preferably the gas used by us in carrying out our method and in our apparatus is of this "rare" or "chemically inert" group and, preferably, we use helium gas which is placed in the tube electrode D². For the purpose of differentiating the gas used in our electrode it will be referred to by us as "inert gas" in the following claims, meaning a gas of the "rare" or "chemically inert" family as this type of gas is preferably used. It is also well known that the "gas" which produces ultraviolet rays is a mixture of mercury vapor and argon gas and that this "gas" when electrically charged, ionizes the air in said field. The use of such "gas" would destroy the operation of our invention as it would cause an effect on the particles of the mass similar to that produced by the needle electrode D⁴ and this would defeat the operation of our process. Our process demands that the particles be first subjected to a convective electric spray, which causes certain particles to adhere, or partially adhere, to the separator electrode B, and then subjected to the electrically energized gas tube electrode, which causes certain particles to be released, or deflected, from the separator electrode B, thus causing a separation of the two classes of particles. We have discovered that the combination of the convective spray D⁴ and the electro-static field induced by the electrically charged gas tube electrode D² causes the separation of the particles as described in this applica-

tion. The amount to cause illumination such as is used in illuminating signs we find to be sufficient for normal operation, but the amount and kind of gas can be varied to suit the nature of the separation required as well as varying the density of the gas within the tube to vary the electrical conditions of the electrode by varying the density of the static charge on this electrode and thus controlling the electrical field of force between this electrode and the separating electrode.

Two or more separating partitions I' and I² are adjustably mounted on suitable supports 28 and 29 in a similar manner as the said electrodes D and D².

All parts of the separator—excepting the gas tube electrode D²—as well as the pointed electrode D including the partitions I' and I² are composed of metal and connected to the earth through wires Z, 17, 13, 23 and 11 and their branch connections. The insulated electrodes D' and D² are connected to a suitable source of high tension electricity at A' while the opposite side of the high tension source A² is connected through the lines Z and 11 to the earth.

A current regulator 37 composed of two electrodes V and VV composed of a series of sharp points are attached to rods JJ that are suitably mounted in the supports KK. One of these rods J is connected through a wire Y² to the wire Y that supplies the electrodes D' and D² while the opposite rod J is connected through a ground wire 13 to the earth or any similar controlling means may be used. It will be observed that the electrical supply wire Y connects to both electrodes D' and D² connecting through the glass electrode D² first and then continuing to the pointed electrode D'. The regulator 37 is for the purpose of regulating the amount of current delivered to the electrodes D' and D² by short circuiting out the surplus current into the earth. A heater N is placed under the feed pan L and connected to a suitable source of electrical supply either A. C. or D. C., through wires 31 and 32. A rheostat X is placed in the circuit to regulate the amount of heat supplied to the particles that are fed out of the feed pan L to the separating electrode B. It will be noted that the pointed electrode D is adjustable to deliver its stream of electrified particles of air—i. e. a convective electrical discharge—in either one of the positions shown as at D³, D⁴ and D⁵. The direction of this convective discharge depends entirely on the character of material to be operated upon.

The most depressed form D⁵ is best suitable for separating particles of good conductivity from those of poor conductivity, and operates as follows:

With motion being applied to the various parts the particles fed from the feed pan L after passing the curtain E find themselves in the field of this convective spray discharge. The non-conductors of the mass become polarized by having static charges built up on their faces which initially causes them to cling tightly to the separating electrode B as long as they are within its field of influence. The good conductors, on the other hand, are passing these convective charges through or across their surface to the separating and grounded electrode B as fast as they receive them and therefore remain electrically inert. This condition exists until a further revolution of the electrode B brings these particles within the electrostatic field of the gas composed electrode D². The operation of this electrode is diametrically opposite to that of D'

for while D' impresses the static charge directly upon the particles by conveyance, electrode D² acts only by induction thereon and consequently the static charges induced on the particles is of the opposite sign to that of the electrode D² itself. The result of this action is that with electrode D² set the proper distance from the separating electrode B and charged to the proper degree it will just neutralize the attractive force exerted by the static charges impressed upon the poorer conductors of the mass to where they will drop inertly from the electrode B, but the better conductors on the other hand being inert are strongly attracted toward the electrode D² and drop on top of the first partition I while the relatively inert non-conductors drop behind it onto partitions I² and both particles can be separately collected as desired.

The advantage of this type of separator over those heretofore known to us is as follows: In the operation heretofore obtained the non-conductors of the mass cling so tightly to the separating electrode that they mechanically imprison with them some of the conductors. This requires frequent retreatment by passing this mixed mass over additionally similarly acting electrodes, thus greatly increasing the cost of the apparatus and the treatment in proportion. The result of our present method overcomes this defect by releasing the charges on the non-conductors to a point where they are normally inert, which allows the release of any conducting particles that may be otherwise imprisoned, so that they can be attracted with its fellows towards the electrode D². This enables one rotating electrode to do the work where four or five otherwise would be required.

We have thus far described one type of separation that our present improvement is capable of making, that is of separating conductors from non-conductors, but this is by no means the most important branch of its work. Our present improvement is capable of separating what ordinarily is classed as non-conductors from each other.

To carry out this separation of non-conductors from each other the electrode D has preferably its pointed end D⁴ directing the bulk of its brush discharge directly at the rod 30 and only a small leakage of these rays or charges that leave the pointed electrode at an angle reaches the upper part of the separating electrode B and the particles thereon.

The field of action is shown in Fig. 3 where we illustrate the slight convective discharge polarizing the particle 10 with a + on one side and naturally a - sign on the other. In this condition that particle adheres to the separating electrode B. Another particle 8, for instance, may not have the same degree of polarization. With the electrode D² set at just the proper distance such particles have the force exerted by their charges not only completely neutralized but are attracted towards the electrode D² and are separated from the others as in the manner described in connection with Fig. 1.

This difference in electrical susceptibility may depend on several factors—some particles classed as dielectrics appear capable of storing up a residual charge in a similar manner to that observed in the dielectric that separates the two metal coatings of an electrical condenser when subjected to electrostatic stresses by having their metal plates or coatings connected to a source of electricity of sufficiently high potential. This

residual charge is apparent in some dielectrics after the static stress has been removed by discharging the condenser, while in other dielectrics there is no residual charge apparent under these conditions. Similar conditions exist in whole or in part when the particles to be separated are placed upon a grounded electrode carrier and subjected while resting thereon to the imposed static charges from the pointed electrode D and those particles which will carry a residual charge after removal from this field will respond differently in the electrostatic field of electrode D² from those that do not. This effect varies very materially with the different classes of particles undergoing separation that are usually classed as nonconductors, as this separation then takes place more by the difference in their dielectric capacities than by their difference in conductivities, and these particles so differentiated can be separately collected from each other.

There are other factors that may also enter into this separation. Some particles of a mass show a decided preference to positive charges of electricity over negative ones in its electrostatic field D² and can be separately collected by this means. It may then be necessary to reverse the charges delivered to the electrode D and D² or connect these electrodes to separate sources of high tension electrical supply so that their electrostatic fields in which the particles are undergoing separation can be separately controlled not only as to polarity but also as to static charge density. This entire process of separation depends on two important factors: First, passing the particles to be separated while resting on a carrier electrically grounded electrode through the field of a convective electrical discharge of ionized air particles that impose static charges directly upon them. Secondly, simultaneously submitting these particles to an electrostatic field of force in which an opposing electrode acts on them by induction only. The two electrostatic fields act in an exactly opposite manner. The first electrostatic field, that of the convective discharge causes those of the particles that have varying electrical characteristics to adhere more or less firmly to the carrier electrode, while the second electrode acting by induction only acts to neutralize the attractive force or reverse the direction of the force acting on those particles that respond to certain densities of its controlled electrostatic field, thus separating one class of particles from the other.

There is another important feature we wish to call attention to in this case and that is the heating unit N placed under the feed tray. To this heating unit you will observe is controlled by a rheostat X through wires 31 and 32 that are connected to a suitable electrical supply, so that the temperature of the particles delivered to the electrode B can be controlled to agree in temperature with the density of the static charge imposed on some of the particles.

Our Patent No. 1,386,287 is broadly for the above idea but we have found out later that a critical temperature is necessary for a good separation of certain classes of particles; in other words, that the heat applied to the particles to be separated should be in some cases proportional to the electrostatic charge applied to them. This can be readily understood if we consider a mass of particles submitted for separation which contain some whose heat conductivity is greater than others. Thus the mass when delivered to the separating electrode B contains particles that

differ in temperature from their fellows and those of the poorer conducting particles that maintain the greater temperature will be more strongly polarized than the others and are thus separated in the manner already described in connection with the apparatus shown in Fig. 1.

We have found that our gas electrode D² produces a more uniform electrostatic field between itself and the separating electrode B than those of electrostatic separators of the prior art that employ an electrode opposite the separating one composed of conducting or semi-conducting material. These electrodes, of which there are one or more opposite each separating electrode are charged to a static potential of opposite sign to that of the separating electrode. In operation certain particles that are partial conductors adhere momentarily to these opposing electrodes and produce localized static fields of different densities from that of the main field of force in which the separation is taking place. This causes an irregular separation of the particles and thus impairs the entire process of separation. We have overcome this difficulty entirely with our gas tube electrode. This is due to the high speed movement of the ionized gas particles within the tube that impose their static charges uniformly on its inner walls which, of course, induces a static charge of opposite sign on its outer periphery which is the active static field that we employ. The uniformity of the static field between this electrode and the separating electrode is then due to the fact that these semi-conductors will not adhere to the nonconducting surface of the gas tube electrode or produce localized static fields of different densities within the main field of operation.

In Fig. 2 we show a speed change transmission device consisting of reverse cone pulleys WW that are connected to the separating electrode B by means of belts 34 and 24. This is an important feature of this separator, as the speed at which the electrode B revolves is determined by the size of the material being treated.

In Figs. 1 and 2 we show a cleaning roller 0 that is operated by a belt drive 14. This cleaner roller is preferably composed of felt washers packed closely together and its object is to keep the separating electrodes free of adhering particles. This roller is operated, of course through the general power used to drive the moving parts of the separator.

We do not wish to be limited to the precise construction shown in this application and the same may be varied so long as the variation is within the scope of a fair interpretation of the claims.

We claim:

1. An apparatus for the separation of particles of a mass having different electrical susceptibilities, consisting of a rotating separating electrode, means for feeding the mass to the said electrode, electric means for causing some of said particles to adhere to the electrode and a second electrode consisting of a tube extending across the width of the separator electrode containing a chemically inert gas, from which said second electrode an electrical influence is directed upon the particles to be separated for the purpose of separating some of said particles from the separator and said third tube electrode being evacuated to a degree such as is required for illumination means for conveying the separated particles to suitable places.

2. An apparatus for the separation of particles of a mass said particles having different charac-

teristics, comprising a movable separating electrode, means for feeding the mass to the moving electrode, an electrode for causing an electrical influence on the said particles flowing to the separating electrode and a third electrode consisting of a tube extending across the length of said separator electrode containing a chemically inert gas, said third electrode tube being evacuated to a degree such as is required for illumination and electrically influencing the particles to be separated for the purpose of releasing some of the particles from the separating electrode and thereby releasing them, and upwardly extending separating partitions adapted to receive the separated particles as they fall from the separating electrode.

3. An apparatus for separating particles of a mass comprising a movable electrode, means for feeding said particles to the electrode, a heater for heating said particles as they flow to the separating electrode, a member supported above the said separator electrode, said member having an outer metallic face projecting downwardly adjacent the particles as they flow to the separating electrode, a pointed electrode located between the said metal facing and the particles flowing to the separating electrode, and a second electrode consisting of a tube extending across the length of the separator electrode which contains a chemically inert gas affecting the polarization of the part of the material flowing on the separating electrode tube being evacuated to a degree such as is required for illumination and, said second electrode changing the polarization of the particles by the first electrode thereby effecting the release of said particles and thereby effecting a separation thereof.

4. An apparatus for separating particles of a mass having different electrical characteristics, comprising a movable electrode, a hopper containing the particles, a shaker pan feeding the said particles from the hopper to the electrode, a member located in front of the hopper having a metal face, a pointed electrode directing its current against said metallic face and electrically influencing the material flowing on the separating electrode, and a second electrode located between said first electrode and the separating electrode said second electrode consisting of a tube which contains a chemically inert gas whereby that part of the mass that is polarized by the first electrode is affected by electricity having a different sign from that of the first electrode whereby the particles affected by the first electrode are released by the second electrode to effect a separation thereof, said second electrode tube being evacuated

to a degree such as is required for illumination means for operating the electrode, a changeable speed means operating the said separating electrode the first and second electrode acting to electrically affect the said particles by electricity having different signs whereby the second electrode releases those affected by the first electrode thereby causing a separation of the particles.

5. An apparatus for the separation of particles having different electrical characteristics, comprising a separating electrode, means for feeding the said particles to the said separating electrode, an electrode polarizing part of the particles of said separating electrode, a second electrode extending throughout the length of said separator electrode and containing a chemically inert gas said last mentioned electrode positioned below the first electrode and de-polarizing the said particles polarized by the first electrode throughout the length of the separator electrode, said second electrode tube being evacuated to a degree such as is required for illumination a heater for the particles as they flow to the separating electrode and a rheostat for regulating said heat, for the purpose set forth.

6. A mechanism for the separation of particles of a mass having different electrical characteristics, comprising a single separating electrode, a hopper above the same, means for feeding the material from the hopper to the separating electrode, a second electrode delivering a convective charge on the material, a third electrode consisting of a tube being evacuated to a degree such as is required for illumination and containing a chemically inert gas having a different electrical sign from that of the first electrode for the purpose of releasing the particles affected by the first electrode, the parts combined for the purpose set forth.

7. An apparatus for the separation of material having different electrical characteristics, comprising a movable electrode, means for feeding the particles on the electrode, a pointed second electrode delivering an electric charge on said material as it is fed to the separating electrode, a third electrode consisting of a tube being evacuated to a degree such as is required for illumination and containing a chemically inert gas for releasing the particles affected by the said second electrode, a current regulator controlling the current supplied to said electrodes, means for feeding high tension electricity to the electrical parts of the apparatus, for the purpose set forth.

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