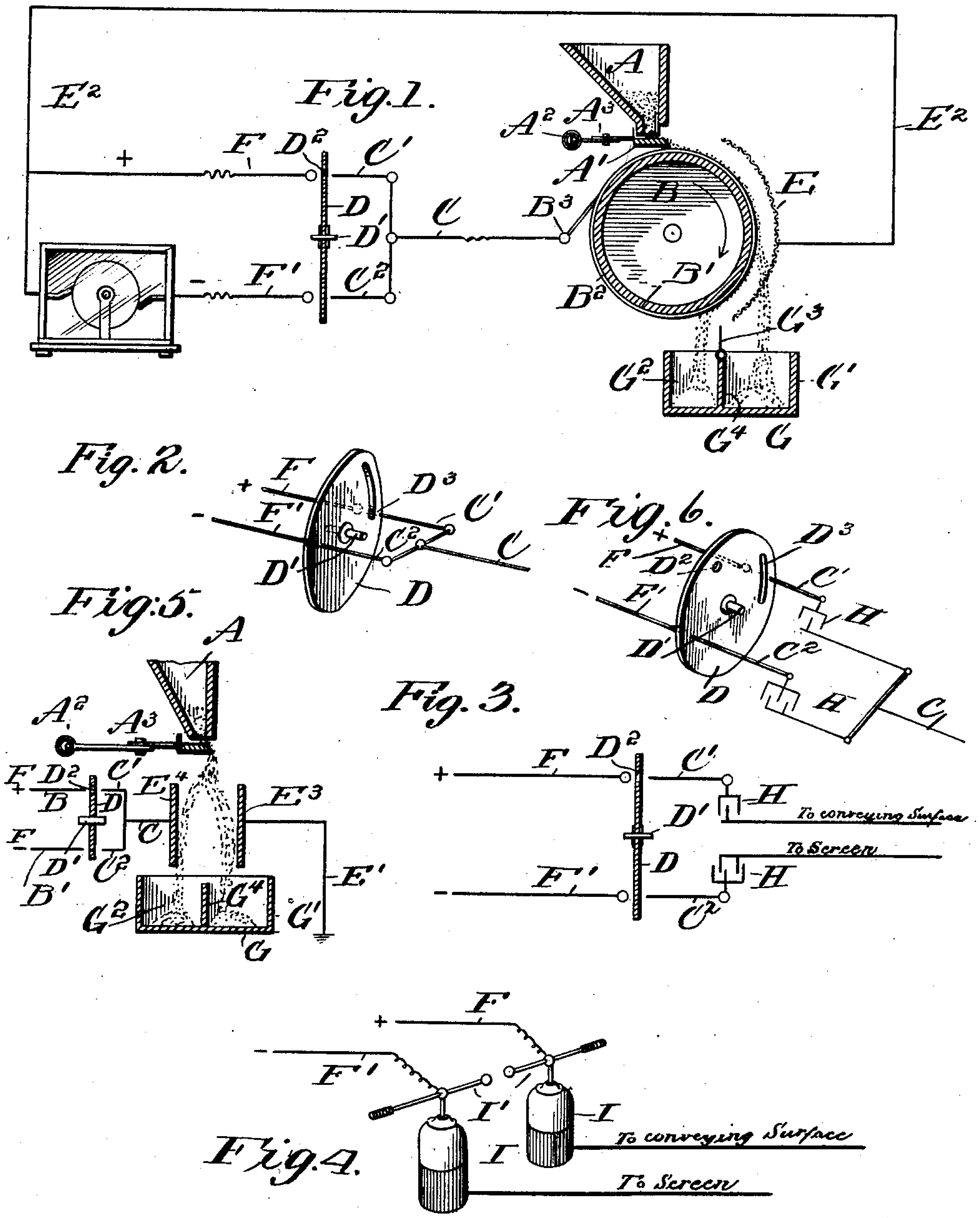
No. 813,063. PATENTED FEB. 20, 1906.

H. M. SUTTON & W. L. & E. G. STEELE.

PROCESS OF SEPARATING SUBSTANCES OF DIFFERENT DIELECTRIC CAPACITIES.

APPLICATION FILED APR. 18, 1903.



WITNESSES:
W. F. Kaye.
Alfred T. Gage.

INVENTORS
Henry M. Sutton,
Walter L. Steele, and
Edwin G. Steele.
BY
E. B. Stocking
Attorney

UNITED STATES PATENT OFFICE.

HENRY M. SUTTON, WALTER L. STEELE AND EDWIN G. STEELE, OF DALLAS, TEXAS.

PROCESS OF SEPARATING SUBSTANCES OF DIFFERENT DIELECTRIC CAPACITIES.

No. 813,063. **Specification of Letters Patent.** **Patented Feb. 20, 1906.**

Application filed April 18, 1903. Serial No. 153,305.

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, in the county of Dallas, State of Texas, have invented certain new and useful Improvements in Processes of Separating Substances of Different Dielectric Capacities, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to an electrical process of separating the particles of a mass or the components of a mixture or of material in solid, (pulverized,) liquid, or gaseous form.

Heretofore separation has been effected by utilizing the difference in conductivity of the particles or substances and also by magnetic or diamagnetic effects produced upon a limited number of certain substances introduced into the field of an electromagnet excited by an alternating current, the diamagnetic particles tending to move from the strongest to the weaker part of said field, the maximum effect manifesting itself in particles which are conductors of electricity.

One of the principal objects and advantages of our invention is to provide an electrical process of separation which can be applied to substances regardless of their being or not being electrically conductive or magnetic.

Our invention, briefly stated, consists in developing in the particles or components to be separated dielectric hysteretic impedance.

Our invention also consists in various modifications in the degree, periodicity, and maintenance of said impedance, as will hereinafter be more fully set forth.

Dielectric hysteretic impedance may be produced from various sources of energy and by various manners of and means for applying the same. In the present instance we employ an alternating, varying, or it may be a pulsating static current to produce dielectric hysteresis in the substances we desire to separate, and this dielectric hysteresis impedes the static charges on the surface of the particles of the mixture and is what we have denominated "dielectric hysteretic impedance." This, the governing factor in our process, may be produced by static currents that alternate in polarity, making an alternating static field, or by static charges which are pulsating, but of the same polarity, making a pulsating static field, or by static charges which vary in strength, making a static field of varying intensity, or by alternating static currents of unequal periods, the positive polarity being of longer duration than the negative, or vice versa, or of greater strength than the negative, or vice versa, or the said impedance may be produced by any one of the above-mentioned types of currents or by a combined or simultaneous use of any one or more of them, and variation of a static current will produce dielectric hysteresis; but the latter seems more marked in an alternating static current, and we have discovered that certain substances respond to a given periodicity more readily than others, the range observed, though not to be taken as a limitation of our invention, being from two to twenty-five alternations per second. The development of a sufficient dielectric hysteretic impedance to cause particles to be swerved from a normal path or to adhere to a conveying-surface is the proper measure of frequency of alternation or variation, and this differs with the different particles of substances. This result having been produced in some of the particles, other particles thereof in which impedance develops at a different speed of alternation or variation are in condition for actual separation by subsequent treatment or by mechanical or other means. Again, some particles are more susceptible to a negative charge than to a positive, or vice versa, as the molecules more easily turn on their axis in one direction than the other, so that changes in polarity of the static field and of periodicity have effective value in developing in the particles the desired hysteresis. When subjected to periodic, pulsating, or varied electrostatic influence or stress, particles take on a molecular strain or polarization, which manifests itself after the removal of the influence or charge that causes strain, and its effects are afterward shown by the appearance of a residual charge similar in its nature to that appearing in a Leyden jar after a few moments rest subsequent to a recent discharge. This residual charge varies in amount according to the dielectric which separates the two coatings of the jar. Similar conditions can be brought about in our invention, the substances to be separated being the dielectric between the surfaces that serve as media for the subjection of the substances to the action of the separative force or forces.

While we do not limit our invention to any particular apparatus for practicing the same, reference is had to the accompanying drawings as showing some of the many forms of apparatus which may be utilized.

Figure 1 is a diagram of an apparatus adapted to subject material for separation to an alternating electrostatic field. Fig. 2 shows means for varying the periodicity of the alternations. Fig. 3 shows means for varying the relative strength of the fields. Fig. 4 shows means for producing a pulsating field; Fig. 5, a modification of the apparatus shown in Fig. 1, and Fig. 6 is a diagrammatic illustration of means for varying the alternating current both in periodicity and potential.

Like letters of reference refer to like parts in the several figures of the drawings.

In Fig. 1, A is a hopper provided at its outlet with a shaking pan A′, operated by an eccentric A^2 and connecting-rod A^3 to distribute the mass coming from the hopper upon the cylinder B, which is provided with any suitable means for rotating in the direction indicated by the curved arrow. The cylinder B has an insulating-covering B′ and an outer conducting-surface B^2, which is adapted to be charged by a brush B^3, connected by electrical conductors C, C′, and C^2 with an alternating static generator or pole-changer D. At one side of the cylinder B a metallic plate or screen E is located, and this may be grounded, as at E′, Fig. 5, or connected to the opposite side of the electrostatic generator from that which is connected to the cylinder B, as at E^2, Fig. 1.

One type of pole-changer is shown in Fig. 1 and consists of a disk D, of hard rubber or other insulating material and mounted on a suitable shaft D′ for rotation by any suitable means and having one or more holes D^2 located between its center and its periphery, whereby charges of successive signs, plus and minus, will pass through said holes to one of the terminals C′ or C^2 during each revolution of the disk. A given speed of rotation will deliver a definite number of positive and a definite number of negative charges to the cylinder B, whereby any desired frequency can be attained. To vary the relative periodicity of alternation, a slot D^3, Fig. 2, may be used instead of a hole D^2 in any series of openings which may be formed in the disk D, as above stated.

F and F′ represent connections, plus and minus, with any desired source of energy, preferably a static generator.

G is a receptacle having compartments G′ and G^2 for separated particles and a pivoted gate G^3 on the partition G^4.

The operation in the form shown in Fig. 1 is as follows: The mass is fed from the hopper to the conducting-surface of the cylinder, which is charged from an alternating source of static electricity capable of giving definite periods of alternations. Some of the particles of the mass thus subjected to periodic changes are caused to differ in potential from that of the surface of the cylinder, while others that develop little hysteretic impedance at certain periodicities of the electrostatic charges are practically capable of allowing the charges induced on their surfaces to follow in phase that of the conveying-surface of the cylinder, so that an alternation of one polarity practically neutralizes that of the other, and these particles consequently remain in an approximately neutral condition, and on rotation of the cylinder they drop through the screen into the compartment G′ of the receptacle G. On the contrary, the particles which by impedance in phase caused by their molecular polarity or hysteresis lag in phase of change behind that of the conducting-surface, and this causes a difference of potential to be constantly maintained between the particles and the conducting-surface B^2 of the cylinder, so that they adhere until further rotation of the cylinder carries them beyond the condensing action of the screen E, and they fall into the compartment G^2 of the receptacle G. The screen E serves to bring about the opposite relation of the conducting-surface B^2, so as to intensify the electrostatic field of the same.

Fig. 3 shows one means of applying our process to those classes of substances which show preference for the different signs of electrification, which means is adapted to deliver to the conducting-surface B^2 static charges of unequal strength. This can be done by varied means. In this instance the condensers H H of relatively unequal capacity are placed in the branches C′ and C^2, the former leading to the surface B^2, the latter to the screen E, or it may be vice versa.

Fig. 4 shows one means for applying pulsating charges to the surface B^2, said means involving the use of Leyden jars I I in the connections C and C′, leading to the screen E and surface B^2. F and F′ are the terminals of a static generator which has suitable knobs I′ I′, so that by adjusting these knobs sufficiently close the discharge which takes place across the air-gap causes electrical oscillations at the connections C and C′ and in the screen and the conducting-surface. In these cases the frequency of the discharges may be regulated by adjusting the sizes of the condensers or Leyden jars, adjusting the air-gap, or providing the condensers with adjustable plates.

In Fig. 5 a plate E^4 is substituted for the cylinder B, while the material is allowed to fall by gravity between said plate and a screen or plate E^3, grounded at E′, whereby the particles are separated sufficiently to fall in separate receptacles.

Fig. 6 illustrates a form of the invention wherein a current from the generator through connections F F′ of Fig. 1 may be alternated by the insulating-disk D, pivoted at D′ and provided with a slot D^3, and such alternation varied in periodicity by a hole D^2 in the disk in connection with the slot D^3. In this instance the alternation would possess successive long and short periods, the former through the slot and the latter through the hole. The alternating current thus varied may be further varied in its potential by condensers H H of relatively unequal capacity placed in circuit with the conductors C′ C^2, by which successive alternations over the conductors C′ to the screen E of Fig. 1 differ in potential, thus causing both alternations and variable intensity in the field.

In all the forms of apparatus herein shown no dependence is required upon the specific gravity, electrical conductivity or non-conductivity of the particles of a mass, all of which in actual practice are so slight as to render practical separation difficult; but by using our process the substances are exposed to an electrostatic field of a pulsating or an alternating or of a varying potential, the alternations, variations, or pulsations being so timed as to cause and maintain a difference of potential between certain substances in the mass in or on surfaces that they are in contact with or adjacent to. The actual and practically-demonstrated separation is effected by taking advantage of the effects of dielectric hysteresis set up in the different particles in the mass when it is exposed to stresses of an alternating or varying electrostatic field. The result of developing in the particles of the mass dielectric hysteresis is to counteract in part the true charge induced on their surfaces, so as to cause them to carry a charge of a different value to that of a conveying (or of an influencing) surface on which (or near which) they travel, while those particles whose hysteretic impedance is not so sufficiently manifested at certain periodicities or alternations or pulsations practically follow the phase of the conducting-surface, so that charges of opposite signs follow each other on the surfaces of such particles and cause them to practically remain in a neutral condition, which facilitates subsequent actual or mechanical separation.

In our development of this invention it has been discovered that when the inductive member—for instance, the screen E in Fig. 1—is charged at a constant static potential intead of an alternating potential, while the conducting-surface—for instance, at B^2 in Fig. 1—is charged with an alternating, pulsating, or varying potential static current or charges, as we have previously described, the efficiency of the process is very greatly increased. This is due to a state of "tension" in which the molecules are placed by the continuous static charge, which renders them more responsive to the alternating static charges, and thus comprises a simple and efficient manner of increasing the sensitiveness of substances to electrostatic charges or impulses.

The screen or inductive member may be connected with one side of an electrostatic generator, as shown in Fig. 1 at E^2, or may be grounded, as at E′ in Fig. 5.

Various changes and modifications may be made in the manner of applying our process in actual practice and use. Therefore we do not limit the same to those hereinbefore shown and described, but apprehend any such as of our invention when such changes adopted are within the expected skill of persons conversant with the electrical principles involved. For example, in subjecting materials to the action of varied electrostatic charges for the purpose of separation said variations may be in degree or intensity, potential, polarity period of maintenance, periodicity or rapidity of alternation, and each of these may be in conjunction with changes of polarity for equal or unequal periods and of equal or unequal strength, the positive or negative being the stronger, and by employing simultaneous or successive alternating and pulsating static currents and by other variations which will induce or develop dielectric hysteretic impedance.

The term "dielectric hysteretic impedance" as hereinafter used is what may be termed a "lag of charge in dielectrics under the influence of alternating or irregular stress produced from any desired source of energy." The lag of charge results in maintaining a difference of potential in or on the particles.

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

1. In a process of separating the particles of a mass or the components of a mixture, developing in said particles or components dielectric hysteretic impedance, and separately collecting the particles.

2. In a process of separation, subjecting a mass or mixture to the action of a varied static charge to establish dielectric hysteretic impedance, and separately collecting the components.

3. In a process of separation, subjecting material to be separated to the action of alternating and varied electrostatic charges to establish dielectric hysteretic impedance, and separately collecting the separated components of the material.

4. In a process of separation, subjecting material to alternating electrostatic charges of unequal periodicity to establish dielectric hysteretic impedance, and separately collecting the separated components.

5. In a process of separation, subjecting

material to the action of electrostatic charges in periods adapted in rapidity to establish dielectric hysteretic impedance in any particular material being separated, and separately collecting the separated components.

6. In a process of separation, subjecting material to the action of electrostatic charges varied in periods, potential and in polarity in accordance with the preference of the material being separated to establish dielectric hysteretic impedance, and separately collecting the separated components.

7. In a process of separation, subjecting material to the action of alternating electrostatic charges varied in potential to establish dielectric hysteretic impedance, and separately collecting the separated components.

8. In a process of separation, subjecting material to the action of electrostatic charges varied in the potential of their opposite signs to establish dielectric hysteretic impedance, and separately collecting the separated components.

9. In a process of separation, subjecting material to the action of electrostatic charges varying in the duration of their opposite signs to establish dielectric hysteretic impedance, and separately collecting the separated components.

10. In a process of separation, subjecting material to the action of electrostatic charges varying in the duration and potential of their opposite signs to establish dielectric hysteretic impedance, and separately collecting the separated components.

11. In a process of separation, subjecting particles of a mass or components of a mixture to the action of an alternating electrostatic charge to establish dielectric hysteretic impedance, and separately collecting the separated components.

12. In a process of separating particles of a mass or components of a mixture, developing in said particles or components dielectric hysteretic impedance and simultaneously exposing them to the inductive action of a polarized terminal, and separately collecting the separated particles or components.

13. In a process of separation, passing material through a field having at one point an alternating static charge and at an opposite point a constant static charge to establish dielectric hysteretic impedance, and separately collecting the separated components.

14. The process of separation which consists in subjecting material to the action of an alternating varied electric field of force capable of maintaining a difference of potential between the particles of the mass and a supporting device for said material to establish dielectric hysteretic impedance, and separately collecting the separated components.

15. The process of separation which consists in subjecting material to an electrostatic field of alternating and of variable intensity to establish dielectric hysteretic impedance, removing from the said field by an auxiliary force such particles as are electrified, and separately collecting the separated components.

16. The process of separation which consists in constantly charging a mass or mixture to be separated with a varied and alternating potential to establish dielectric hysteretic impedance, feeding the mass into a dielectric medium and removing therefrom such particles as differ in their electrical relation thereto, and separately collecting the separated components.

17. The process of separating particles of a mass or components of a mixture which consists in charging the same with an electrostatic current of varied potential to establish dielectric hysteretic impedance, simultaneously exposing the same to the inductive action of a polarized terminal, and collecting separately the particles which are sufficiently responsive.

18. In a process of separating the particles of a mass or the components of a mixture producing therein a lag of charge on said particles or components, and separately collecting the separated particles or components.

19. The process of subjecting the particles of a mass or the components of a mixture to the action of an electrostatic current of varying potential so as to cause and maintain a difference of potential between the particles, simultaneously exposing the same to the inductive action of a polarized terminal, and separately collecting the particles that are sufficiently responsive.

20. In a process of separation, subjecting a mass or mixture to the action of a varied static charge regulated to effect a separation by its action upon the dielectric capacity of the particles and separately collecting the components.

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

HENRY M. SUTTON.
WALTER L. STEELE.
EDWIN G. STEELE.

Witnesses:
GEO. W. JALOWICK,
EMMA CURTRIGHT.