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METHOD AND APPARATUS FOR SEPARATING CONDUCTING AND NON-CONDUCTING PARTICLES

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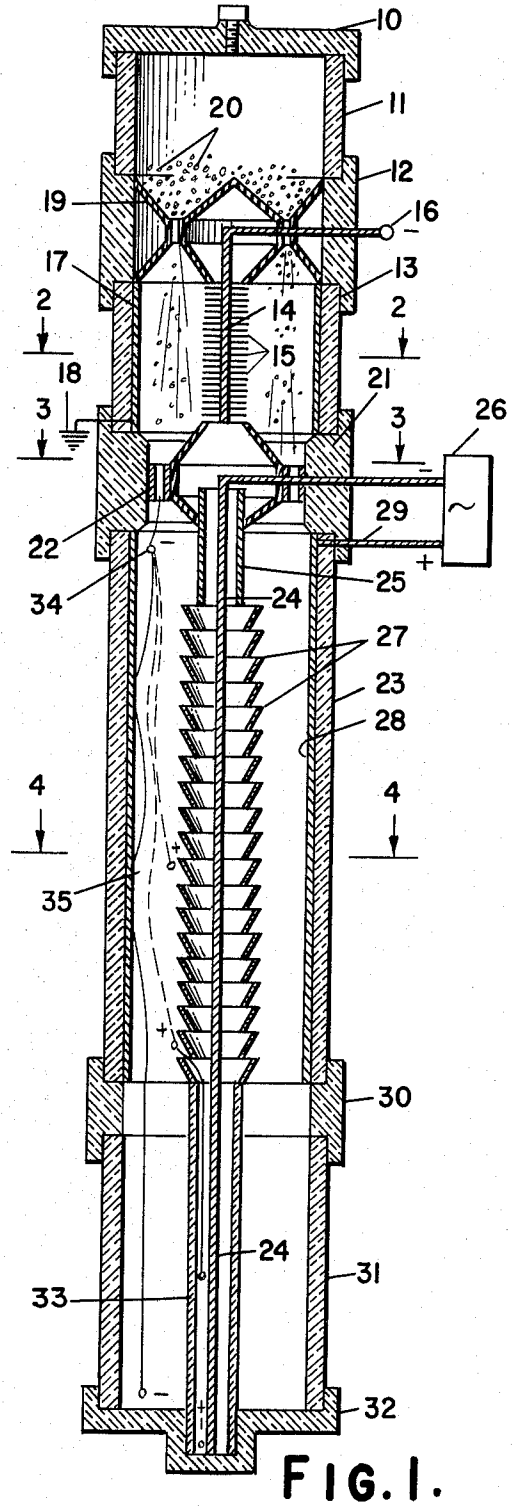


FIG. 1.

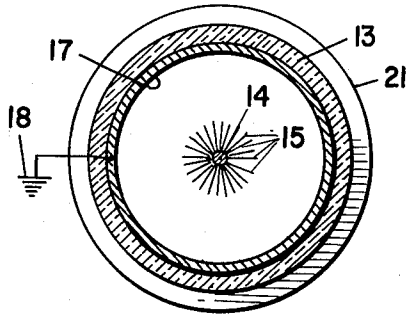


FIG. 2.

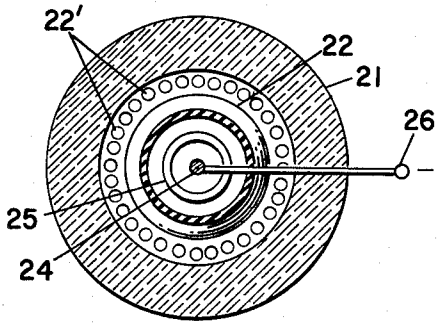


FIG. 3.

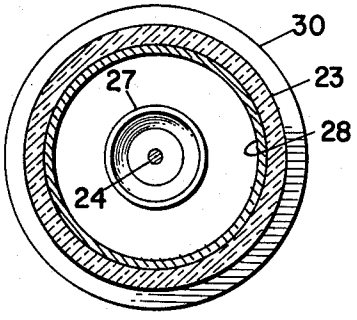


FIG. 4.

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METHOD AND APPARATUS FOR SEPARATING CONDUCTING AND NON-CONDUCTING PARTICLES

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This invention relates generally to material separation processes and apparatus and more particularly to a novel method and apparatus for separating conducting and non-conducting particles from a mixture of such particles by electrical means. The term "non-conducting particles" as used herein is meant to include semi-conductors or relatively poor conductors as compared to electrically conducting particles.

In certain mining operations, it is desirable to separate out from a mixture of particles conducting particles from non-conducting particles. While simple magnetic separating means is useful when the conducting particles are also magnetic in nature or contain iron in certain forms, there are other conductors which have no magnetic properties whatsoever. It would be desirable, accordingly, to provide a separating means which is effective for all types of particles that are conducting in nature to the end that such particles may be separated from non-conducting particles.

With the foregoing in mind, it is accordingly a general object of this invention to provide a novel method and apparatus for separating conducting particles from non-conducting particles.

More particularly, it is an object to provide a novel method and apparatus for separating from a given mixture of particles conducting particles from non-conducting particles by electro-dynamic means.

Other objects of this invention are to provide a novel method and apparatus for separating conducting and non-conducting particles which is relatively compact in construction, economical to operate, and highly effective regardless of the magnetic properties of the particles.

Briefly, these and other objects and advantages of this invention are attained by employing electro-dynamic principles in the separation process. More particularly, in accordance with the method of the invention, all of the particles of the mixture of conducting and non-conducting particles are provided with an electrical charge of like polarity. In the preferred form of the method, this polarity constitutes a negative polarity and may be accomplished by passing the various particles through an electron cloud or stream. In the next step of the method, the charged particles are caused to pass through an electric field. In the event the electric field is supplied by first and second electrodes, the particles will physically engage one or the other of the electrodes. The conducting particles will then lose their charge because of their conducting properties whereas the non-conducting particles will tend to retain the original electron charge imparted thereto. In the next step of the method, the polarity between the first and second electrodes is periodically reversed to reverse the electric field and thus effect a separation of the now differently charged particles.

In the preferred apparatus for carrying out the method, there is provided an elongated cylindrical housing formed of non-conducting material. Within the upper end of this housing, there is provided a center electrode having radial points for discharging electrons into the space surrounding the electrode. The mixture of particles to be separated are then all passed through the resulting free electrons so that they will acquire negative charges.

Further down in the housing, there is positioned a

center electrode and an outer electrode in co-axial arrangement to define an annular passageway therebetween. The particles travel down this passageway by gravity and will strike one or the other of the electrodes. The conducting particles will then lose their charge and become effectively positively charged whereas the non-conducting particles will tend to retain the initial negative charge. By reversing the polarity of the electrodes, the positively charged particles will be drawn towards the negative electrode, and the negatively charged particles towards the positive electrode. The attracting of the particles in different directions thus enables the desired separation to be achieved. The housing serves to enclose the electron charging, the first and second co-axial electrodes, and suitable collecting means. Preferably, the housing is hermetically sealed and partially evacuated so that the electron dynamics are predictable when the polarity between the first and second electrodes is altered.

A better understanding of the method and apparatus of this invention will be had by now referring to a preferred form of the apparatus for carrying out the method as illustrated in the accompanying drawings, in which:

FIGURE 1 is an enlarged cross section of the preferred embodiment of the separating apparatus;

FIGURE 2 is a plan cross section taken in the direction of the arrows 2—2 of FIGURE 1;

FIGURE 3 is another cross section taken in the direction of the arrows 3—3 of FIGURE 1; and,

FIGURE 4 is still another cross section taken in the direction of the arrows 4—4 of FIGURE 1.

Referring first to FIGURE 1, there is illustrated generally an elongated enclosure closed at its upper end by an upper end sealing cap **10** and including an upper chamber defined by a non-conducting cylindrical section such as glass **11**. The lower end of the cylindrical section **11** is shown coupled to a plastic or non-conducting type sleeve **12** to a second cylindrically shaped glass enclosure **13**. Within this upper portion of the housing, there is provided a charging means in the form of a central electrode **14** having a plurality of radially extending points **15**. As shown, the electrode **14** extends upwardly and then laterally out of the sleeve **12** to a negative terminal connection point **16**. Co-axially surrounding the electrode **14** is a grounding sleeve **17** connected to ground as at **18**. This sleeve is secured directly to the inside of the glass cylindrical section **13**. There is thus defined an annular space between the ground sleeve **17** and central electrode **14** and points **15** to which an entrance way is defined by an annular chute **19**. The upper end of the chute **19** is positioned to receive a mixture of both conducting and non-conducting particles **20**.

At the lower end of the cylindrical glass section **13** adjacent the bottom of the charging means is a second sleeve **21** serving to support a distributor plate structure **22**. This structure is for the purpose of distributing the particles in a relatively uniform annular ring for proper entrance into the main separation section of the housing. This separation section of the housing is defined by a cylindrical glass tube **23** connected to the lower end of the sleeve **21**.

Within the separation section of the housing, there is provided a first or center electrode **24** supported by an insulated sleeve **25** at its upper end in turn secured to the distributor plate **22**. The electrode **24** extends above the sleeve **25** and thence laterally to connect to an alternator **26**. As shown in FIGURE 1, the center or first electrode **24** is co-axially surrounded by a plurality of cup-shaped members **27** constituting part of a first collecting means as will be described in greater detail as the description proceeds.

Also incorporated in the separator section is an outer

or second electrode 28 which is connected through a lateral connection 29 to the alternator 26.

The lower end of the main cylindrical glass cylinder 23 connects to a third sleeve 30 formed of non-conducting or plastic material. The portion of the housing below the sleeve 30 is defined by a glass cylinder 31 connected to the lower end of the sleeve 30 and constituting a collecting means for non-conducting particles. The floor of this sleeve is closed off by a lower end cap 32 as shown. The first collecting means for the conducting particles includes an insulated tube 33 surrounding the central electrode 24 as shown and connecting to the last of series of cups so that particles entrapped within the cups will flow into the annular space between the electrode 24 and the inner wall of the collector 33. The separated particles may be removed by removing the end cap 32 after the separation process has been completed.

In FIGURE 2, the arrangement of the radial extending points 15 from the charging electrode 14 will be clear.

FIGURE 3 illustrates in plan view the distributor structure 22, and it will be noted that there are provided a plurality of openings 22' which will aid in distributing the particles annularly about the upper portion of the housing so as to fall relatively uniformly between the first and second electrodes 24 and 28.

In FIGURE 4, the relative size of the lower opening of the cup-shaped elements 27 will be visible relative to the diameter of the conductor 24, and it will be noted that particles entrapped within any one of the cups will thus fall downwardly generally parallel to the electrode 24 into the first collector 33.

In operation, the housing is positioned in an upright position as illustrated in FIGURE 1. The mixture of conducting and non-conducting particles 20 is then fed into the top of the housing by removing the upper end cap 10. The cap is then replaced and the housing partially evacuated.

A source of negative electrical charges such as electrons is then connected to the terminal 16 so that negative charges will pass from the electrode 14 to the ends of the radially directed points 15 and thence to the grounded sleeve 17. The particles 20 will fall annularly about the center electrode through the radially directed electron stream and will all acquire a charge of like negative polarity. Since the particles are all charged with electrical energy of the same polarity, they will repel each other and tend to fan out or separate as they descend by gravity. The distributor plate 22 will collect these particles and re-form them into an annular array for entryway into the main separating section of the housing.

In accordance with an important feature of the method and apparatus of this invention, the first electrode 24 is initially charged negatively and the outer second electrode 28 is provided with a positive charge from the alternator 26. With a positive potential on the outer electrode 28, consider first the path of a non-conducting particle. This non-conducting particle will have a negative charge such as indicated at 34. It will thus be initially attracted to the electrode 28 as it falls downwardly thereby following the arcuate solid line path as shown. However, the particle 34 will not lose its charge since it is a non-conductor but will merely cling to the side of the wall 28. If now the polarity of the electrodes 24 and 28 is reversed by the alternator 26 so that the outer electrode 28 becomes negative and the center electrode positive, the particle 34 will be repelled away from the outer electrode and drawn towards the center electrode. Before it reaches the center electrode, however, the polarity is again reversed so that it will be drawn back towards the outer electrode. This process will continue until the particle 34 drops into the annular space between the lower cylindrical glass wall section 31 and the outer wall of the first collector 33.

With respect now to a conducting particle having an initial negative charge when received within the separator section, consider the particle 35 indicated by the plus sign. This particle, as in the case of the non-conducting particle, will initially be attracted to the outer electrode 28 because of the positive charge thereon. However, when the conducting particle strikes the electrode 28, it will immediately lose its negative charge because of its conducting properties and thus essentially become positively charged. When the outer electrode 28 then becomes positive, the positive charge 35 will be repelled therefrom and drawn towards the center electrode 24. When the outer electrode is positive, the center electrode is negative so that it will tend to draw the positive particle towards the center electrode.

By making the polarity changes asymmetrical, that is by making the center electrode negative for a longer period than it is positive and the outer electrode positive for a longer period than it is negative, the non-conducting particles which essentially retain their negative charge will be attracted towards the outer electrode over the average length of time that it traverses down the elongated housing whereas the positive particles will be drawn towards the center electrode over this average length of time. As a consequence, the positive particles will be caught in one of the cup-shaped elements and thence fall within the annular space between the central electrode 24 and annular wall 33 to be collected in this first collecting means as described heretofore.

The change of polarity by the alternator is of relatively low frequency; for example, from 10 to 30 alterations per minute. The asymmetry of polarity may be about 3 to 1 so that the center or first electrode is negative for a period three times as long as it is positive and the outer or second electrode is positive for a period three times as long as it is negative.

By removing the end cap 32, the non-conducting particles which are retained in the second outer annular collection chamber may thus be separated from the conducting particles which are trapped between the tube 33 and central conductor 24.

From the foregoing description, it will thus be evident that the present invention has provided a unique method and apparatus for electro-dynamically separating conducting particles from non-conducting particles. While only one specific embodiment has been set forth and described, it will be evident to those skilled in the art that variations within the scope and spirit of the invention may be carried out. The method and apparatus is therefore not to be thought of as limited to the exact embodiment disclosed merely for illustrative purposes.

What is claimed is:

1. A method of separating from a mixture of particles, conducting particles from non-conducting particles, comprising the steps of: charging all of said particles with electrical charges of like polarity; establishing an electric field; passing all of said particles through said field; and asymmetrically changing the polarity of said field as said particles are passed therethrough, so that said field is of one polarity for a period of time longer than at the opposite polarity whereby said conducting particles acquire a charge opposite to that of said non-conducting particles and whereby said conducting particles are attracted in a first direction by said field for collection and said non-conducting particles are attracted in a second different direction by said field for collection.

2. An electro-dynamic separator for separating from a mixture of particles, conducting particles from non-conducting particles, comprising, in combination: charging means for charging all of the particles of said mixture with electrical charges of like polarity; first and second electrode means for establishing an electric field; means for passing all of said particles through said electric field between said first and second electrode means; and means for asymmetrically changing the polarity of said first and second electrode means so that said field is of one polarity for a period of time longer than at the

opposite polarity, whereby said conducting particles will lose their charge and attain an opposite charge and said non-conducting particles will retain their original charge so that said conducting particles are attracted towards said first electrode means and said non-conducting particles are attracted towards said second electrode means.

3. A separator according to claim 2, including: first collecting means for said conducting particles and second collecting means for said non-conducting particles.

4. A separator, according to claim 3, in which said first and second electrode means comprise a central elongated center electrode and surrounding cylindrically shaped outer electrode respectively; non-conducting housing means supporting said electrodes in coaxial relationship, said housing means including said charging and collecting means.

5. An electro-dynamic separator for separating from a mixture of particles, conducting particles from non-conducting particles, comprising, in combination: an elongated cylindrical non-conducting housing means; particle charging means in the form of a plurality of radially extending discharge points positioned within the upper portion of said housing and adapted to be connected to a source of electrons; means in the upper portion of said housing for passing said mixture of particles past said points whereby said particles will acquire negative charges; first and second coaxial electrodes positioned in the central portion of said housing for receiving charged particles from said upper portion of said housing within the annular space between said first and second electrodes; means for asymmetrically changing the polarity of said

first and second electrodes as said particles pass through said annular space therebetween so that the polarity of said first electrode is negative for a longer period of time than positive and the polarity of said second electrode is positive for a longer period of time than negative, whereby the non-conducting ones of said particles will retain their initial negative charge and the conducting ones of said particles will lose their electrical charge to one of said electrodes; and first and second collecting means associated with said first and second electrodes respectively for receiving said particles after they have traversed between said electrodes, the conducting particles falling within said first collecting means and the non-conducting particles falling within said second collecting means.

6. A separator according to claim 5, in which said first collecting means includes a series of cup-shaped elements coaxially positioned about said first electrode so that particles drawn within a given distance of said first electrode will fall within one of said cups and be channeled towards the lower end of said housing.

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