March 20, 1956 I. M. LE BARON 2,738,875

METHOD AND APPARATUS FOR ELECTROSTATIC SEPARATION

Filed March 30, 1951

Fig. 1

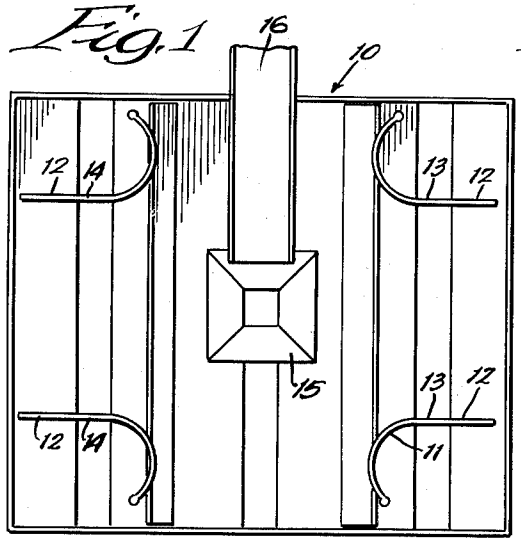


Fig. 2

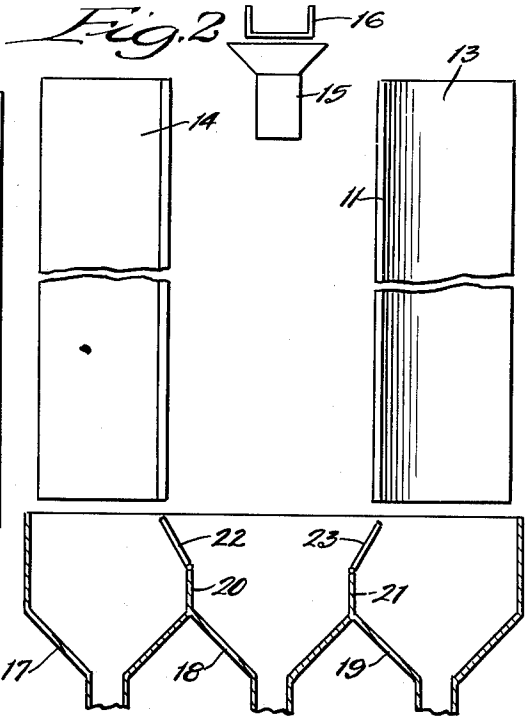
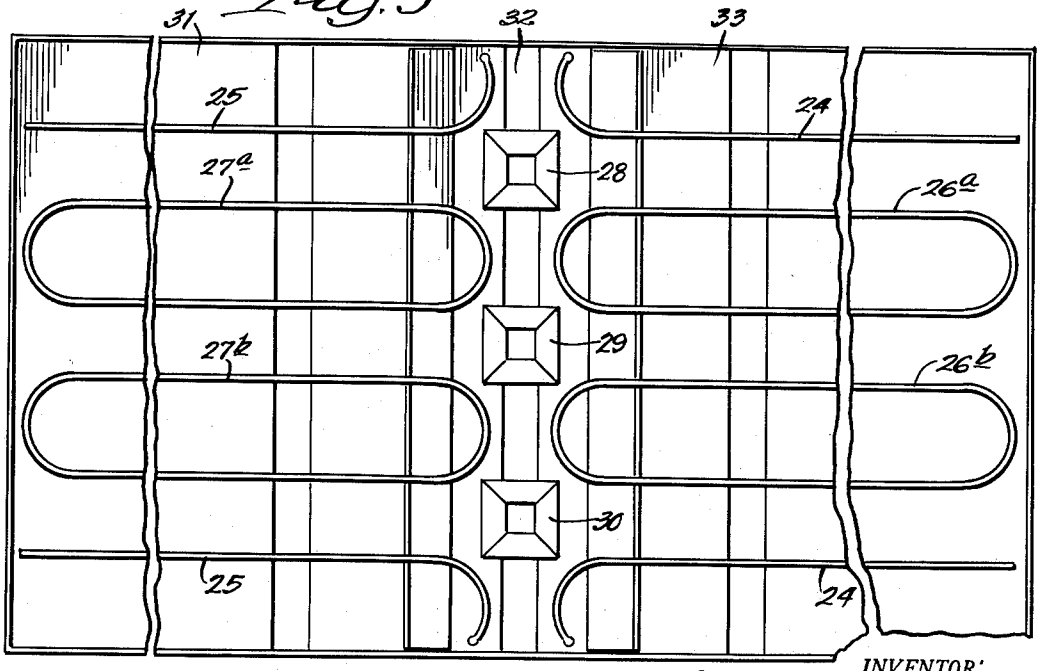


Fig. 3



INVENTOR:
Ira M. LeBaron,
BY
Ernest V. Haines
ATTORNEY.

United States Patent Office 2,738,875
Patented Mar. 20, 1956

2,738,875

METHOD AND APPARATUS FOR ELECTROSTATIC SEPARATION

Ira M. Le Baron, Lakeland, Fla., assignor to International Minerals & Chemical Corporation, a corporation of New York

Application March 30, 1951, Serial No. 218,472

11 Claims. (Cl. 209—127)

This invention relates to electrostatic separation of material particles. More particularly, it relates to a method and apparatus for effecting electrostatic separations. Still more particularly, it relates to electrodes of improved design for electrostatic separation apparatus.

One of the simplest methods for separation of non-conductor materials is to pass the composite material or ore through one or more electrostatic fields formed between essentially paired and oppositely charged plate electrodes. In the past, these electrodes have consisted of smooth surfaced, straight, flat, or curved plates.

Plate electrodes have, however, been a source of numerous difficulties. A primary difficulty has been the tendency of particles to ride down the face of the electrode and to take on an opposite charge by contact with the electrode. When the polarity of the particle charge is reversed, the particles are repelled and travel towards the oppositely charged electrode. Repelled particles of reversed polarity thereupon mix with repelled particles originally of opposite charge reducing the effectiveness of the separation. Additionally, the electrodes tend to build up material on the face thereof which does not reverse the charge but which does interfere with the electrostatic field. Further, straight electrodes must be divergent from parallel vertical planes in order to give the stream of falling particles room to spread out according to their relative charges and intensity of charge. This divergence weakens the electrostatic field and therefore the efficiency of separation effected between the lower portions of the divergent electrodes falls off rapidly.

It is an object of the instant invention to overcome the disadvantages and shortcomings of apparatus heretofore utilized.

It is a further object of the invention to provide an electrostatic method of beneficiating ores wherein charged particles are moved in an unobstructed path thus permitting the movement of charged particles of opposite polarity a greater distance in opposite directions.

It is a still further object of the invention to provide an electrostatic method of beneficiating ore wherein negatively and positively charged particles are moved such distances in opposite directions relative to one another than cleaner separations may be effected.

It is a further object to provide electrodes which are maintainable equidistantly spaced over their entire length.

It is a further object to provide electrodes which produce an elongated field free of impediments to particle travel.

It is a further object to provide electrodes which constrict the particle travel path into elongated relatively narrow channels.

It is a still further object to provide electrodes such that the material fed betwen the electrodes is moved laterally a greater distance and thereby purer end products are produced.

It is a further object to provide electrodes which have a configuration such that the body portion of the electrodes is substantially parallel to the direction of material movement in response to the electrostatic field.

These and other objects will be apparent to those skilled in the art as the description proceeds.

It has now been discovered that, provided the path is unobstructed, an electrostatic field of high flux density in the area of introduction of a multicomponent ore feed will give the particles an initial thrust and cause the particles to pass into an area having a field of substantially zero flux density, bounded by electrode plates of identical polarity and magnitude of charge, thereby allowing considerable horizontal movement within the shields due to initial impetus, which horizontal movement permits segregation of high purity products in a single pass through the electrostatic field.

The method of beneficiating ore in accordance with the novel method and apparatus comprises feeding charged multicomponent finely divided material as liberated ore particles, in such spaced relationship as to be free moving, into an electrostatic field which gives particles a thrust in the direction of elongated relatively narrow channels, bounded by electrodes of like polarity and magnitude of charge on both the negative and positive electrode sides of the field, and collecting a plurality of fractions, one of which on each side of the field is enriched as to one component of the feed.

In the preferred embodiment of the invention, an electrostatic field of high concentration is built up in the vertical plane in line with the feed inlet. This field progressively decreases in strength as it is constricted into the portion of the channels between companion electrodes of the same polarity closest to the feed.

That portion of the material which moves through the channels between electrodes of like polarity apparently has been given sufficient initial energy to travel through an area having a field gradient which has been substantially reduced to zero. The particle is permitted, by such a field, to travel in its original direction without adding energy to the electrical field. Material contacting the electrodes tends to travel along the surface of the electrode toward the weak end of the electrostatic field before dropping in collection hoppers.

In this method of beneficiating ore, material is subdivided until reduced to suitable particle size, the ore is then dried and the dry ore of relatively uniform particle size is induced to accept an electric charge. Charged material subsequently is passed through an electrostatic field set up between convex electrodes of opposite polarity and is collected as concentrate fractions in the vicinity of the lower portions of said electrodes or conductors.

In the operation of this method, the feed material, generally a raw ore, is sized if it is of the nature of Florida phosphate pebble or is crushed sufficiently to unlock or liberate its constitutents, and is screened by the usual procedures to produce a granular product having a previously determined or selected particle size; for example, in the range of approximately —14 mesh and +200 mesh obtained by the use of standard screens.

Comminuted ore is dried and then induced to accept an electric charge. The material is preferably charged in the absence of an electric field by causing the particles to contact a conducting or donor surface connected to a source of free electrons as by being grounded through an electrical conductor. One method of accomplishing this result is to convey warm particles having a temperature in the range of approximately 150° F. to approximately 500° F. to a feeder having a grounded contact chute surface of iron, lead, zinc, aluminum, copper, tin, and the like. When the particles flow in a thin stream over the chute surface, which is connected by an electrical conductor to the earth, the individual particles take on a

charge either negative or positive according to the nature of the material.

The charged particles are preferably fed as free-falling bodies between the oppositely charged electrodes of one or more electrostatic separating units, i. e., in a path normally not in contact with said electrodes. The strength of the electrostatic field which will effectively alter the path of particle movement varies with the average particle size of the ore fed to the separator. This voltage may vary from 5,000 volts per inch of distance between electrodes in separating material of relatively fine particle size, to 15,000 volts per inch of distance separating electrodes for beneficiation of relatively coarser particles. In all such discussion of field strength, it must be borne in mind that corona discharges which ionize air are to be avoided. In general, it is preferred to operate with a total impressed difference in potential of voltage in the range of 50,000 volts to 250,000 volts. This voltage should be maintained at a high direct voltage potential substantially free of alternating current components, i. e., filtered D. C. current should be low in the so-called A. C. ripple. A steady supply of D. C. voltage may also be obtained without expensive filtering apparatus by the use of such equipment as radio frequency power supply.

The invention will be more fully understood by reference to the drawings in which:

Figure 1 is a top plan view of a set of electrodes shaped and arranged in accordance with the instant invention.

Figure 2 is a side elevational view of the electrodes of Figure 1.

Figure 3 is a top plan view of a multiple electrode arrangement having some electrodes common to two electrode separation paths or channels.

Referring to Figures 1 and 2, the numeral **10** indicates an electrode having a convexly curved face or shoulder portion **11** and an elongated extension or body portion **12** of lesser or even zero curvature. These electrodes must be operated in clusters of four, or the equivalent, with units of opposite polarity arranged in a spaced, shoulder-to-shoulder, endwise alignment. Companion negatively charged electrodes are indicated by numeral **13** and companion positively charged electrodes are indicated by numeral **14**. Intermediate the electrode cluster is an ore feed distributor mechanism **15**.

The curvature of the electrodes is subject to marked variation. Units may be formed, for example, as a segment of a circle, the body portion formed as a straight line tangent to the circle at the end point of the segment; or, the unit may be a segment of a parabola terminating at the point of greatest width; or, the configuration may be a segment of an ellipse from approximately the intersection with the longest axis to approximately the intersection with the shortest axis, hyperbolic in shape, or equivalent construction.

Material is delivered to distributor **15** through grounded chute **16** which is preferably of the vibratory type. Adjacent the bottoms of electrodes are collection hoppers **17**, **18**, and **19**. Hoppers **17** and **18**, and hoppers **18** and **19**, have common walls **20** and **21**, respectively, provided with pivot arms **22** and **23**, respectively, adapted to be secured at any desired angle for altering the cut-point of material to be collected in the various hoppers.

In Figure 3 is shown an arrangement of a multiplicity of parallel channeled portions of the electrostatic field as set up between electrodes wherein each electrode, except those at the extremities of each group, serve as electrodes for two individual channels. Electrodes at the extremities of a group of like polarity are the type shown in Figure 1 and are indicated as **24** for negative electrodes and **25** for positive electrodes. Intermediate the end negative electrodes **24** are negative electrodes **26***a* and **26***b*, each consisting of parallel walls connecting semicircular ends. Intermediate positive electrodes **25** are positive electrodes **27***a* and **27***b* of construction similar to negative electrodes **26***a* and **26***b*. Material is distributed to an area intermediate the electrodes by distributors **28**, **29**, and **30**, respectively. Material passing through the electrostatic field is directed outwardly and downwardly. Positively charged material passes between electrodes **24** and **26***a*, electrodes **26***a* and **26***b*, and electrodes **26***b* and **24**, while negatively charged material passes between electrodes **25** and **27***a*, **27***a* and **27***b*, and **27***b* and **25**. The separated material is collected in hoppers **31**, **32**, and **33**.

Operation of the equipment illustrated in Figures 1 and 2 is shown by the following example.

Example

Florida pebble phosphate ore was ground to a particle size in the range of approximtaely −14 mesh to approximately +200 mesh. It had a B. P. L. content of approximately 25%. The ore was heated to dryness in an electric oven maintaining a temperature of about 300° F. The warm material was charged by passage through a zinc-coated trough grounded to the earth by an electrical conductor. Two separate portions of ore were electrostatically tested, and one portion was fed to the distributor of the apparatus of the instant invention at a rate of one ton per hour per linear foot of electrode. The ore travelled as free-falling particles between electrodes of the instant invention, 10 feet long, about 4 feet in width, and having a convex curvature shoulder of 30 inch radius of curvature arranged as shown in Figures 1 and 2. Electrodes of like polarity were spaced 3 inches apart adjacent the shoulder and 1 inch apart at the outer end, and electrodes of opposite polarity were spaced 3 inches apart in shoulder-to-shoulder arrangement. Material was collected in hoppers approximately as shown in Figure 2. The second portion of ore was passed between plate electrodes 10 feet long and 18 inches wide in face-to-face arrangement at approximately the same rate of feed. These electrodes were spaced 9 inches apart. The potential difference between electrodes in both types of apparatus was about 90,000 volts. In each instance the material was given one pass between electrodes and results were as follows:

Plate electrodes give slightly higher than 5% B. P. L. in the tail product when producing a concentrate having slightly more than 40% B. P. L. in the concentrate. Electrodes of the configuration described, on the other hand, have approximately 2.5% B. P. L. in the tail product when producing the 40% B. P. L. concentrate. When utilizing plate electrodes to produce concentrates of greater than 50% B. P. L. content, the B. P. L. content of tail fractions rapidly rises to the 10% to 15% B. P. L. level; whereas, when utilizing the electrodes of the instant invention, concentrates of about 65% B. P. L. content are obtained before there is any appreciable increase in B. P. L. content of the tail product. In addition, the B. P. L. content of the concentrate may be pushed almost to 70% before the B. P. L. content of the tail product rises to the 10% to 15% level.

Having thus fully described and illustrated the character of the invention, what is desired to be secured and claimed by Letters Patent is:

1. An electrostatic separation machine comprising a source of unidirectional electricity, at least a first pair of electrodes electrically connected to be of like polarity, at least a second pair of electrodes electrically connected to be of the same polarity, said polarity being opposite to that of said first pair of electrodes, each of said electrodes in cross sectional configuration being formed with a straight body portion and a shoulder formed as a segment of a circle, the various pairs of electrodes being arranged with straight body portions substantially parallel and with shoulders diverging, said pairs of electrodes of opposite polarity being arranged with shoulders adjoining one another and with straight body portions in substantially straight line alignment, means to feed ore particles between said electrodes of opposite polarity, and collection hoppers for receiving separated material.

2. An electrostatic separation machine comprising a source of unidirectional electricity, a plurality of spaced electrodes connected to said source of electricity, said electrodes extending vertically parallel to the free fall path of feed material and being in cross sectional configuration formed with a convex curvature shoulder and an elongated straight body portion, said electrodes being arranged in spaced pairs with convex curvature shoulders adjoining one another and body portions substantially parallel, said pairs of electrodes being arranged in parallel as groups having one polarity, said groups of electrodes of opposite polarity being positioned with electrode shoulders adjacent and with the straight body portions in substantially straight line alignment, and collection hoppers for separated material.

3. For use in an electrostatic machine, the unit comprising a plurality of spaced electrodes, said electrodes extending vertically parallel to the free fall path of feed material and in cross sectional configuration being formed with a convex curvature shoulder and an elongated straight body portion, said electrodes being arranged in spaced pairs with body portions substantially parallel, and convex curvature shoulders adjoining one another and diverging, said pairs of electrodes being arranged in parallel groups having one polarity, groups of pairs of electrodes of opposite polarity being positioned with electrode shoulders adjacent and with the straight body portions in substantially straight line alignment.

4. Electrostatic separation apparatus comprising a first pair of horizontally spaced electrodes facing each other, a second pair of similarly horizontally spaced electrodes facing each other, the electrodes of said second pair being horizontally spaced from and positioned opposite the corresponding electrodes of the first pair, means for feeding particles to be separated to fall freely in a zone substantially equidistant from all said electrodes, electrical means for applying an electrical charge of like polarity to the electrodes of the first pair and for applying an electrical charge of like polarity to electrodes of the second pair with the charges on the electrodes of the second pair being opposite to the charges on the electrodes of the first pair, and collection means for receiving separated particles.

5. A method of electrostatic separation of oppositely electrically charged particles which comprises dropping said particles to fall freely into an electrostatic field having an elongated zone of uniform positive potential and

an oppositely extending elongated zone of uniform negative potential in alignment with the first mentioned zone, the particles being introduced between the two zones and in substantial alignment with the two zones, thus giving the positively charged particles a horizontal thrust in a direction to impart to such positively charged particles a movement having a horizontal component through said elongated zone of uniform negative potential, and giving the negatively charged particles a horizontal thrust in a direction to impart to such negatively charged particles a movement having a horizontal component through said elongated zone of uniform positive potential, and collecting the separated particles falling through at least one of said zones.

6. A process as in claim 5 wherein the particles to be separated are particles of phosphate ore of −14 to +200 mesh.

7. A process as in claim 5 wherein the difference of potential between the zone of positive potential and the zone of negative potential ranges between about 50,000 volts and about 250,000 volts.

8. A process as in claim 7 wherein the particles to be separated are particles of phosphate ore of −14 to +200 mesh.

9. A process as in claim 5 wherein the oppositely electrically charged particles are particles of a finely divided multicomponent ore.

10. A process as in claim 5 wherein the oppositely electrically charged particles are particles of comminuted ore.

11. A process as in claim 10 wherein the difference of potential between the zone of positive potential and the zone of negative potential ranges between about 50,000 volts and about 250,000 volts.

References Cited in the file of this patent

UNITED STATES PATENTS

1,335,758	Schmidt	Apr. 6, 1920
2,247,596	Boer	July 1, 1941
2,536,693	Okolicsanyi	Jan. 2, 1951

OTHER REFERENCES

Bureau of Mines Report of Investigations 3667, dated November 1942, pages 2, 3, and Figure 1.

Bureau of Mines RI 3667, dated November 1942, page 11. (Copies in Scientific Library.)