May 27, 1969

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3,446,355

PROCESS AND APPARATUS FOR PNEUMATICALLY CLASSIFYING PULVERULENT MATERIAL

Filed Feb. 28, 1967

Sheet 1 of 4

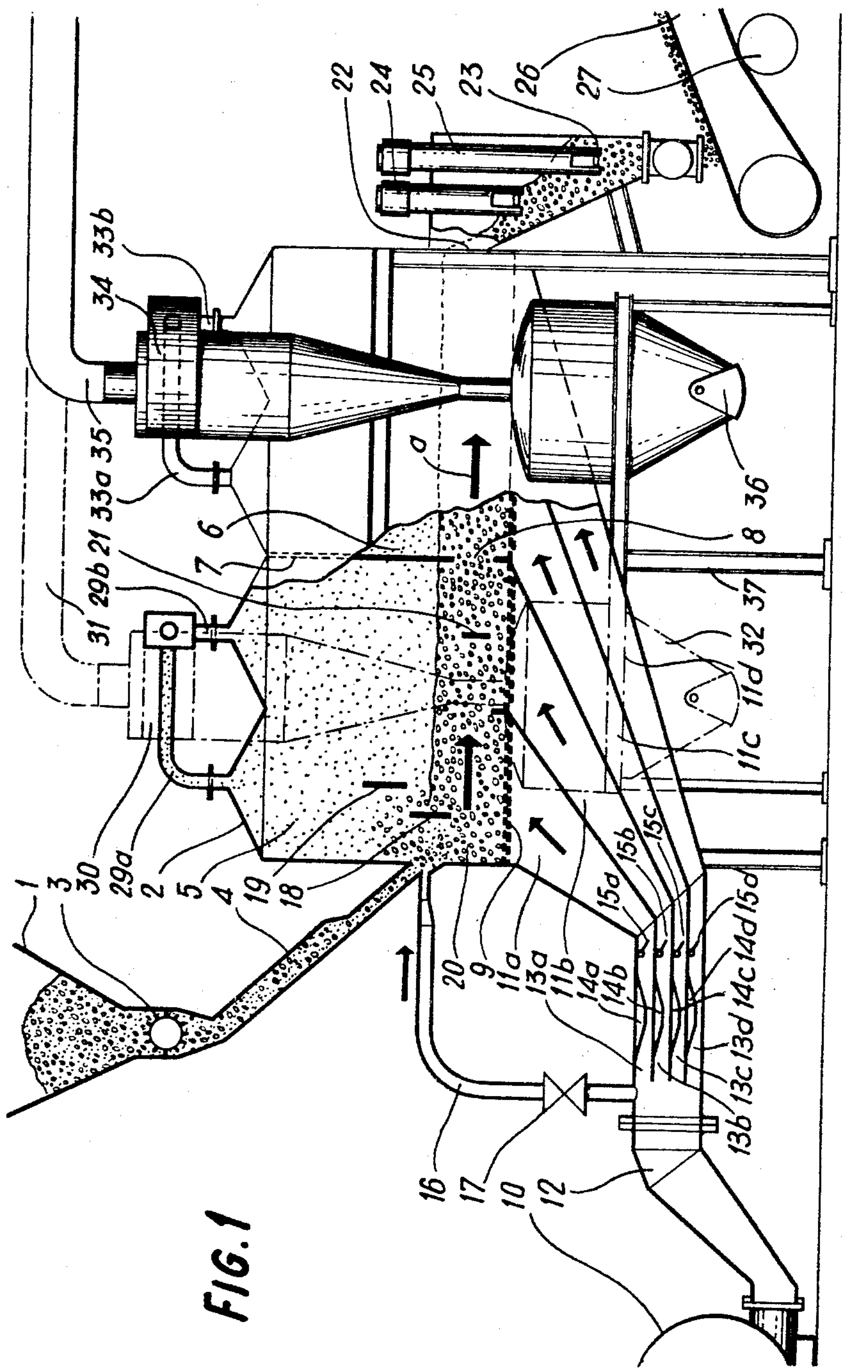

FIG. 1

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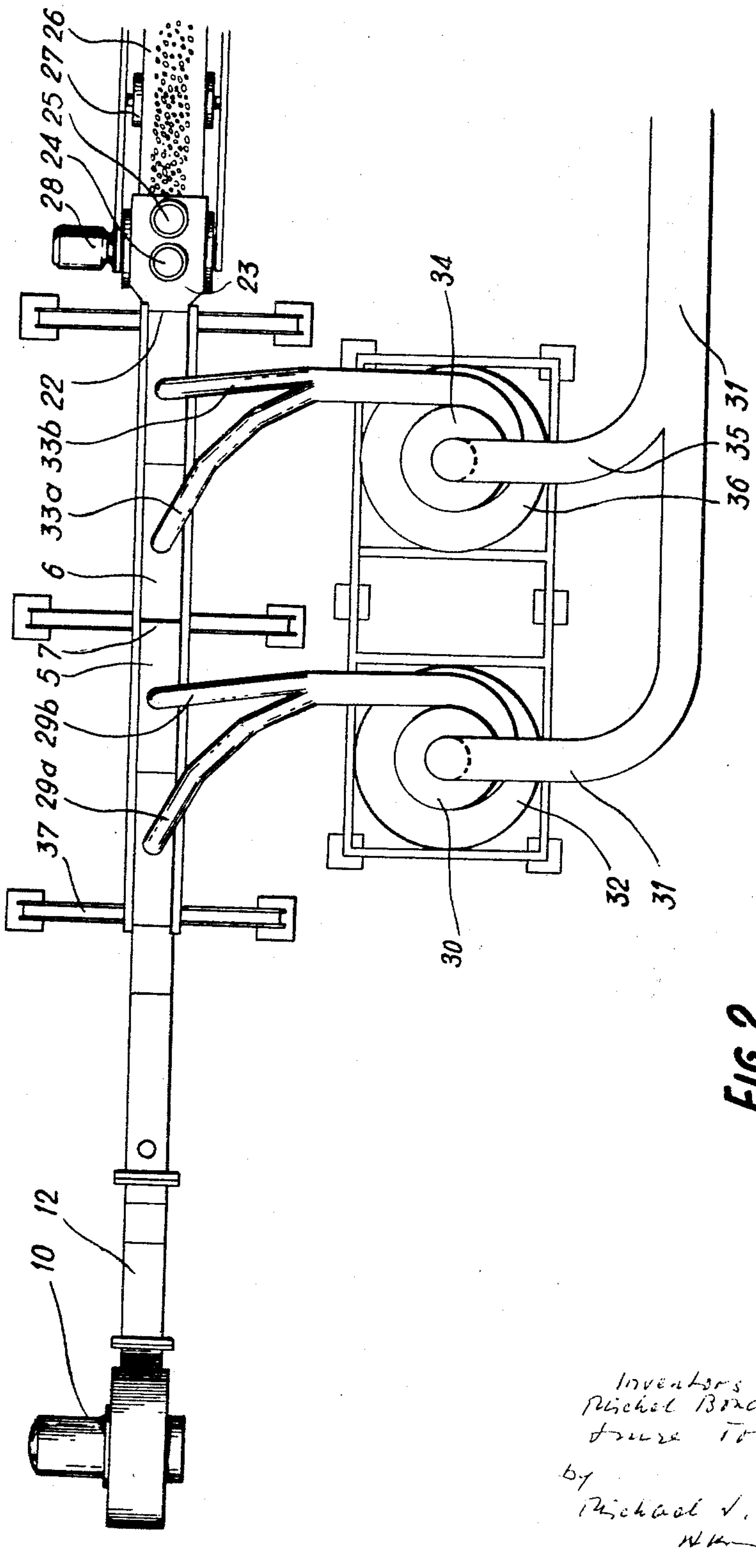

FIG. 2

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FIG. 3

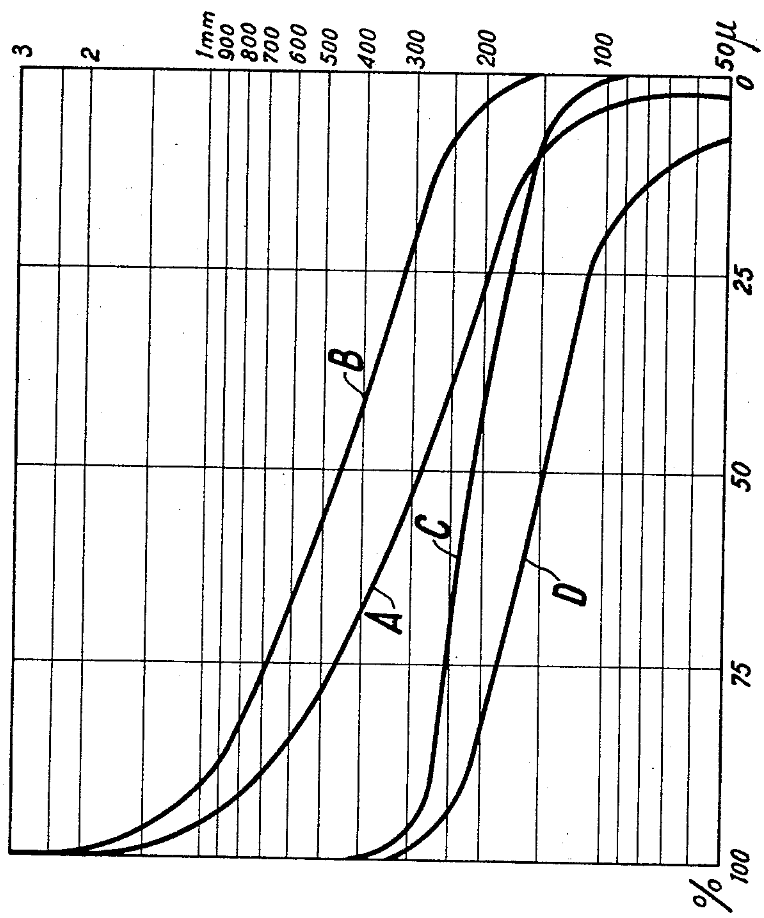

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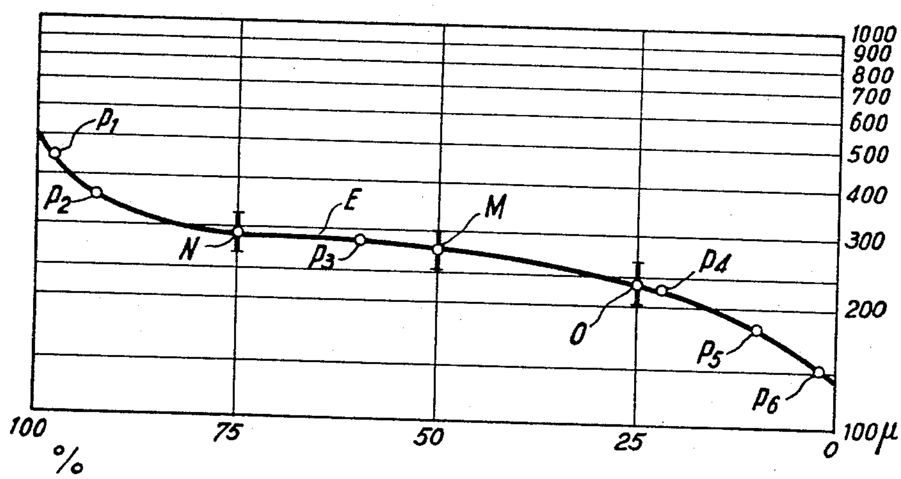
FIG. 4



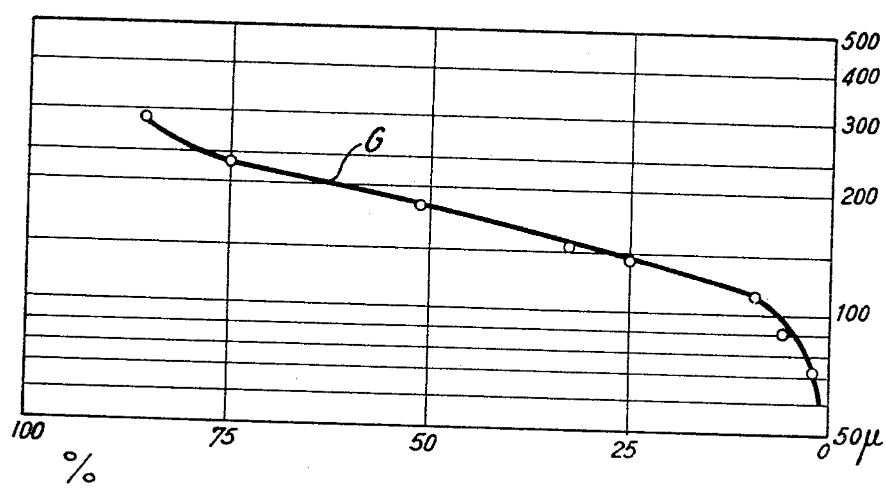


FIG. 5

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United States Patent Office

3,446,355

Patented May 27, 1969

3,446,355

PROCESS AND APPARATUS FOR PNEUMATICALLY CLASSIFYING PULVERULENT MATERIAL

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Filed Feb. 28, 1967, Ser. No. 619,275
Claims priority, application France, Mar. 2, 1966, 51,582
Int. Cl. B07b 3/02
U.S. Cl. 209—474 16 Claims

ABSTRACT OF THE DISCLOSURE

A process and apparatus for pneumatically classifying pulverulent material in which a continuous stream of pulverulent material is fed at one end of an elongated relatively high and narrow receptacle into the latter and in which a stream of gas under pressure is fed with such a speed through the perforated bottom of the receptacle to form above the perforated bottom a layer of large size particles in suspension without lifting the largest particles out of the layer, while the small size particles are lifted out of the layer into the space above the latter, and in which the larger size particles are continuously discharged from the other end of the receptacle while the small size particles are discharged together with the gas from the top region of the receptacle.

Background of the invention

The present invention relates to a process and apparatus for pneumatically classifying pulverulent material, that is to separate large size particles contained in a mass of pulverulent material from small size particles contained therein.

Various apparatus are known for pneumatically classiing pulverulent material.

It is an object of the present invention to provide for a process and an apparatus for pneumatically classifying pulverulent material in an efficient continuous process in which the separation of the pulverulent material according to grain size can be carried out with great precision.

Summary of the invention

With these objects in view, the process according to the present invention of pneumatically classifying pulverulent material mainly comprises the steps of forming an elongated fluidized bed of pulverulent material of a height not exceeding 30 cm. and of a length at least six times the width of the bed by feeding into the pulverulent material upwardly directed gas with a speed at least equal to the fluidizing speed of the largest particles of the pulverulent material and inferior to a speed to lift the largest particles out of the fluidized bed, but superior to a speed to carry away the smallest particles, continuously feeding a stream of pulverulent material to be classified into one end of the elongated bed, continuously withdrawing the largest particles at the opposite end of the bed so that the largest particles will move from the one to the other end of the bed, maintaining above the fluidized bed a free space at least eight times the height of the fluidized bed into which the finest particles of the pulverulent material are carried by the upwardly directed gas, evacuating the gas stream with the finest particles suspended therein from the space, and separating the finest particles from the gas streams.

The process may also have the following characteristics combined with the characteristics set forth above:

(a) At least two upwardly directed streams of gas are

introduced into the bed with one of the streams closer to the other end of the bed having a higher speed than the other.

(b) A lateral stream of gas is introduced into the stream of pulverulent material fed at the one end into the fluidized bed so as to facilitate removal of dust clinging to the largest particles.

(c) The upwardly directed gas is fed under an angle inclined in direction toward the other end of the bed to the vertical into the bed to enhance displacement of the largest particles from the one to the other end of the bed.

It is also an object of the present invention to provide for an apparatus for carrying out the above set forth method, which apparatus mainly comprises an elongated receptacle having at least a length six times its width and a perforated bottom wall, means communicating at one end of the receptacle and at a distance of 5–30 cm. above the bottom wall with the interior of the receptacle for continuously feeding a stream of pulverulent material into the latter, means for feeding a gas under pressure in upward direction and at the aforementioned speed through the perforated bottom wall of the receptacle so as to form from the largest particles of the pulverulent material fed thereinto a fluidized bed above the bottom wall, means for discharging the largest particles from the other end of the receptacle, the receptacle having above the fluidized bed a height of at least eight times the height of the fluidized bed, and means communicating with the top portion of the receptacle for discharging the gas carrying the finest particles of the pulverulent material from the interior of the receptacle.

The apparatus according to the present invention may also have the following characteristics combined with the characteristics stated above:

(a) The means for feeding a gas stream in upward direction through the perforated bottom wall into the interior of the receptacle may comprise at least two gas passages, one of which communicates at its inner end with the interior of the receptacle closer to the other end thereof than the other of the two passages, and means for feeding gas streams of different speeds through the aforementioned two passages.

(b) The apparatus may also include a means for introducing into the air stream of pulverulent material as it is fed into the receptacle a stream of gas under pressure in direction transverse to the stream of pulverulent material to enhance separation of large size particles of the pulverulent material from small size particles at the point of introducing the pulverulent material into the receptacle.

(c) The means for feeding gas under pressure through the perforated bottom wall may extend inclined toward the other end of the receptacle to the vertical so as to enhance flow of the large size particles of the fluidized bed from the one to the other end of the receptacle.

As far as understood, the present invention consists of pneumatically classifying a pulverulent material into distinct fractions according to grain size by suspending the particles in upwardly directed gas stream circulating in a receptacle in such a manner that the particles of a size superior to a certain limit are concentrated in a layer forming a fluidized bed at the bottom region of the receptacle, whereas the particles having a dimension inferior to the predetermined limit are lifted by the gas stream toward the top of the receptacle. In order to do so, the speed of the upwardly directed gas stream is maintained at such a speed that the large size particles are not carried away by the gas stream but only held in suspension, whereas the small size particles are lifted by the gas stream out of the bed in suspension formed by the large size particles.

The process according to the present invention in which the product to be classified is placed in suspension and in which the finest particles are lifted by the gas currents, closely resembles the pneumatic separation process known as "elutriation." This process essentially differs from a classification process by fluidization in which the pulverulent material to be classified is fluidized above a grill in a fluidized bed through which upwardly directed air streams circulate and in which the speed of the air streams is such that the fluidized mass is progressively separated into layers of different grain sizes and densities and in which the particles of different grain size in the various sections are separately collected at different levels of the fluidized bed. Since the pulverulent product to be classified always contains a small proportion of very fine dust, there is always, in the classifying process in which all of the particles are maintained in a fluidized bed a small fraction of the particles which are carried away by the fluidizing gas; however, this peculiarity should not lead to confuse the classifying process in which the whole mass of particles to be classified are maintained in a fluidized bed with the process of classifying by elutriation according to the present invention, since the quantity of dust carried away by the fluidizing gas is relatively small, for instance 5% compared to the total mass of pulverulent material contained in the fluidized bed and the size limit of the dust thus carried away will always be uncertain and not precise.

Contrary thereto, the present invention proposes to effect classification by elutriation by placing the pulverulent material to be classified in suspension. This placing in suspension according to the present invention differs from the fluidizing according to the prior art by the speed of the gas in the interior of the pulverulent material and by the effect of this gas speed on the product, during fluidization the speed of the gas streams is such that practically the whole mass of pulverulent material is fluidized in the bed and only the extremely fine dust mixed with the product to be classified is carried away by the gas, whereas in the elutriation process according to the present invention a notable fraction per weight of the product to be classified, for instance at least 20%, are carried away by the gas streams whereas the largest particles form a very agitated layer in suspension in which no stratification according to dimensions or densities takes place.

It is an important advantage of the present invention to permit a sharp separation into fractions of different grain size due to the combination of the characteristics of the process. In order to realize a sharp and precise separation according to grain size, it is necessary to give the receptacle in which the separation takes place the form of an elongated channel having a leugth which is very great as compared to its width and the ratio of these two dimensions should be at least 6 and preferably equal to 10. This ratio of the length to width of the receptacle is an essential characteristic according to the present invention since it is absolutely necessary that the particles to be classified follow a substantially rectilinear path from the point of their introduction into the receptacle to the point of discharge therefrom without having the possibility to return. In the fluidizing receptacles known in the art which do not have the aforementioned ratio of dimensions, the particles will move erratically and in all directions through the receptacle which in turn will cause a homogenization of the fluidized mass.

In the process according to the present invention, the mass to be classified flows only in one direction while forming a layer in which the particles of larger size are maintained in suspension and from which the small particles are gradually exhausted during progression of the material along the channel. The progressive exhaustion of the small size particles from the layer does not proceed as a linear function of the distance travelled by the material along the channel, but the progressive exhaustion follows rather a logarithmic function and it is therefore necessary in order to obtain a very good separation according to grain size to give the treating receptacle a considerable length, for instance a plurality of meters since doubling the length of the channel does not produce doubling of the perfection of the separation according to grain size. In carrying out the method of the present invention, it has been ascertained that if the width of the receptacle is made relatively large as compared to its length, the efficiency of the apparatus to properly classify the pulverulent material according to grain size diminishes rapidly which justifies the necessity to form the receptacle with the width and length relationship as mentioned above and this feature distinguishes the process according to the present invention from similar processes of classification by fluidization known in the art.

Another important characteristic of the process according to the present invention is the thickness of the layer of material which is held in suspension. In order to obtain a good efficiency of separation according to grain size, the thickness of layer of material which is held in suspension has to be relatively small in order not to prevent movement of the particles of small size out of the layer by the upwardly directed gas streams. A too great thickness of the aforementioned layer entails the risk to retain a relatively large part of the fine particles imprisoned in the layer, especially such particles which have a grain size in the neighborhood of the grain size limit at which a division or separation of the particles should be attained, which would evidently diminish the precision of the desired separation according to grain size. The most effective thickness of the aforementioned layer will depend on the material to be classified and it can be exactly determined in each case by experiments. For finely ground iron ore the thickness is chosen between 5 and 10 cm. and in general the thickness of the aforementioned layer should not exceed 25 cm. It is likewise important to maintain in the treating receptacle a free space above the layer in suspension which is a multiple of the thickness of the aforementioned layer, at least eight times the layer thickness and preferably 20 to 30 times of the same. In order to obtain an efficient process, it is also necessary to maintain a speed of the upwardly directed gas streams much greater than in known processes of fluidization. The gas speeds used in the process according to the present invention are, for example, 1–2 meters per seconds, while in processes of fluidization known in the art, gas speeds of 60–70 cm. per second are used. In this way a layer in suspension is obtained which forms a very turbulent bed out of which some particles of a grain size superior to the grain size limit at which separation is to be made are projected upwardly from the bed due to a "pseudo-viscosity" present in the turbulent bed. These particles are thrown upwardly to a certain height and it is necessary to maintain above the layer in suspension enough space so as to give these particles a decisive chance to fall back in the layer of suspension before they are carried away by the gas stream.

The combination of the above-mentioned essential characteristics according to the present invention permits to obtain an exact separation of pulverulent material according to grain size not obtained so far with pneumatic processes known in the art.

The apparatus according to the present invention comprises a receptacle in the form of a relatively narrow and long passageway having a bottom wall in form of a grate of fluidization over which circulate the products to be classified and through which gas streams are passed in order to maintain the products in suspension. The pulverulent material to be classified is introduced at one end of the passageway at a point located above the grate so as to communicate with the interior of the receptacle at a point slightly above the layer in suspension. The particles which form the large particle size fraction of the pulverulent material are discharged at the opposite end of the receptacle and move therefore in horizontal direction above the grate of fluidization. The large size particles are discharged through a discharge opening located a small distance above the grate, which distance defines in fact the thickness of the layer of suspension. Since as mentioned above the length of the receptacle is considerable, the separation of the particles according to their dimension will be very precise, since the particles while passing horizontally along the length of the receptacle are constantly subjected to the action of the upwardly directed gas streams.

Due to the intense mixing action in the bed of suspension, the larger particles or the granular particles are subjected to an especially intense dust removal action which contributes to the excellent result of separation according to grain size. The granular particles of the pulverulent material are frequently covered with very fine dust particles which adhere lightly thereto but sufficient to resist a short dust removing action. Due to the prolonged passage of these granular particles in the vertical gas stream, the dust particles adhering thereto are pulled off and carried away by the upwardly directed gas stream to be evacuated from the interior of the receptacle. According to a further feature according to the present invention this pulling away of the dust particles is enhanced by the introduction of a lateral air stream into the receptacle in the vicinity of the point of introduction of pulverulent material to be treated in the receptacle.

In order to enhance the regularity of the horizontal movement of the layer of particles in suspension toward the discharge opening, a horizontal component is imparted to the gas stream introduced through the bottom of the receptacle. This horizontal component may be derived in various ways which may be used separately or in combination. Thus, gas passages may be provided which communicate through the bottom of the receptacle inclined at an angle with respect thereto, or the grate constituting the bottom of the receptacle may be formed by two superimposed perforated sheet metal members, the openings of which are slightly displaced in such a manner that the gas streams passing through the thus formed grate will follow a path obliquely inclined to the bottom of the receptacle in such a manner so as to direct the granular particles toward the discharge opening, or it is also possible to use an inclined grate or bars descending toward the discharge opening. Other known means may also be used in order to impart to the gas a horizontal component. Due to the oblique path of the gas, the length of the gas stream is somewhat extended which also contributes to an improved separation of the granular material into the desired sections according to grain size.

The present invention permits also regulation or change of the line of separation, that is according to the usual definition, the dimension of a particle, the chances of which to be classified in the section of the small particles are the same as the chances to be classified in the section of large particles. By increasing the speed of the gas stream the line of separation is shifted toward the large particle size, and inversely by reducing the speed of the gas stream the line of separation is shifted toward the small particle size.

According to a further feature according to the present invention it is also possible to divide the elongated container in a plurality of succeeding parts along the length of the container and to feed into the succeeding parts gas with increasing speeds in order to displace the particles in suspension toward the outlet opening of the container. Likewise, the space in the receptacle above the layer of particles in suspension may be divided by partitions in corresponding compartments, which partitions end short of the bottom of the container so that the layer of particles in suspension above the bottom is not divided by the partitions. The compartments thus formed above the layer are isolated from each other and gas streams of different speeds may thus act independent from each other. The use of gas streams with increasing speed is especially advantageous since in the first compartment the gas stream will act on the finest parts of the pulverulent material which are thus carried away, while the particles carried away in the following compartments where the speed of the gas stream is increased further and further are less and less small so that in this way a progressive separation of the small size particles from the pulverulent material will take place. It is likewise possible to collect the different fine fractions thus obtained in the various compartments separately from each other.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

Brief description of the drawing

FIG. 1 is a schematic, partly sectioned side view of an apparatus according to the present invention;

FIG. 2 is a top view of the apparatus shown in FIG. 1;

FIG. 3 illustrates a plurality of classification curves of a pulverulent mineral which are obtained with the process according to the present invention;

FIG. 4 illustrates a curve of division obtained from the curves of FIG. 3; and

FIG. 5 illustrates another curve of division obtained from the curves of FIG. 3.

Description of the preferred embodiments

Referring now to the drawings, and more specifically to FIGS. 1 and 2 of the same, it will be seen that the apparatus for carrying out the method according to the present invention may comprise a hopper **1** which may be filled with ground iron ore having a grain size of for instance 0–3 mm. and from which the ground ore is fed by means of a feed screw **3** and a conduit **4** into one end of a receptacle **2** in form of an elongated rectangle, which receptacle may be formed from sheet metal.

The receptacle **2** may be divided into two compartments **5** and **6** separated from each other by a partition **7**, the lower edge of which is spaced from the bottom of the receptacle so as to form an opening **8**. The bottom of the receptacle **2** is formed by a grate **9** constituted by two superimposed perforated metal sheets the openings of which are slightly displaced, in one direction from each other as clearly shown in FIG. 1.

A blower **10** blows air through air passages **11*a*, 11*b*, 11*c*** and **11*d*** arranged beneath grate **9** and obliquely inclined with respect thereto. The blower **10** communicates with the air passages through a common conduit **12** and branch conduits **13*a*, 13*b*, 13*c*** and **13*d***. The latter are respectively provided with Venturis **14*a*, 14*b*, 14*c*** and **14*d*** which permit to measure the amount of air passing into the air passages and with regulating valves **15*a*, 15*b*, 15*c*** and **15*d***. A conduit **16** branched off from the common conduit **12** and provided with a valve **17** permits to send a lateral air stream into the compartment **5** in the region where the conduit **4** communicates with the latter. The pulverulent material introduced into the compartment **5** through the conduit **4** is thus immediately dispersed by the lateral air currents coming from the conduit **16**. The dust covering the granular particles is thus easily stripped therefrom, which action is further enhanced by a pair of deflectors or baffle plates **18** and **19** which will cause formation of eddy currents at the entrance end of the receptacle and which will increase the dust removal action.

A plurality of air streams are fed into the compartments **5** and **6** through the perforated bottom **9** of the receptacle and through the air passages **11*a*, 11*b*, 11*c***, and **11*d***. The speeds of the air streams passing through the aforementioned passages are regulated by means of the regulating valves **15*a*, 15*b*, 15*c***, and **15*d*** in such a manner that the air streams form with the large size particles a turbulent bed of suspension **20** and so that the finest particles are carried upwardly in the compartments **5** and **6**. The regulating valves **15***a* and **15***b* may be adjusted in such a manner that the air streams entering into the compartment **5** have the same speed and the regulating valves **15***c* and **15***d* may be adjusted in such a manner that the air streams entering into the compartment **6** are likewise of the same speed, which is however superior to the speed of the air streams entering the compartment **5**. On the other hand, it is also possible to adjust each of the regulating valves in such manner that the speeds of the air streams passing through the passages **11***a*, **11***b*, **11***c* and **11***d* are all different from each other and so that the air speeds increase from the passage **11***a* towards the passage **11***d*, that is in direction of displacement of the particles in suspension.

Due to the horizontal component of the air streams resulting from the inclination of the air passages with respect to the grate formed by the two perforated sheet metal members the openings thereof are displaced with respect to each other in the manner so that the air streams in passing therethrough can continue their oblique path, the granular particles in suspension of the bed **20** will follow a horizontal path indicated by the arrow *a*. The particles which thus circulate along the very extended passage are subjected during their passage to the action of upwardly directed gas streams passing through the bottom of the receptacle.

The finest particles are thus lifted toward the top of the receptacle and discharged therefrom. Due to a certain "pseudo-viscosity" of the bed of particles in suspension, certain particles having a dimension superior to the dimension of the desired dividing line are likewise upwardly projected. The whole bed represents a turbulent mass with projections of particles extending upwardly. Therefore, the height of the compartments **5** and **6** is preferably 20 times the height of the bed of particles in suspension so that the large particles which are upwardly projected out of the bed will fall downwardly again into the latter to be discharged with the other large size particles of the turbulent bed at the discharge opening **22**. In this way the separation of the particles according to grain size is made more precise.

Obstacles in form of transverse baffle plates **21** may be disposed in the bed in suspension in the path of the granular particles in order to increase the turbulence of the bed.

In this way, only the large size granular particles will arrive at the discharge opening **22** located at the end of the receptacle **2** which is opposite the end at which the feed conduit **4** communicates with the receptacle. The height of the discharge opening **22** determines the thickness of the layer in suspension. The particles after passing through the discharge opening **22** are collected in a hopper **23** provided with level indicators **24** and **25** of known construction. The indicator **24** controls, in a manner known per se and not illustrated in the drawing, means for discharging the material from the hopper **23** onto a transporting band **26** when the material in the hopper **23** reaches an upper level, while the indicator **25** controls a means known in the art and not illustrated which stops discharge of material from the hopper **23** when the material in the hopper reaches a minimum level. During normal operation, that is when the level of the material in the hopper is between the maximum and the minimum level, the granular particles are discharged from the hopper **23** onto a rubber transporting band **26** which may be supported by rollers **27** and driven by a motor **28**.

The fine particles which are suspended in the upwardly directed air streams in the compartment **5** are discharged through the conduits **29***a* and **29***b* into a cyclone separator **30** in which they are separated from the air which is evacuated upwardly through the conduit **31**, whereas the particles move downwardly in the cyclone **30** and are collected in a container **32**. As pointed out above, the more or less small dimensions of the particles thus carried away by the air streams are a function of the speed of the air streams and in this way it is possible to adjust at will the line of separation by regulating the speed of the air streams. Due to the greater speed of the air streams in the compartment **6**, particles of a dimension superior to that carried away in the compartment **5** are carried by the gas streams through the conduit **33***a* and **33***b* into the cyclone separation **34**, from which the air is upwardly discharged through the conduits **35** and **31** while the semi-fine particles pass to the bottom of the cyclone **34** and are collected in a container **36**. The air evacuated through the conduit **31** may contain a very small amount of extremely fine dust and therefore this air is passed through a dust remover of known type, not illustrated in the drawing. The receptacle **2** and the elements connected thereto are supported on a frame **37** of known construction.

Following is a description of a classification operation carried out according to the present invention with the apparatus illustrated in FIGS. 1 and 2.

An iron ore from the region of Droitaumont (France) has been ground in a ball mill of known construction. The product discharged from the grinder had a grain size from 0–3 mm. and its granulometric distribution is represented by the curve A of FIG. 3 in which the abscissa scale is graduated in the lower part in microns and in the upper part in milimeters.

The thus obtained product has been treated in an apparatus as illustrated in FIGS. 1 and 2, and it is fluidized by air streams introduced through the grate **9**. The speed of the air streams entering into the compartment **5** was 1.4 m./sec. and the speed of the air streams entering the compartment **6** was 2.1 m./sec.

The width of the receptacle was made 12.5 cm. and its length 4 m.

The height of the layer in suspension was in the neighborhood of 10 cm., whereas the height of the compartments **5** and **6** was 2 m.

After classification three granulometric fractions are obtained, that is a first fraction of granular particles evacuated by the band **26**, the granulometric analysis of this first fraction is represented by the curve B in FIG. 3; a second fraction of semi-fine particles collected in the container **36**, the granulometric analysis of this second fraction is represented by the curve C of FIG. 3; and a third fraction of very fine particles collected in the container **32**, and the granulometric analysis of this third fraction is represented by the curve D in FIG. 3.

From the curves A, B, C and D the curve E is derived indicating the division between the large and the fine grain sizes which in the present case include very fine and semi-fine grains, which curve is illustrated in FIG. 4. The curve of division is established in the following manner: on the abscissa is entered on a linear scale the probability of a particle to pass into one of the fractions and on the ordinate are entered, on a logarithmic scale, the dimensions of the particles. Within a narrow range in the neighborhood of the dimension considered the probability of passage of the particles in one of the fractions is the same with respect to the respective weight of this fraction in the mixture, and in practice this narrow range will be comprised between two successive mesh sizes of a sieve, for example between mesh sizes of 400 to 500 microns when the dimension considered is 450 microns.

The calculation of one point of the curve E is made in the following manner:

Assuming the percentage in weight of the fraction of large grain size is G% in the original mixtures and the proportion in weight of the fraction of small grain size is F%.

Assuming further that A% is the proportion in weight at a narrow range in the neighborhood of the dimension considered of the fraction of large particles and $a\%$ is the proportion in weight of the fraction of fine particles at the same narrow range.

The probability of a particle to pass into the fine fraction for the dimension considered will be, expressed in percentage:

$$\frac{aF}{aF+AG}$$

and the probability to pass into the granular fraction will be:

$$\frac{AG}{AG+aF}$$

If, as in the above-mentioned example three fractions are present, the fine fraction may be considered as the sum of the fractions formed by the semi-fine and fine particles. In this case, the probability of a particle to pass into the fine division will be:

$$\frac{a_1F_1+a_2F_2}{a_1F_1+a_2F_2+AG}$$

and the probability of a particle to pass into the granular fraction will be:

$$\frac{AG}{AG+a_1F_1+a_2F_2}$$

wherein a_1 and a_2 respectively represent the weight proportions of the particles within a narrow range in the neighborhood of the dimension in the fraction of semi-fine and fine particles and F_1 and F_2 represent the proportions in weight of the semi-fine and fine particles in the original mixture.

From the pulverulent material having grain sizes from 0–3 mm. of the above-mentioned sample the following results have been obtained:

The fraction of the granular particles (curve B of FIG. 3) represented 52% of the total weight of the raw product ($G=52\%$); the fraction of the semi-fine particles (curve C) represented 24% of the total weight ($F_1=24\%$) and the fraction of the fine particles (curve D) represented likewise 24% of the total weight ($F_2=24\%$).

In order to establish for instance the probability of a particle of a dimension around 450 microns (between 400 and 500 microns) to pass into the fine fraction constituted by the semi-fine and fine particles assuming that:

$$A=15\%;\ a_1=0.5\%;\ \text{and}\ a_2=0.2\%$$

one obtains:

$$\frac{a_1F_1+a_2F_2}{a_1F_1+a_2F_2+AG}=2.1\%$$

In a similar manner the probability of this particle passing into the granular fraction is:

$$\frac{AG}{AG+a_1F_1+a_2F_2}=97.9\%$$

in other words, the probability of a particle the dimension of which is in the neighborhood of 450 microns to pass into the granular section is 97.9% as indicated by the point p_1 in the division curve E shown in FIG. 4. In the same manner the points P_2, P_3, etc. are established and the locus of the points $P_1 \ldots P_n$ forms the curve E.

The dimension D_{50} of a particle of which the chances of being classified with the granular particles or with the fine particles is equal is called the dimension of separation. In the curve E the dimension of separation is indicated by the ordinate of the point M (270 microns) and the abscissa of which is 50%.

The quality of the separation can be evaluated by considering the central part of the curve E; the "imperfection" defined by the number:

$$I=\frac{D_{75}-D_{25}}{2D_{50}}$$

marks this quality.

From the above, it will be evident that D_{75} is the dimension of a particle the chances of which of being classified with the granules is 75% (point N of the curve E) and that D_{25} is a dimension of a particle the chances of which to be classified with the granules is 25% (point 0 of the curve E). From this follows that the smaller is the imperfection, the greater will be the quality of separation.

In the example represented in the curve E of FIG. 4, the imperfection is:

$$I=\frac{295-230}{2\times 270}=0.12$$

which is an excellent value which favorably compares with results obtained with processes known in the art.

In the same manner the curve of division G (FIG. 5) is established for the semi-fine particles (curve C of FIG. 3) and the fine particles (curve D), by applying the formulas

$$\frac{a_1F_1}{a_1F_1+a_2F_2}$$

or

$$\frac{a_2F_2}{a_2F_2+a_1F_1}$$

and the imperfection is in this case 0.25 which is still an excellent value.

The process according to the present invention is particularly applicable to classify pulverulent iron ore into distinct granulometric fractions before subjecting the fractions to different treatments. In the above mentioned example the mean iron content of the pulverulent material to be classified was 31%. In the large grain size fraction, the iron content was reduced to 26% and this fraction is subsequently subjected to an enrichment process by magnetizing roasting followed by a magnetic separation at high intensity; in the semi-fine fraction the iron content was 35% and this fraction may be treated with great efficiency because it does not contain ultra-fine material in a magnetic separator of great intensity, whereas the fine fraction, in which the iron content was up to 38%, did not require a complementary enrichment process.

An additional advantage of the present invention resides in the fact that the novel apparatus can be extended as desired whereby it is only necessary to elongate the fluidized bed in order to increase the production. This can be carried out in a very simple manner by prolonging the receptacle by addition of further compartments. The production, that is the quantity of the pulverulent material treated per time unit, is proportional to the surface of the grate, and during experiments carried out by the inventor, it has been found that 7 tons of ground iron ore may be treated per hour for each square meter of grill.

A further advantage of the present invention is that a relatively small gas pressure is necessary for carrying out the classification of the product. In fact, only a pressure of 300 mm. water column is required to obtain a gas speed of 2 m./sec. From this follows that the electric energy utilized for driving the blower is relatively small and the electric energy is about 1 kilowatt/hr. per ton of pulverized iron ore to be treated.

Furthermore, the process according to the present invention leads to a perfect classification of the pulverulent material, and the "imperfection" of the classification, as defined above, is about 0.12.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of pneumatic classification of pulverulent materials differing from the types described above.

While the invention has been illustrated and described as embodied in pneumatic classification of pulverulent iron ore or other materials, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claim:

1. A process of pneumatically classifying pulverulent material comprising the steps of forming an elongated bed of pulverulent material in suspension of a given height and of a length at least six times its width by feeding into the pulverulent material upwardly directed gas with a speed at least sufficient to keep the largest particles of pulverulent material in suspension and less than the speed necessary to lift the largest particles out of the bed in suspension, but greater than the lifting speed of the smallest particles; continuously feeding a stream of pulverulent material to be classified into one end of the elongated bed in suspension; continuously withdrawing the largest particles at the opposite end of the bed at the level of the top face of said bed so that the large particles in the bed will move horizontally from the one to the other end thereof; maintaining above said bed in suspension a free space at least eight times the height of said bed into which the finest particles of the pulverulent material are carried by said upwardly directed gas streams; evacuating said gas streams with the finest particles suspended therein from said space; and separating said finest particles from said gas stream.

2. A process as defined in claim **1**, wherein at least two upwardly directed streams of gas are introduced in to said bed with one of said streams closer to said other end of said bed having a higher speed than the other.

3. A method as defined in claim **1**, and including the step of feeding into said stream of pulverulent material fed at said one end into said bed a lateral stream of gas so as to enhance removal of dust clinging to said largest particles and to enhance movement of said large particles from said one to said other end of said bed.

4. A method as defined in claim **1**, wherein said upwardly directed gas is fed into said bed at an angle inclined in a direction toward the other end of said bed to the vertical to enhance thereby displacement of the largest particles from said one to said other end of said bed.

5. A process as defined in claim **1**, wherein said pulverulent material to be classified is pulverulent ore, and wherein the gas is fed with a speed of 1–2 meters per second into said bed of pulverulent material.

6. A process as defined in claim **1**, wherein the height of said bed does not exceed thirty centimeters.

7. An apparatus for pneumatically classifying pulverulent material comprising, in combination, an elongated receptacle having at least a length six times its width and a perforated bottom wall; means communicating at one end of said receptacle and at a given distance above said bottom wall with the interior of said receptacle for continuously feeding a stream of pulverulent material to be classified thereinto; means for feeding a gas under pressure in upward direction and at such speed through said perforated bottom wall so as to form from the largest particles of the pulverulent material fed into the receptacle a fluidized bed above said bottom wall; means for discharging the largest particles from the other end of said receptacle at a distance from said bottom wall substantially equal to said given distance so that a fluidized bed of a height substantially equal to said given distance will be maintained in said receptacle, said receptacle having a height of at least nine times said given distance; and means communicating with the top portion of said receptacle for discharging the gas carrying the finest particles of pulverulent material from the interior of said receptacle.

8. An apparatus as defined in claim **7** and including means for separating said finest particles from said gas.

9. An apparatus as defined in claim **8**, wherein said separating means comprise at least one cyclone.

10. An apparatus as defined in claim **7**, wherein said means for feeding gas in upward direction through said perforated bottom wall into the interior of said receptacle comprise at least two passages one of which communicates at its inner end with the interior of said receptacle closer to said other end thereof than the other of said two passages, and means for feeding gas of different speeds through said passages.

11. An apparatus as defined in claim **10**, wherein said passages communicate at the outer ends thereof with each other, and wherein said means for feeding gas at different speeds through said passages comprise a single blower means communicating with said outer ends of said passages, and regulating means located in each of said passages for regulating the speed of the gas passing therethrough so that the speed of the gas entering through the inner end of said one passage into said receptacle is greater than that entering through said inner end of said other passage.

12. An apparatus as defined in claim **7** and including means for introducing into said stream of pulverulent material as it is fed into said receptacle a stream of gas under pressure in direction transverse to said stream of pulverulent material to enhance separation of large size particles of said pulverulent material from said small size particles at the point of introducing said particles into said receptacle.

13. An apparatus as defined in claim **7**, wherein said means for feeding gas under pressure through said perforated bottom wall extend inclined toward said other end of said receptacle to the vertical so as to enhance flow of the particles in said bed from said one to said other end of said receptacle.

14. An apparatus as defined in claim **7** and including a partition extending from the top of said receptacle toward but short of the bottom wall and dividing said receptacle into two compartments communicating with each other adjacent said bottom wall, said means for feeding gas under pressure into said receptacle comprising at least two gas passage means respectively communicating through said perforated bottom wall with said compartments, and said means for discharging the gas carrying the finest particles communicate with a top portion of each compartment.

15. An apparatus as defined in claim **14**, wherein said gas discharge means comprise a pair of separate conduits respectively communicating at the inner ends with top portions of the two compartment, and cyclone means communicating with the outer ends of said conduits.

16. An apparatus as defined in claim **7** and including at least one baffle plate extending transverse to the elongation of said receptacle at least partly through said bed of large size particles in suspension.

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U.S. Cl. X.R.

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