Oct. 10, 1950 E. M. BARODY 2,525,390

METHOD OF SEPARATING FINE GRANULAR MATERIALS ACCORDING TO SPECIFIC GRAVITY

Filed Dec. 26, 1946

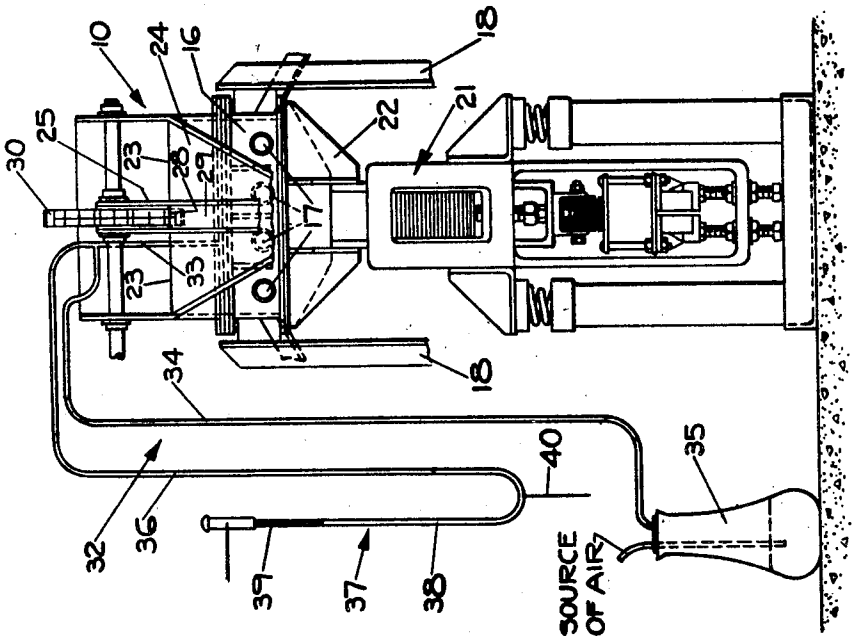


Fig. 1

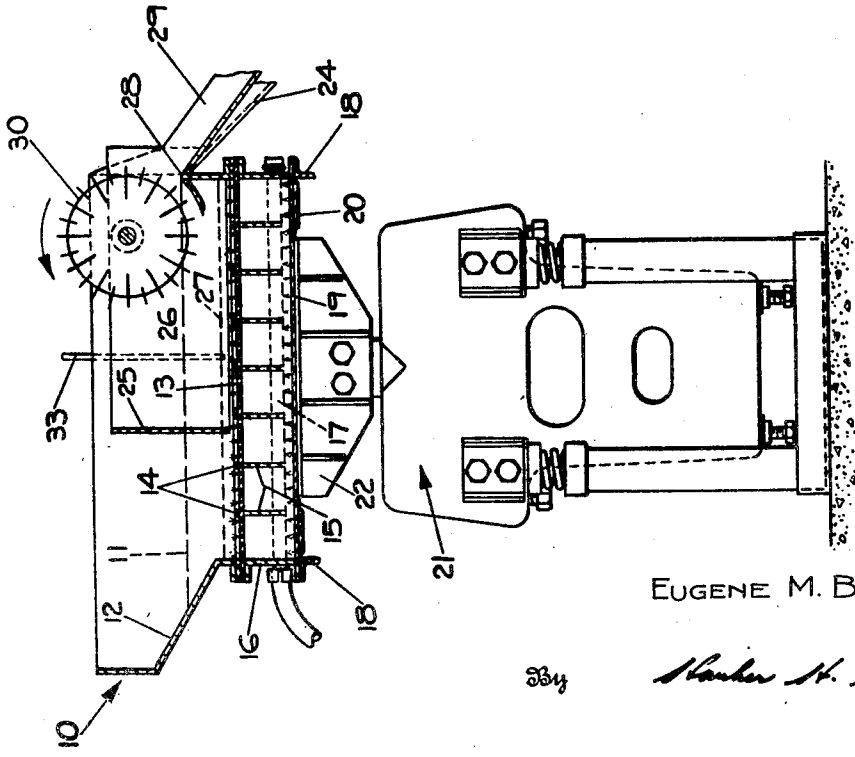


Fig. 2

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Patented Oct. 10, 1950 2,525,390

UNITED STATES PATENT OFFICE

2,525,390

METHOD OF SEPARATING FINE GRANULAR MATERIALS ACCORDING TO SPECIFIC GRAVITY

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Application December 26, 1946, Serial No. 718,422

4 Claims. (Cl. 209—422)

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This invention relates to an improved method of separating fine granular materials according to specific gravities.

An object of the invention is to provide an improved method of the above mentioned type which will treat granular mineral material, particularly of small sizes, to effect a separation according to specific gravity, involving the combined action of upwardly flowing fluid, such as water, and vertical vibration in which the frequency of vibration bears a predetermined relation to the characteristic frequency of the particles of one of the minerals being separated.

Other objects of the invention will appear hereinafter, the novel features and combinations being set forth in the appended claims.

In the accompanying drawings,

Fig. 1 is a front elevational view of one form of apparatus for carrying out my invention; and

Fig. 2 is a side view of said apparatus, with parts shown in section.

The jig or classifier disclosed for carrying out my invention is disclosed in full detail in the application of Frank P. Smith, Serial No. 668,845, filed May 10, 1946. Briefly described, it includes a deck, container or tank 10 which provides a compartment or receptacle for receiving granular mineral, such as fine iron ore, which is to be separated into two groups of particles according to specific gravity. The apparatus is designed particularly for treating relatively small size particles.

The fine iron ore to be separated from its gangue, particularly silicon, is fed to the deck 10 with an appreciable quantity of water so as to provide an ore pulp which will have a normal level in the container or compartment 10, as indicated at 11 in Fig. 2 of the drawings. The pulp will flow freely down an inclined feed chute 12 into the main part of the compartment 10. The container 10 is provided with a false bottom 13 in the form of a screen which is held down by appropriate hold-down means 14 in cooperation with a supporting egg-crate partition which helps distribute the water through the perforations in the false bottom screen 13. In one successful form of the device the screen or false bottom 13 was a multipore rubber screen. It is preferably a very fine mesh screen. I have successfully used screens 13 with a mesh varying from 65 to 115. If desired, a shot bed may also be used on screen 13, or as a substitute therefor.

The egg-crate partitions 15 are contained in

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a hutch compartment 16 which is formed as a part of the container 10 and below the screen 13. Hutch compartment 16 is provided with a plurality of longitudinally extending water feed pipes 17 by which a relatively small amount of water is introduced into the various cells of the egg-crate partition 15, which water flows upwardly through the screen plate 13 into the pulp compartment 10. The hutch compartment 16 and through it the container 10 is supported on a stationary frame 18.

The central bottom portion of the hutch compartment 16 is in the form of a diaphragm 19 which is attached to the adjacent bottom portion by means of a rubber ring 20 which provides a fluid-tight bottom for said hutch compartment 16 but which allows reciprocation of the diaphragm 19 rectilinearly upwardly and downwardly. This rectilinear vibratory motion is delivered to the diaphragm 19 by a vibratory electro-magnetic motor 21, the armature head 22 of which is rigidly attached to said diaphragm 19. The motor 21 preferably follows the structure shown in the patent to James A. Flint, No. 2,094,698, dated October 5, 1937, for a Device for Packing Materials.

Adjacent the discharge side of the container 10, which is to the right, as viewed in Fig. 2, there is a weir 23 over which the gangue or refuse flows, being guided therefrom by gangue discharge chute 24. Preferably located along the longitudinal center of and within the container or compartment 10 and provided by a substantially U-shaped upstanding wall, plate or partition 25 is a concentrate or high gravity material cell or compartment 26. As is clearly illustrated, particularly in Fig. 2 of the drawings, the plate 25 extends both above and below the normal pulp level 11, and the bottom edge thereof is close to but slightly above the false bottom or screen 13.

As hereinafter described more completely, the bottom edge of the plate 25 also extends slightly below the level of the bed of concentrates or high gravity material which forms in the bottom of the compartment 10 under the classifying or jigging action which takes place. The depth of a typical concentrates bed is illustrated at 27 in Fig. 2 of the drawings. A weir 28 having preferably the same height as the weir 23 is provided for the concentrates cell or compartment 26 and the concentrates which flow over the weir 28 are received by a trough 29.

It is evident from the above description that the cell 26 formed by the plate or partition 25

provides what is, in effect, a dam and seal concentrates draw. It has been found, however, that the dam and seal type of concentrates draw may have its efficiency very vastly improved so as to prevent all land-sliding, which such draws tend to produce, by providing a skimmer means, or other functionally equivalent mechanism, for removing concentrates from the concentrates cell or compartment **26**. In the illustrated form of mechanism for thus removing concentrates and causing them to flow over the weir **28** a skimming mechanism is provided in the form of a skimming paddle wheel **30** which is preferably continuously operating at a variable speed, as described more completely in the above identified Smith application, the wheel **30** being preferably rotated in a counter-clockwise direction, as viewed in Fig. 2 of the drawings, so as to skim the top of the concentrates from the cell **26** and to cause it to flow over the weir **28** into the trough **29**.

Mechanism for controlling the rate of withdrawal of concentrates from the cell **26** is described completely in said Smith application and will not be here repeated.

A study of the operation of the high frequency jig above described reveals that improved separation of fine granular materials may be effected if certain conditions of operation are realized. Without attempting to explain the theory or reason which produces these improved results, it may be stated that the small or fine particles suspended in a fluid or liquid and subjected to a constant velocity upwardly flowing water upon which there is superposed a harmonic vibration have, what I call, a characteristic frequency, designated f_0. The characteristic frequency of particles in water may be calculated from the equation f_0 is equal to

$$\frac{9v}{4\pi r^2 d}$$

in which

f_0=characteristic frequency
v=kinematic viscosity of liquid (coefficient of viscosity divided by density);
r=radius of material particles in centimeters;
d=ratio of particle density to fluid density.

From this equation a table may be made which shows the characteristic frequencies of various size particles, the size being given in both mesh and radius in centimeters where the particles are in water and the specific gravity is 3 in one case and 5 in the other.

Characteristic frequencies (f_0)

[Particles in water.]

Size		Specific Gravity	
Mesh	Radius, Cm.	d=3	d=5
20	0.04	1.5/sec.	0.9/sec.
100	0.007	50	30
150	0.005	100	60
200	0.004	150	90
400	0.002	600	360

In this table and in the above equation, since the fluid is water, with a specific gravity of 1, d in the equation will be equal to the specific gravity of the particle.

For sample calculations the coefficient of viscosity in "poises" for water at 20° centigrade is

.01 and calculated for this value v will become .01 divided by 1 or .01.

To give an example of the calculation of f_0 in the equation for a particle of 100 mesh size or .007 centimeters radius and a specific gravity of 5, we have

$$f_0=\frac{9\times.01}{4\pi(.007)^2\times5}=29.3=30 \text{ approx.}$$

To effectuate a very efficient separation of minerals of a single size in accordance with my improved method, the operating frequency of the jig (f) should be approximately equal to or greater than (f_0), the characteristic frequency of the smallest particles. Under these conditions there will be a very efficient gravity separation, with the high gravity particles forming a layer of concentrates, as seen at **27**, and the gangue flowing over the weir **23**.

In many practical installations it will be undesirable to treat only a single size range and in such circumstances generally three mesh sizes of the same minerals may be treated and obtain practical successful results. Under these circumstances the natural frequency of vibration employed is to be selected near the characteristic frequency of the smallest particle being separated. Furthermore, it is found very desirable that the stroke be a few times larger than the diameter of the largest particles being separated, for example, from 2 to 5 times, which is to be understood as the meaning of the expression "few times" as used in the claims. This is because experience has shown that some vibration is essential to effectuate the improved classifying action while requiring a much smaller amount of upwardly flowing current than normally employed in an upward current classifier, but if the amplitude becomes too great the unit will tend to act as a barrel packer and pack all of the granular material solid which, of course, is disastrous to a classifying action.

In this particular it may be mentioned that while one of the effects of the vibration is to impart mobility to the bed, this is by no means the principal effect of it, because mobility might be imparted by horizontal vibration as against a vertical vibration. However, the improved classifying action derived by tuning the operating frequency (f) to the characteristic frequency (f_0) of the smallest particles is only realized to its greatest extent where there is vertical rectilinear vibratory movement or at least vibratory movement having a vertical component. In other words, there is a definite supporting action on the minerals derived from the vertical vibration. Furthermore, vibration alone will not support the particles and consequently some upwardly flowing current of fluid is found necessary, though with my improved method the amount of upwardly flowing current is greatly reduced, as compared with that of an upward current classifier.

Where, in the claims, reference is made to "fine" material, or the equivalent, without specifically limiting the size or size range, it is to be understood that the material is between 50 mesh and 400 mesh.

It may further be mentioned that in the carrying out of the method by the disclosed apparatus the vibration of the diaphragm **19** is reproduced in the column of water supported by it so that the column of water moves upwardly and downwardly with the diaphragm.

Obviously those skilled in the art may make various changes in the details and arrangement

of parts without departing from the spirit and scope of the invention as defined by the claims hereto appended, and I therefore wish not to be restricted to the precise construction herein disclosed.

Having thus described and shown an embodiment of my invention, what I desire to secure by Letters Patent of the United States is:

1. The method of separating fine iron ore from gangue including subjecting a bed of said materials to the combined influence of upwardly flowing fluid current and substantially rectilinear vertical vibration in which the frequency of the vibration is approximately equal to and greater than the characteristic frequency of the smallest particles being separated and in which the amplitude of said vibration is a few times larger than the particle sizes, the characteristic frequency (f_0) substantially satisfying the equation

$$f_0=\frac{9v}{4\pi r^2 d}$$

2. The method of separating fine iron ore from gangue including subjecting a bed of said materials to the combined influence of upwardly flowing fluid current and substantially rectilinear vertical vibration in which the frequency of the vibration is approximately equal to the characteristic frequency of the smallest particles being separated and in which the amplitude of said vibration is a few times larger than the particle sizes, the characteristic frequency (f_0) substantially satisfying the equation

$$f_0=\frac{9v}{4\pi r^2 d}$$

3. The method of separating fine iron ore from gangue including subjecting a bed of said materials to the combined influence of upwardly flowing fluid current and substantially rectilinear vertical vibration in which the frequency of the

vibration is approximately equal to the characteristic frequency of the smallest particles being separated, the characteristic frequency (f_0) substantially satisfying the equation

$$f_0=\frac{9v}{4\pi r^2 d}$$

4. The method of separating fine iron ore from gangue including subjecting a bed of said materials to the combined influence of upwardly flowing fluid current and substantially rectilinear vertical vibration in which the frequency of the vibration is approximately equal to the characteristic frequency of the smallest particles being separated.

EUGENE M. BAROODY.

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