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Yoshimori et al.

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[54] **GAS-SEPARATING METHOD AND APPARATUS THEREFOR**

[72] Inventors: **Nobuo Yoshimori; Tsuguo Nagayama; Toshio Sato,** all of Tokyo, Japan

[73] Assignee: **Kabushiki Kaisha Sato Seisakusho,** Ohta-ku, Tokyo, Japan

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[52] **U.S. Cl.** .....**209/139 A,** 209/144

[51] **Int. Cl.** **B07b 7/083**

[58] **Field of Search** .....209/139 R, 144, 139 A

[56] **References Cited**

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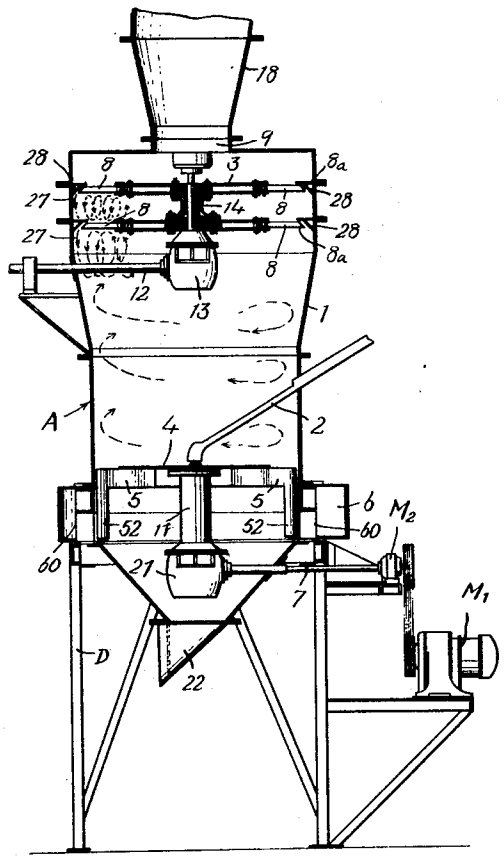
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Primary Examiner—Frank W. Lutter
Assistant Examiner—Ralph J. Hill
Attorney—George B. Oujevolk

[57] **ABSTRACT**

The invention relates to a method of separation of particulate material using a fluid and an apparatus therefor wherein first whirling vanes are used to disperse a material-charged gas supplied into the central part of a casing and float this material in a whirling ascending current fed to the bottom part of the casing, providing a first separating effect due to the gravity acting on the rising current, leading the charged gas to an upper outlet, and providing the second separating effect due to second whirling vanes in the course of said whirling ascent, said second whirling vanes being located above and spaced from said first whirling vanes, as well as guiding to the lower part of the casing, the separated heavy particles which are descending from the upper part of the casing. A third separating effect is also provided due to the first whirling vanes dispersing and supplying the inflowing charged materials to falling rough particles which are led to the lower part of the casing so as to separate fine powders mixed in rough particles, and as a result of this continuous sequence of separating steps, the work flows smoothly and efficiently.

6 Claims, 13 Drawing Figures

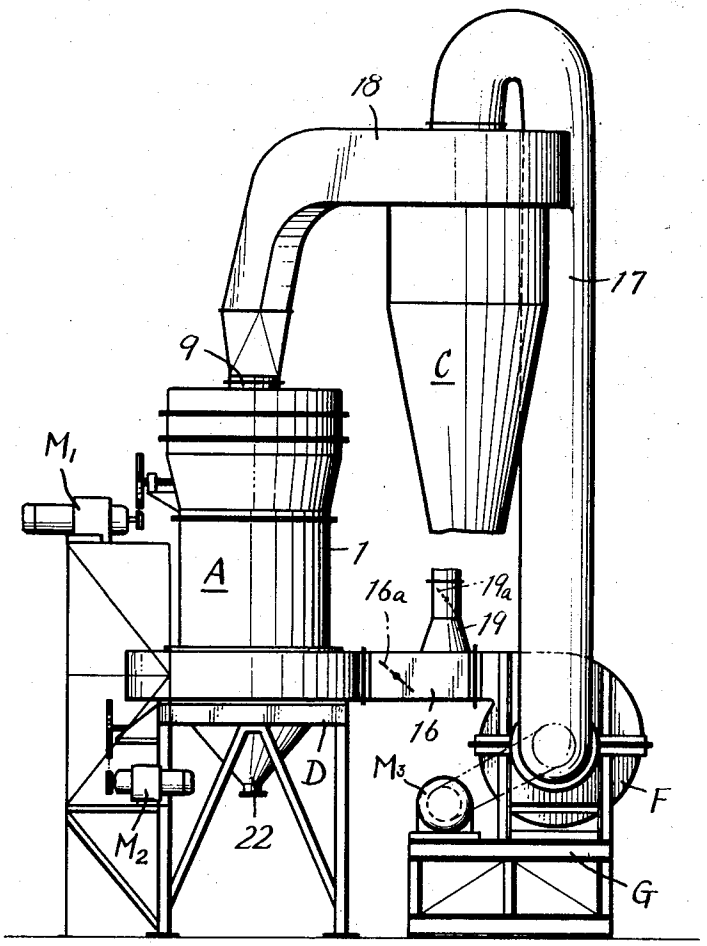


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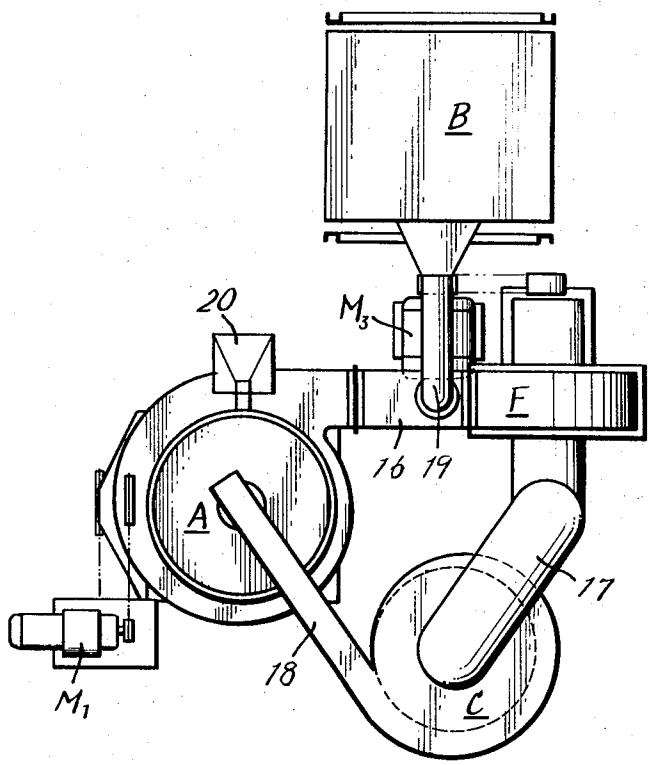
SHEET 1 OF 5

~~FIG.~~ 1



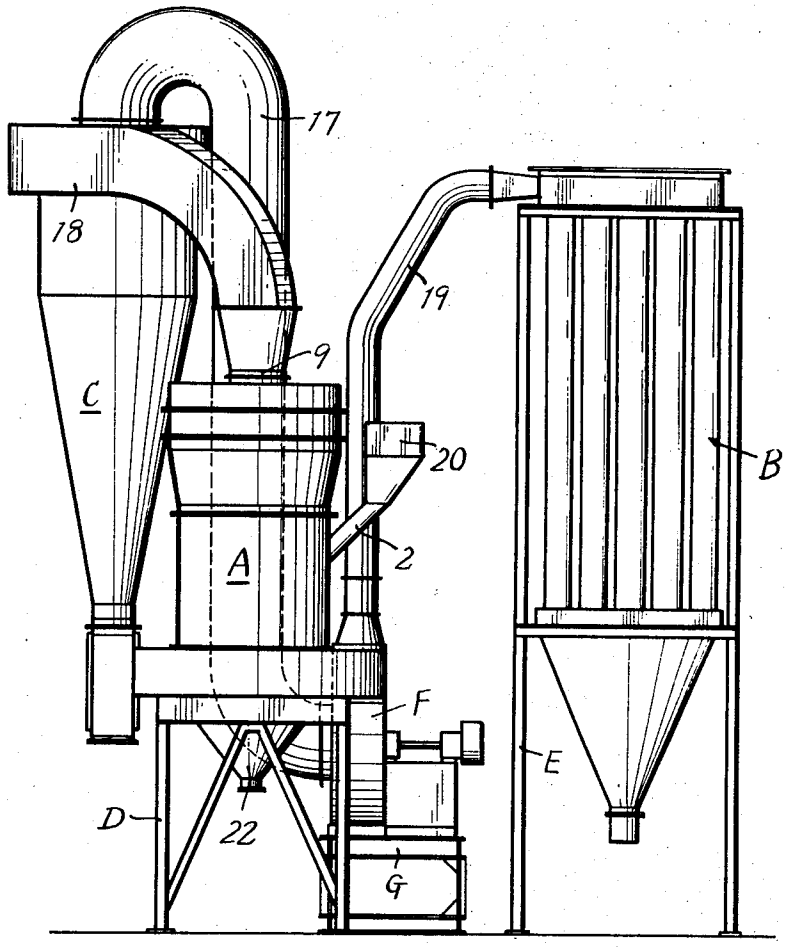
INVENTORS
Nobuo Yoshimori
BY Tsuguo Nagayama
Toshio Sato
George B. Oxenwald
Attorney

FIG. 2



INVENTORS
Nobuo Yoshimori
Tsuguo Nagayama
Toshio Sato
BY George B. Oujevolk
Attorney

FIG. 3

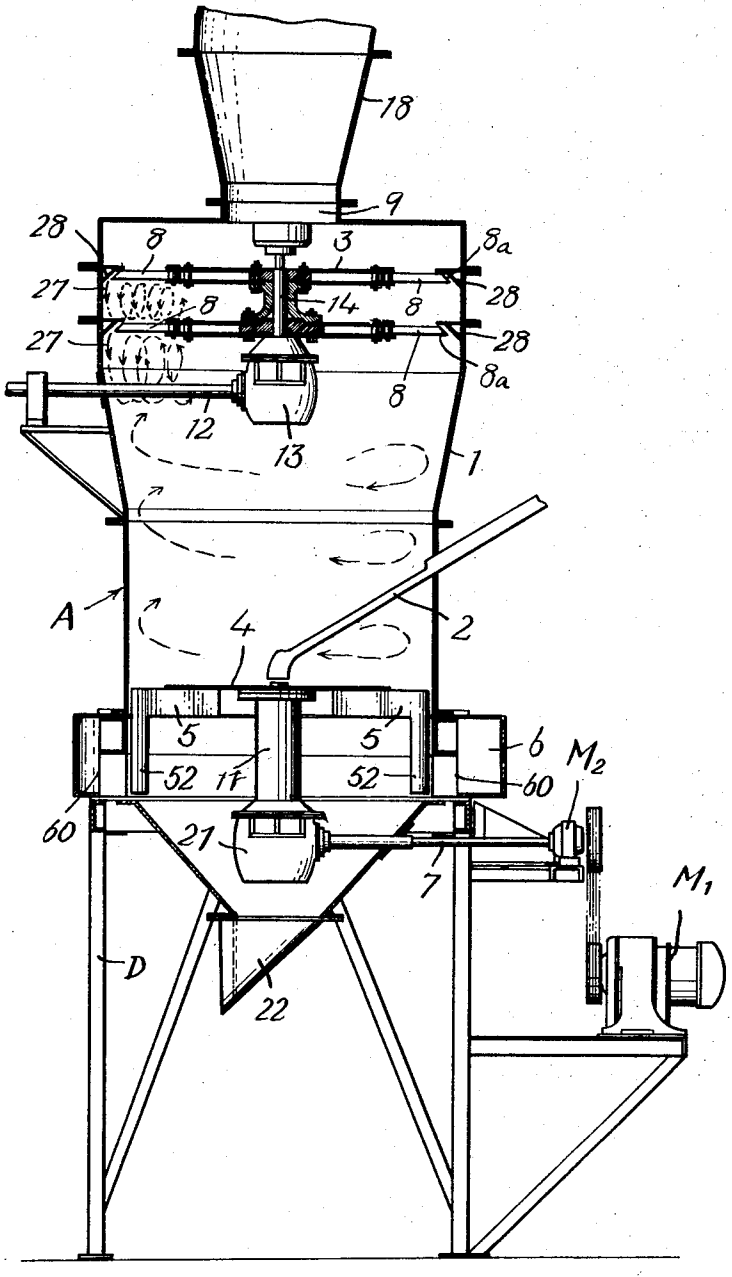


INVENTORS

BY

Attorney

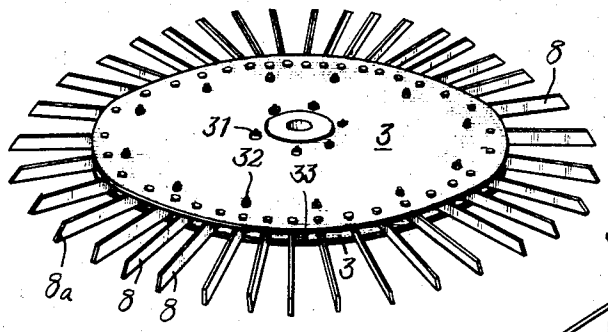
FIG. 4



INVENTORS
Nobuo Yoshimori
Tsuguo Nagayama
BY Toshio Sato

George E. Dupuoli
Attorney

FIG. 5



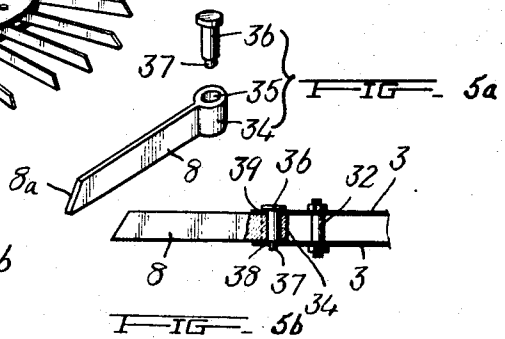
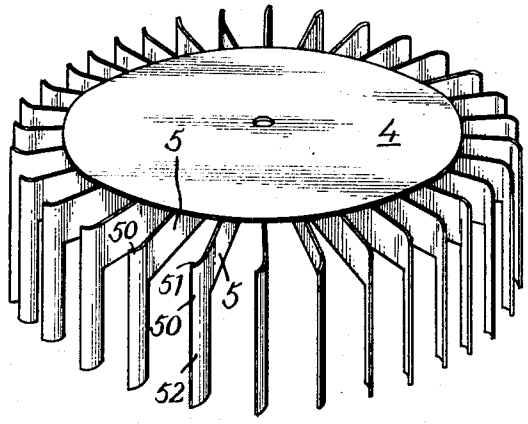


FIG. 5a

FIG. 5b

FIG. 6



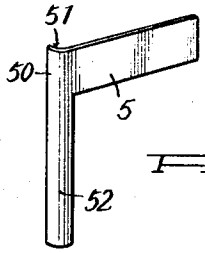


FIG. 6a

FIG. 7

FIG. 8

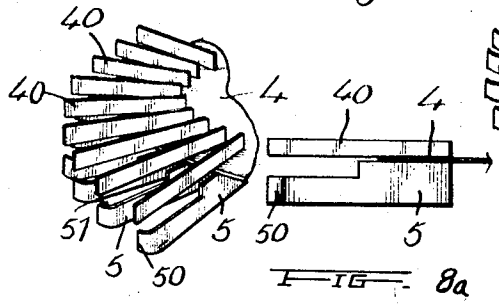


FIG. 8a

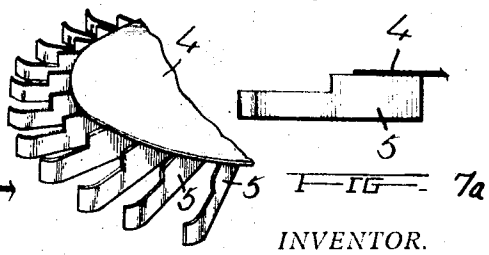


FIG. 7a

INVENTOR.
Nobuo Yoshimori
Tsuguo Nagayama
Toshio Sato

BY George B. Oujevolk
Attorneys

GAS-SEPARATING METHOD AND APPARATUS THEREFOR

BACKGROUND OF THE INVENTION

This invention relates to a separating method using a fluid, e.g., a gas, and to an apparatus therefor, and more particularly relates to an arrangement wherein materials or particles may be removed form a gas charged with these materials.

OBJECTS OF THE INVENTION

Thus, the basic object of this invention lies in providing a separating method of high efficiency and an apparatus therefor. The prior methods or apparatus do not have a favorable separating efficiency so that the desired grain sizes in the charged materials are not yielded effectively by the separating operation, and separators of the prior art require a long and exhaustive work time wherein batches of charged materials are used or there is a repeated inefficient treatment. The object of the present invention is to remove such disadvantages of the prior art and to provide a useful treatment of high efficiency. Partially to accomplish this objective, the present invention repeatedly adds the separating effects of whirling vanes to the charged materials which are carried on a whirling ascending current, and, powders mixed with the descending rough particles are repeatedly separated to be floated upwards on the ascending current. Accordingly, separation is very efficiently performed.

Another object of the present invention lies in providing the separating effect by means of a comparatively simple construction. The present invention uses whirling vanes in order to uniformly disperse and develop the charged materials to be floated on a whirling ascending current, and uniformly disperses the charged material by the revolution of the vanes as well as provide a repeated separating effect to rough particles which descend by current owing to the revolution of vanes. The dispersing and charging mechanism itself also displays a separating effect so that a high efficient separation can be realized with the simple equipment and power, through turbulence in the ascending flow.

A further object of this invention is to provide a separation of high treating efficiency. The amount of charged material treated, or the amount of products of the desired particles sized compositions can be obtained without adding repeated treating operations, and therefore the treating efficiency becomes inevitably higher. Moreover, according to the present invention, the materials to be treated are charged into the central part of a cylindrical casing and dispersed continuously by high speed revolution of a rotary disc to supply them to a whirling ascending current from the lower part, thus making it possible to perform efficient and continuous treatment work. Continuous charges are similarly treated, with the separating effect caused by whirling vanes and a rapid separation is accomplished in a compact mechanism.

A still further object of this invention is to perform separating work and to treat particle materials in a clean ambient working environment. For this purpose a cyclone collector and a fan are specially arranged relatively to a separator and those are connected to a closed circuit which causes circulation. Besides a duct connecting a fan to a separator, there is also a branched duct which is connected to a back-filter, so that purifying gases are supplied into air discharged from the circulating closed circuit. In this way, the separating process is smoothly performed with little loss in a clean working ambient environment, with excellent separating efficiency.

Yet another object of the present invention is to provide a method and an apparatus for separation of such charges as zeolite which is difficult to separate. Although in such commercial papers as catalogues, the separating efficiency for this kind of mechanism shows high values of more than 90 percent, this applies only to cases where the charges have been selected specially to be easily separated and to perform the separating operation at the values pertinent for those charges. However, in the case of other general charges, such a high separating efficiency cannot be obtained. Those who are engaged in this field are well aware that the separating efficiencies for the general materials charged are around 60 percent or less. Especially, materials such as zeolite are difficult to separate and the separating efficiencies are very low. According to the present invention not only a high separating efficiency above 80 percent is provided for general kinds of materials, but also higher values above 90, 98 or 99 percent are provided for such materials as zeolite.

SUMMARY OF THE INVENTION

Generally speaking, the present invention contemplates a method of separating particulate material and an apparatus therefor, wherein first whirling vanes are used to disperse a material-charged fluid supplied into the central part of a casing and float this material in a whirling ascending current fed to the bottom part of the casing, providing a first separating effect due to the gravity acting on the rising current, leading the charged gas to an upper outlet, and providing the second separating effect due to second whirling vanes in the course of said whirling ascent, said second whirling vanes being located above and spaced from said first whirling vanes, as well as guiding to the lower part of the casing the separated heavy particles which are descending from the upper part of the casing. A third separating effect is also provided due to the first whirling vanes dispersing and supplying the inflowing charged materials to falling rough particles which are led to the lower part of the casing so as to separate fine powders mixed in rough particles, and as a result of this continuous sequence of separating steps, the work flows smoothly and efficiently.

Other objects, advantages and novel features of the present invention will become apparent in the following description when taken in connection with the accompanying drawings.

BRIEF EXPLANATION OF DRAWINGS

The drawings illustrate the actual embodiment of the invention and in the drawings:

FIG. 1 is a front view, partially in section, of a separating arrangement contemplated herein where the separating mechanism of this invention is used;

FIG. 2 is a plan view of the arrangement shown in FIG. 1;

FIG. 3 is a side view of the arrangement shown in FIG. 1;

FIG. 4 is an enlarged cross-sectional view of the mechanical separating part of the arrangement shown in FIG. 1;

FIG. 5 is an oblique view of whirling vanes which serve to disperse and separate charged materials;

FIG. 5*a* is an exploded perspective view of a vane shown in FIG. 5;

FIG. 5*b* is a side view of a vane shown in FIG. 5;

FIG. 6 is an oblique view of whirling vanes used for separation;

FIG. 6*a* is a perspective view of a vane shown in FIG. 6;

FIG. 7 is a partial oblique view showing the deformation of vanes;

FIG. 7*a* is a side view of a vane shown in FIG. 7;

FIG. 8 is a partial oblique view showing how dispersing vanes are also provided; and,

FIG. 8*a* is a side view shown in FIG. 8.

DETAILED EXPLANATION OF THE INVENTION

Equipment contemplated herein shown in FIG. 1 to FIG. 3 is composed of a separating mechanism A, a back-filter B and a cyclone collector C. The separator A and the cyclone collector C are on a first bed D. The back-filter B is on a second bed E at the rear and cannot be seen in FIG. 1. The cyclone collector C and the separator A are connected to a fan F located on a third bed G through ducts **16**, **17**, that is, the duct **16** supplies a blast from the fan to the lower part of the separating mechanism A, and the duct **17** connects the top of the cyclone collector C to the central part of the fan F and another duct **18** led from the top center of the separating mechanism A is connected to the top side of the cyclone collector C. A branch duct **19** formed at the center of said duct **16** is connected to the top of the back-filter B and to control dampers **16***a*, **19***a* so that the blast from the fan F to the separator A is suitably diverged completely or partially to be purified and outwardly exhausted. In this connection, the fan F is driven by a motor M_3 on 3rd bed G, and two brake-motors M_1, M_2 are arranged as shown in FIG. 1 relative to the separator A. Thus, motor M_1 rotates second rotary vanes **5** and the motor M_2 rotates first whirling vanes **8**, **8**. The separator A is arranged with a hopper **20** on its side so as to accept a continuous charge by means of the belt system or screw system, and especially when materials are supplied with the belt system the takeup feeder or others are appropriately set up in order to supply stationary charges, but these details are not shown since they are well known in the art and are not part of the inventive concept. The inner construction of separating mechanism A is shown in FIG. 4. The casing **1** which is circular in cross section is on bed D and has a spiral blow-in opening **6** at the lower part thereof to supply a blast through duct **16**. The exhaust out of casing **1** is through an out-let **9** in a whirling condition. A chute **2** of hopper **20** is introduced from one side of the casing **1**, and charged materials fed at a fixed rate are supplied to the center of the casing **1**, onto a rotary disc **4**, rotatably supported on a pivot shaft **11** under the out-let portion of said chute **2**. The charged materials are thrown onto this rotary disc **4**, uniformly dispersing and centrifuging the materials to the inner wall of the casing **1**. When the materials reach the casing wall, the blast fed from the spiral blow-in opening **6** meets the material and disperses the charged material on a whirling ascending current to the top of the casing **1**. Rotary disc **4** is driven by brake-motor M_1 on a bed D through a drive shaft **7** and a gear box **21**. The upper part of the casing **1** is a little wider in diameter than the lower part and, two whirling vanes **8**, **8** in synchronization are provided on upper and lower portions of the upper part of the casing. Those vanes **8**, **8** are rotated by a vertical shaft **14** through a bevel gear mechanism in a gear box **13** and a horizontal shaft **12** by means of motor M_2 placed at the side of the casing **1**. The materials to be separated which ascend by being carried along on said current are first separated with this current, and when reaching the whirling vanes **8**, **8** the materials are separated by a second effect. Powders are fed, as they are, to the out-let **9** by the revolution of vanes **8**, **8** which are so set as to provide a predetermined separating effect. After being thus separated, the rough particles and accompanying powders descend along the inner wall of the casing **1**. To enhance the separation the end portions **8***a*, **8***a* of the vanes **8**, **8** are as shown in FIGS. **4** and **5***a*, i.e., the ends are slanted upwards from the lower parts thereof and circular wall sections **28**, **28** are correspondingly slanted downwards forming flue zone therebetween. Therefore, two types of whirling currents are formed. There is a first whirling current led inwardly around circular walls **28**, **28** and ascends through the vanes **8**, **8** while there is a second, downward whirling current blown owing to the rotation of the vanes **8**, **8** to the inner wall of the casing **1** and then led to the circular walls **28**, **28** and forms such currents as shown with the arrows **27**. This downward current **27** is helpful for the separating effect upon large particles so that large and small particles are effectively separated, the smaller particles ascending, the larger particles descending.

A small amount of powder particles still accompany the thus separated rough particles, but these powder particles again reach the rotary disc **4**. Rotary disc **4** not only performs said dispersing and centrifuging function, but also performs a third separating function, that is to say, rotary disc **4** is furnished with rotary vanes **5** on the circumference thereof, and the mixed powders with rough particles which descend against the current, are again separated a third time by centrifugal force so that powders with rough particles which are separated are again selected to ascend and only heavy rough particles are discharged out of an out-let hopper **22** formed by a narrow funnel at the lower end of the casing **1**.

FIG. **5** shows the preferable embodiment of a rotary disc **3**. The rotary disc **3** is composed of upper and lower disc members which are combined by spacers **31**, **32** so that a space **33** is formed into which is fitted the whirling vanes **8**. Each of those vanes **8** is formed with a boss **34** and a hole **35**, as shown in FIG. **5***a*. The boss **34** is inserted into fitting space **33**, and a pivot **36** inserted through a hole **39** on the upper rotary disc member is fitted into the hole **35**. A lower portion **37** of the pivot **36** is fitted into a hole **38** formed on the lower rotary disc member **3**. The number of the whirling vanes **8** can be increased or decreased in accordance with the properties of the materials to be separated and other factors, and the vane **8** is easily removed by taking off the pivot **36**. Each of the whirling vanes **8** fitted in the holes

35 may move about with regard to the fitting angle to the rotary disc 3, but, because of the rotation of disc 3, centrifugal force effects the vanes 8 so that they each take an accurate radial orientation in spite of the loose fitting of the vanes by the hole 35 and the pivot 36. FIG. 6 shows the preferable embodiment of the lower rotary disc 4. The desired number of rotary vanes 5 may be fixed by means of the welding or other fixing means under the rotary disc 4. The rotary vanes 5, such as shown in FIG. 6 have a bent edge 51, the edge being bent opposite to the rotational direction, and this bent edge extends downward to form a pendant part 52 disposed around circular passage 60 fed by the blow-in opening 6, as shown in FIG. 4. Rotary vane 5 can have the form shown in FIG. 6 and also those shown in FIG. 7.

As shown in FIG. 8, dispersing vanes 40 can also be arranged on rotary disc 4 together with any of the rotary vanes 5 to increase the dispersing effect on the treated materials, and further the speed of the current produced may be appropriately augmented. The inventors increased and decreased the number of rotary vanes 5 for examination, and found there was no special significant difference in the cases of 7 or 8 vanes and more than 20 vanes.

To explain the separating method according to the present invention, it is well known that the blowing rate of the gas fed through blow-in opening 6 is appropriately chosen in the range of around 4 to 12m/sec., according to the particle size of the desired separation and the nature of the material to be separated, e.g., when the particle size of the material is comparatively large, the blowing rate is chosen to be low for the material which has a large specific gravity; on the contrary, when the particle size of the material is small, the blowing rate is chosen to be comparatively high for the material which is small in specific gravity. This blowing rate is similarly adjusted for such things as the amount of water contained or viscosity as well as the specific gravity of the material. The rotation of the whirling vane 8 is generally 3 to 12m/sec. for the peripheral speed, and is determined in accordance to the particle size of the material nature in a manner similar to the blowing rate. Generally, the high speed is chosen when the particle size of the object is small, and/or the specific gravity of the material is small. Lower vane 5 greatly influences the material separation. The inventors tested many materials and made many variances in the number of vanes, and found a significant relationship with the blowing rate of the gas stream current. It is recommended that a range of ± 30 percent to this blowing be selected as the speed for the rotation of vane 5. The preferable perpheral speed of the rotation is in the range of ± 10 percent to the blowing rate. When such operating conditions are adopted, the separating efficiency at which this invention aims is considerably higher than those of the prior art, and it is possible to smoothly obtain a desired separation.

For the purposes of giving those skilled in the art a better understanding of the invention, the following illustrative examples are given.

EXAMPLE 1

Siliceous sand (specific gravity: 2.7) was used for the material to be separated, being considered as moderate or standard.

The particle size composition was as follows.

+150mesh: 49.5%	+270mesh: 11.4%
+200mesh: 21.7%	−270mesh: 17.4%

The charging amount was 1,000Kg/hr and supplied stationarily to the center of the rotary disc 4, and the objective particle size of the separation was −270 mesh (i.e., smaller than 270 mesh) to determine the operating condition, that is, the blowing rate; the whirling ascending gas current was set at 6m/sec. at the opening 60, and the rotation of the upper vane 8 was set at 4.7m/sec. and that of the lower vane 5 was 5.7m/sec. for the operation. Table 1 shows the rough particles obtained at the hopper 22, the compositions and yield of the fine powders at the cyclone collector C in comparison with the charged materials.

TABLE 1

Particle Size(mesh)	Charged Material(%)	Rough particle(%) Hopper	Fine powder(%) Cyclone
+150	49.5	64.4	15.1
+200	21.7	24.5	15.1
+270	11.4	7.5	20.8
−270	17.4	3.6	49.0
Yield(Kg/hr)	1000	698	302

The separating efficiency of the fine powders where the objective was 270 mesh was calculated as being about 85 percent.

The efficiency of the rough particles were calculated as

$$698\times(1-0.036)/1000\times(1-0.174)=0.8146$$

The efficiency was around 81.5 percent.

EXAMPLE 2

The rotation of the lower vane 5 was set at 6m/sec. for the same materials in Example 1, and the operation was performed under the same condition as above. The separating efficiency as to the fine powder of −270 mesh was raised up to 95.0 percent, and that as to the rough particle was 87.5 percent.

EXAMPLE 3

The rotation of the lower vane 5 was set at 6.7m/sec. for the same materials in Example 1 and the operation was performed under the same condition as the above. The separating efficiency as to the fine powder of −270 mesh was 85.3 percent, and that as to the rough particles was 79.0 percent.

Examples 1 to 3 are all the preferable results, and satisfactory separating efficiencies. On the other hand, for the comparative experiments when said rotary vane 5 was set at 9m/sec. (the other conditions being the same in Example 1), the separating efficiency of the fine powders was around 62 percent, and when the rotary vane 5 was set at 4m/sec. the efficiency was around 68 percent. In either case the efficiency was a little higher than the separating efficiency of the prior art. In this connection, the siliceous sand of the same composition as the above was used while only using the rotary vanes 8, 8, and by supplying a quantity such that a product size of more than 95 percent of −270 mesh was obtained under the same conditions as above. The

result of the separating treatment was that the efficiency was only 26.8 percent.

EXAMPLE 4

Zeolite was separated with the same apparatus as in Example 1. The compositions of this zeolite were +300 mesh : 2.2 percent, and −300mesh (i.e., less than 300 mesh) : 97.8 percent; the object of the separation was 300 mesh; the blowing rate was set at 8m/sec.; the rotation of the whirling vane **8** was set at 9.4m/sec.; and the rotation of the rotary vane **5** was set at 9m/sec. Table II shows the rough particles obtained at the hopper, and the compositions and yield of the fine powders at the cyclone collector C.

TABLE II

Particle Size(mesh)	Charged Material(%)	Rough particle(%) Hopper	Fine powder(%) Cyclone
+300 mesh	2.2	82.6	0.3
−300 mesh	97.8	17.4	99.7
Yield(Kg/hr)	1000.	23.0	977

The separating efficiency for fine powders was 99.6 percent.

EXAMPLE 5

When the rotation of the rotary vane **5** was set at 8m/sec. under the same condition as in Example 4, the operation results were as shown in Table III.

TABLE III

Particle Size(mesh)	Charged Material(%)	Rough particle(%) Hopper	Fine powder(%) Cyclone
+300	2.2	91.0	0.2
−300	97.8	9.0	99.8
Yield(Kg/hr)	1000	22.0	978

The separating efficiency of fine powders was 99.8 percent. In this connection, when the vane **5** was set at 7m/sec., the separating efficiency of fine powders was 97.5 percent, and when set at 8m/sec., it was 93 percent. The results were all satisfactory.

On the other hand, for the comparative experiments when the rotation of the rotary vane **5** was set at 16m/sec., the separating efficiency of fine powders was around 62 percent, and when being at 0.5m/sec. it was 66.0 percent. The results were not good.

EXAMPLE 6

Barite particles (specific gravity : 4.5) were separated with the same apparatus as in Example 1. Table IV shows the charged materials and the composition of the separated results in the case wherein the object of the separation was 300 mesh, the blowing rate was set at 6m/sec., the whirling rate **8** was set at 12.5m/sec. and the rotary vane **5** was set at 6m/sec.

TABLE IV

Particle Size(mesh)	Charge Material(%)	Rough particle(%) Hopper	Fine powder(%) Cylcone
+300	18.0	53.8	1.6
−300	82.0	46.2	98.4
Yield(Kg/hr)	300	95	205

The separating efficiency of fine powders was 83 percent. On the other hand, when the rotation of the rotary vane **5** was set at 12m/sec. the separating efficiency of fine powders was 54 percent, and when being at 2m/sec., it was only 63 percent.

In the above mentioned Examples, the rotary disc **4** and the rotary vane **5** were as shown in FIG. **7**, but when the arrangement shown in FIG. **4** or FIG. **6** is used as the rotary vane **5** the separating efficiency will be further enhanced, that is, the separating efficiency is different in accordance with materials to be separated, but it has been confirmed by experimentation that the separating efficiency obtained with the rotary vanes as shown in FIG. **7** may be further enhanced about 5 percent. When the dispersing vanes **40**, shown in FIG. **8** are adopted, the separation is very precise, particularly for materials of large weight.

It is to be observed, therefore, that the present invention contemplates an arrangement for separating particulate material, comprising in combination: a separating mechanism A, including a housing having an inner cylindrical wall, a lower hopper for the removal of heavy particles and an upper axial outlet for the removal of fine particles; a first disc **4** disposed for rotation towards the lower part of said housing, said disc having a plurality of first radial vanes **5** disposed under said disc, said vanes extending almost to said inner wall; at least one second disc **3** with outwardly extending second radial vanes **8** disposed for rotation towards the upper part of said housing, said vanes extending almost to said inner wall; a feed chute **2** extending downwards from outside of the housing to over the center of said first disc for feeding particulate material onto the first disc at the about center thereof; a blow-in opening passage **60** below said first disc to blow-in a gas, whereby particulate material dropped onto said first disc is centrifuged outward to the wall, very heavy particles falling by gravity along the wall and heavy, medium and fine particles being swept up by the blown-in gas current to the second disc, the lighter particles being swept outwards past the vanes of the second disc, whereas the heavier particles fall back on the first disc and are subjected to a third separation; an outlet duct **18** leading outwards from the top of said housing defining a passage for said lighter particles; a vertically disposed cyclone collector C with an opening at the upper part thereof connected to said outlet duct **18** dispersed alongside said separating mechanism for further separating said fine particles; and, gas blowing means F including a blow-in opening **6** connected to said blow-in passage **60** and an air feed duct **17** connected to the top of said cyclone collector.

What is claimed is:

1. An apparatus for separating particulate material into fine and heavy particles, comprising in combination:

a. a housing having an inner cylindrical wall, a lower hopper for the removal of heavy particles and an upper outlet for the removal of fine particles;

b. a first disc (**4**) disposed for rotation towards the lower part of said housing, said disc having a plurality of first radial vanes (**5**) disposed under said disc, said vanes extending almost to said inner wall

and having an edge (51) bent opposite to the rotational direction of said vanes and a pendant part (52) extending downwards;

c. at least one second disc (3) with outwardly extending second radial vanes (8) disposed for rotation towards the upper part of said housing, said vanes extending almost to said inner wall;

d. a feed chute (2) extending downwards from outside of the housing to over the center of said first disc for feeding particulate material onto the first disc at the about center thereof; and,

e. a blow-in circular passage (60) below said first disc to tangentially blow in a gas fluid, said vanes pendant part (52) being disposed around said circular passage (60), whereby particulate material dropped into said first disc is centrifuged outward to the wall, very heavy particles falling by gravity along the wall and, heavy medium and fine particles being swept up by the blown-in gas fluid current to the second disc, the lighter particles being swept outwards past the vanes of the second disc whereas the heavier particles fall back on the first disc and are subjected to a third separation.

2. An apparatus as claimed in claim 1, including a third disc with outwardly extending third radial vanes similar to said second disc and said second vanes disposed a short distance from said second disc and vanes, said second and third disc and vanes producing gas fluid currents, swirling about an axis normal to that of said cylindrical wall.

3. An apparatus as claimed in claim 2, including inwardly projecting collars (28) on said cylindrical wall at the locations of said second and third discs and outwardly projecting blades (8a) on said second and third vanes, the blades projecting under said collars, said collars having a downwardly slanting inner collar wall and said blades having an upwardly slanting outer edge disposed under said slanting inner collar wall, said arrangement selectively allowing only finer particles to pass between said collars and blades.

4. An apparatus as claimed in claim 1, said blowin opening passage (60) extending around the lower portion of said cylindrical wall, outwards of said wall at the location of said first disc and first vanes.

5. An apparatus as claimed in claim 4, said first disc being at the top of said blow-in opening, said pendant part (52) extending downwards the length of said opening.

6. A method of separating particulate material, comprising the steps of:

a. chuting the particulate material angularly downwards from outside a cylindrical workstation onto a vaned rotating disc within a lower-rotary treatment zone within said cylindrical workstation;

b. tangentially blowing in a gas stream below said rotating disc while causing said gas to rise, the blowing rate of the gas being such that said vaned disc rotates within a range of between about 10 to about 30 percent of said blowing rate so that said particulate matter is outwardly centrifuged and a first separation takes place, the heavier particles falling by gravity between the outer periphery of said lower rotary treatment zone and the said cylindrical workstation, the lighter particles being carried upwards with said blown-in gas;

c. passing said material-laden gas through an upper rotary treatment zone having first and second vaned sections wherein vanes rotate adjacent said cylindrical workstation, said upper treatment zone including first and second flue zones defined between said vaned sections and said cylindrical workstation, whereat a second separation takes place, the finer particles flowing outwards past the upper rotary treatment zone, the heavier particles falling back onto said lower rotary treatment zone whereat a third separation takes place as the falling material is mixed with newly chuted fresh material; and,

d. removing the heavier particles from a first accumulation zone below said cylindrical workstation and also removing the finer particles from a second accumulation zone receiving fine particles flowing outwards from the upper part of said cylindrical workstation.

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