

[54] **PNEUMATIC CLASSIFIER WITH GRATING**

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356, 132, 133, 10

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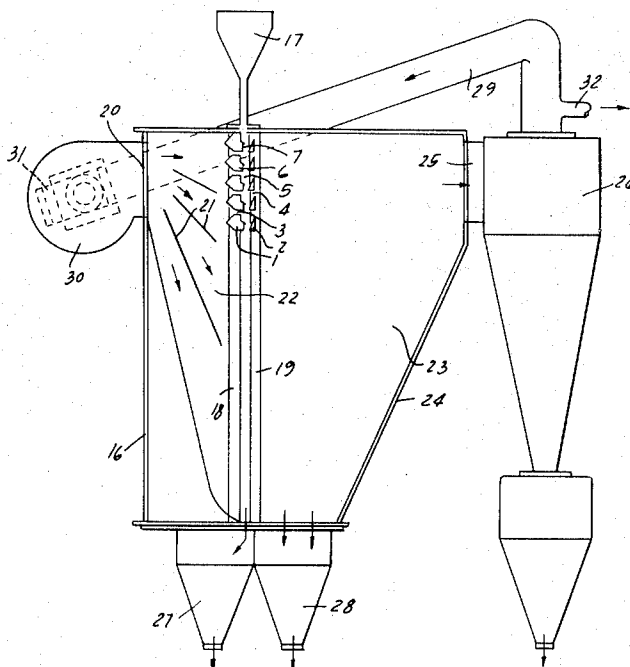
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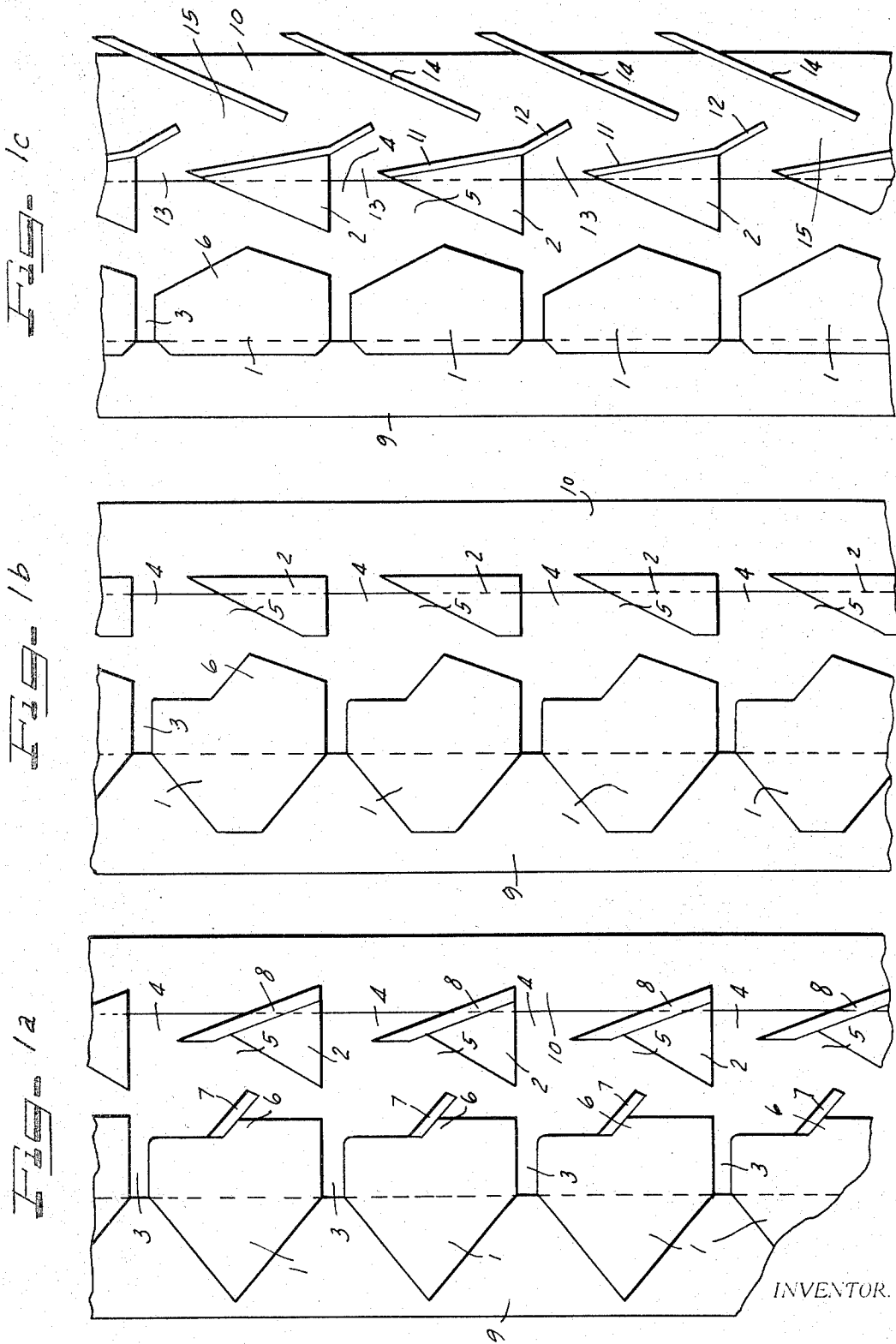
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[57] **ABSTRACT**

An improved apparatus for pneumatic classification of finely divided solids, including primary separation of the material by directing a curtain of finely ground falling solids in a zig-zag course through a gas stream of relatively high velocity and a second separation step of the finer fractions by similar treatment in a lower velocity gas stream.

3 Claims, 7 Drawing Figures



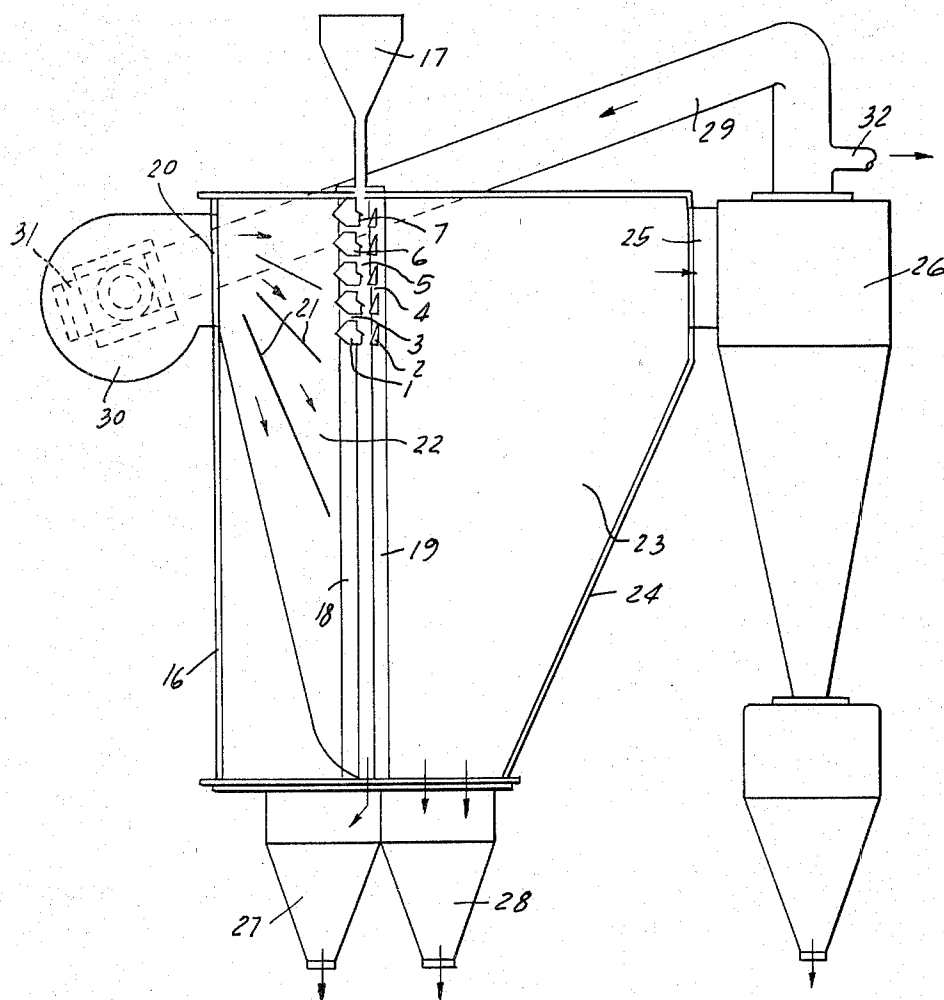


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Fig. 2



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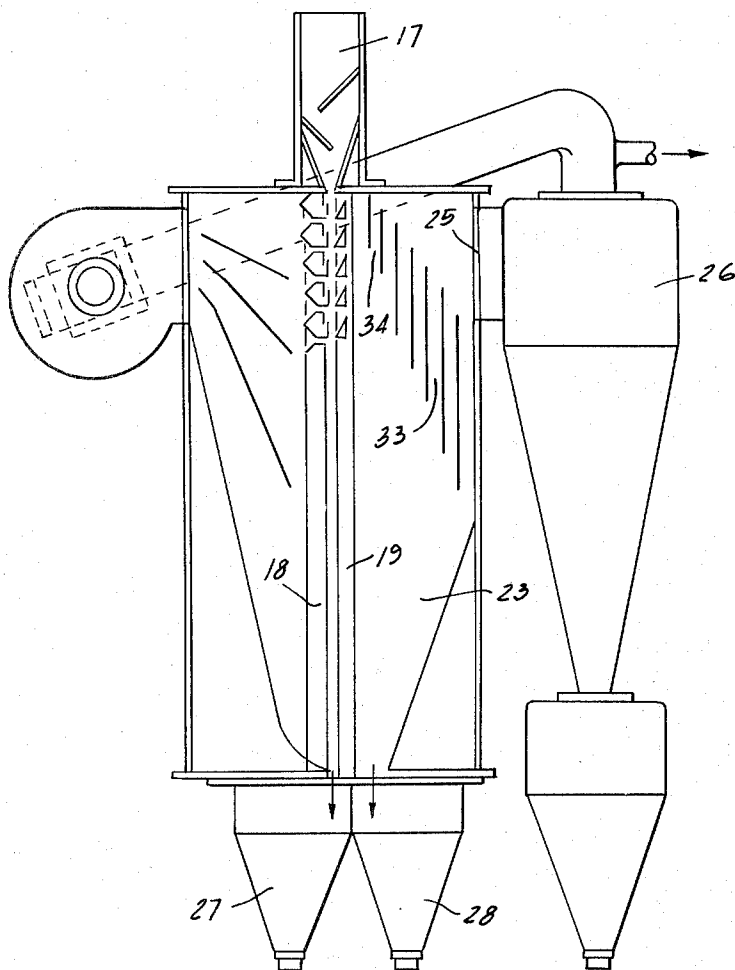
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Fig. 3

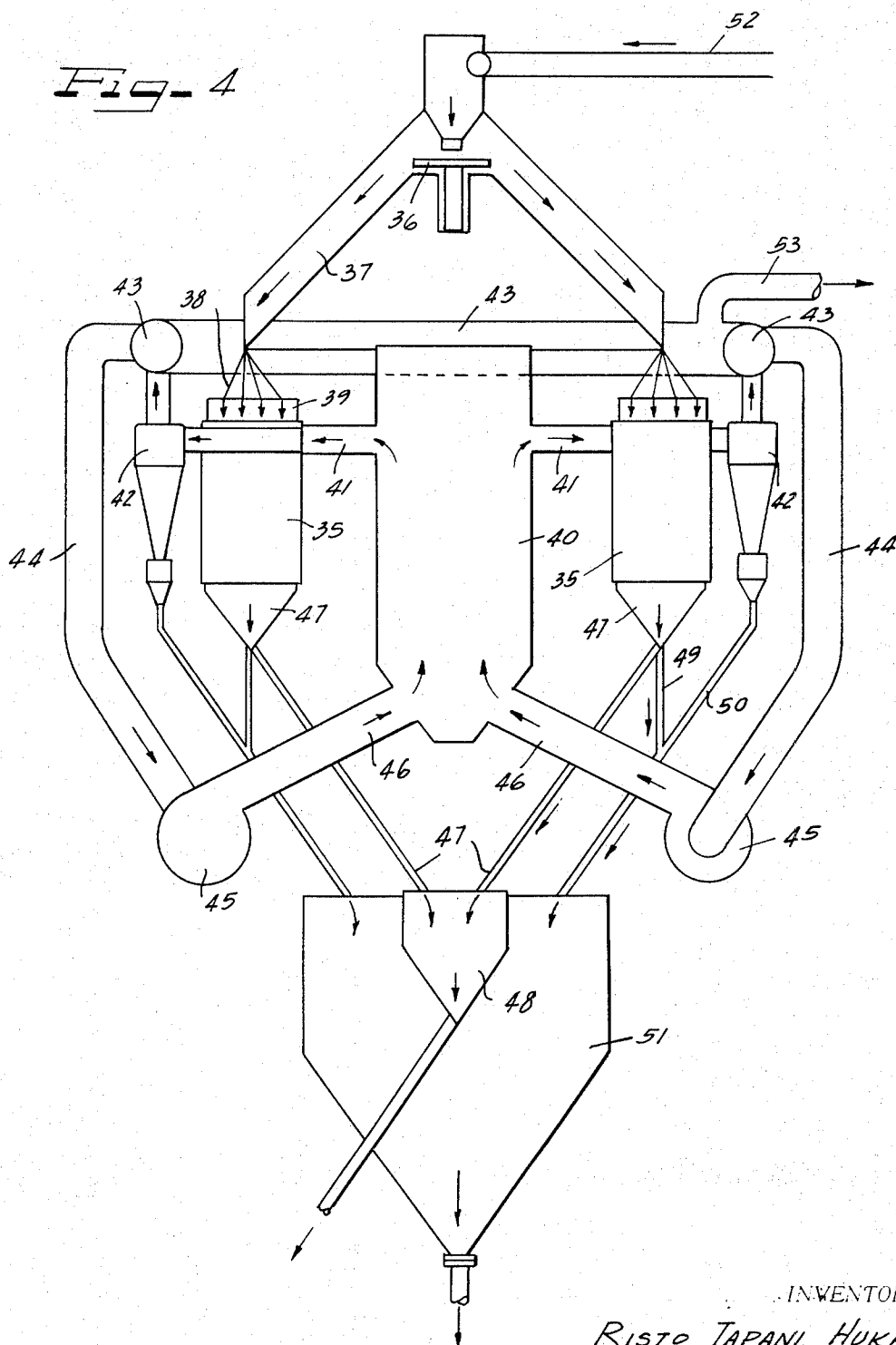


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Fig- 4

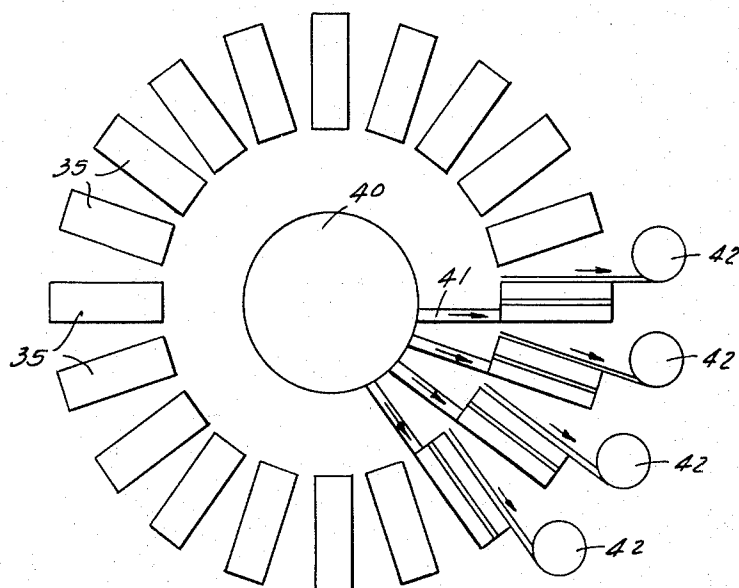


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Fig. 5



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PNEUMATIC CLASSIFIER WITH GRATING

This invention relates to an improved pneumatic apparatus for classification of finely divided solids for small and large scale industrial applications including such closed dry grinding circuits as applied in production of cement and similar pulverized materials.

Pneumatic classifiers are already known where horizontal stream of air is blown across a vertically falling curtain of material whereby two or more products varying in coarseness are obtained.

Although the said classifiers are known from a long time back, their use is rather limited. This may be the result of the insufficient sharp-ness of separation of the apparatus.

It is well known that single step classification does not lead to sharp separation nor to clean products. It is further known that by repeating, e.g., the classification of the coarser product a number of times, the final coarse product will be the cleaner the greater the number of classification steps.

The object of this invention is an improved pneumatic precision classifier whose sharpness of classification is extremely high while the construction of the apparatus is simple and its capacity great.

In the present closed dry grinding circuits used in production of cement and similar finely pulverized materials it is known that there exist, e.g., the following very consequential disadvantages that are difficult to eliminate:

the sharpness of classification of all industrial classifiers used up to now is unsatisfactory;

due to the low sharpness of separation large quantities of material as such of final fineness are returned to the grinding unit, e.g., to a mill, the presence of which fine material reduces the efficiency of the grinding process, lowers its capacity, increases energy consumption and causes strong formation of harmful surface coatings on grinding medium and on mill liners;

the high energy consumption in grinding leads to high temperatures which already as such make the technical performance of the reduction process more difficult and in certain cases cause harmful quality changes in the product;

from the low sharpness of classification it follows also that the final fine product carries an unusually large portion of the very finest size fractions, e.g., of -10 micron material, the share of which fraction should be lowered for various reasons.

The further purpose of this invention is to bring about a substantial improvement to the disadvantages described above by performing the classification with a pneumatic precision classifier complying with given specifications, and on any industrial scale.

It is characteristic to the continuous pneumatic classification process according to this invention that it comprises a long series of primary separation steps. Each such step includes the crossing of a gas jet through a falling curtain of solids whereby a certain quantity of particles having the mean particle size smaller than that of the feed material is carried away with the said gas jet. Those particles that are not removed proceed downward to the next primary separation step on a level below. The particles still retained after the final primary separation step discharge downward as a coarse product.

It has been found that in order to obtain sharp primary separation of the fines from the coarse material, the downward path of the material stream must be caused to take a zig-zag-type flow pattern, e.g., one complete bend for each primary separation step. The zig-zagging bends brake down the downward velocity of the material stream, help further dispersion of the solids and cause effective rearrangement of the particles within the stream.

The process of classification according to this invention includes further a second separation step of the finer fractions removed from the feed material stream by the gas jets. This secondary step comprises a reduction in the flow velocity of the gas medium whereby particles finer than a certain maximum size only are capable of being carried further away from the gas medium as a fine product while the solids not carried away settle now downward into one or more middle products characterized by a mean particle size in-between those of the originally separated coarse product and the fine product taken away with the gas medium.

This secondary separation step can be essentially sharpened by one or more, e.g., substantially vertical series of forced, directed flow changes downward either of the separate primary gas jets or of the entire gas medium stream. Any such downward change may be followed, if desired, by e.g., a substantially vertical, corresponding series of forced, directed flow changes upward. By so doing the coarsest grains within the solids removed by the gas medium from the primary separation zone can be effectively separated away from the fines and directed downward to any of the coarser products.

In order to improve the overall sharpness of classification still further, it is possible to direct by gravity any or all of the coarser products produced to a substantially similar reclassification process performed on a lower level. To improve dispersion of badly agglomerated feed materials, additional gas jets are directed when desirable to the feed stream before any series of separation steps.

The heart of the apparatus for continuous pneumatic classification of finely dispersed solids according to this invention comprises a long substantially vertical series of modular base separators. Each base separator consists of a properly shaped front beam and a rear beam on about the same level. Each base separator includes a narrow, e.g., substantially horizontal air channel defined by the top surface of the corresponding front beam and the bottom surface of the equivalent beam above, fine product discharge outlet defined by the sharp top of the corresponding rear beam and the bottom of the equivalent beam above, and a substantially funnel-shaped collecting space defined by the back surface of the front beam and the front surface of the rear beam in question.

The preferred modular height of the base separator is less than 60 mm. Due to this small height, 16 or more separate modules can be included within a total cumulative height of 1 meter, 32 or more within 2 meters, etc. Unit classifiers including 20 base separators with 50 mm modular height have given excellent results.

The unit classifier constructed according to the principles of this invention comprises essentially a stationary box-like housing

means to introduce gas, normally air, under pressure into a pressure equalizing space situated in the front part of the box

a substantially vertical series of modular base separators constructed as already described

a space for secondary separation

a vertical or sloping back wall

means to introduce feed at a desired steady rate

means to collect the coarse product

one or more means to collect the middle product or products, and

cyclone means to separate gas medium from the fine product and to collect the fine product.

In order to provide the unit classifier with more precise means of quality control of the fine product, the apparatus can be equipped with one or more series of inclined slats or baffles resembling a Venetian blind. The said slats when set at a given steep angle form either downward or upward directed flow channels. One downward and one upward directed flow channel system can simultaneously generate a series of joining downward directed funnel-shaped collecting spaces. Furthermore, the unit classifier can be equipped with substantially vertical multiple-channel means situated in the secondary separation space with uppermost entrance opening being placed nearest to the grates forming the base separators and the lower entrance openings stepwise further away.

Other objects, features and advantages of the present invention will be indicated with reference to accompanying drawings illustrating the preferred embodiments of this invention.

FIG. 1 shows diagrammatically vertical cross sections of three types of modular base separators employed in the apparatus constructed in accordance with the principles of this invention;

FIG. 2 is a diagrammatic vertical cross sectional view of a unit classifier;

FIG. 3 is a diagrammatic vertical cross sectional view of a unit classifier of another construction;

FIG. 4 is a diagrammatic vertical cross sectional view of a classification apparatus compiled of a large number of unit classifiers; and

FIG. 5 is a diagrammatic horizontal cross sectional view of the apparatus shown in FIG. 4.

With reference to FIG. 1a it shows the means employed in the construction of a series of base separators. Each base separator is made up of front beam 1 and rear beam 2, shaped substantially as shown and placed on about the same level. The front beam has preferably parallel top and bottom surfaces. The rear beam is characterized by sharp top and a front surface sloping toward the front beam. Each base separator includes substantially horizontal narrow air channel 3, fine product discharge outlet 4 and below them substantially funnel-shaped collecting space 5. The base separators are placed into a substantially vertical series. Each pair of front beams 1 define one air channel. Each pair of rear beams 2 define one discharge outlet. Each pair of front and rear beams 1 and 2, respectively, define one collecting space.

It has been found advantageous to provide the front beams with steplike downward sloping extension 6, which can be covered with special wear plate 7 whose width is preferably greater than the width of extension 6. Beams 2 can be covered with cutter blades 8 having

a sharp top edge. Blade 8 can be made adjustable in respect to beam 2.

Beams 1 and 2 are supported by substantially vertical supporting beams 9 and 10, respectively, of any suitable design, forming together one front grate and one rear grate. The system of grates thus formed is advantageously provided with means of any convenient construction to regulate the distance between the grates, in other words, the widths of collecting spaces 5. The preferred way is to make the rear grate movable within reasonable limits. The grates can also be provided with vibrating or tapping means of any well known design.

FIGS. 1b and 1c show other types of the base separator elements. In FIG. 1b, the beam-and-cutter combination is replaced by triangular beam 2. In FIG. 1c, extensions 6 in beams 1 slope downward at about 60° angle. The front surfaces of triangular beams 2 slope downward at about 60° angle in an opposite direction. Back surfaces of beams 2 are here covered with slats 11 having bent extensions 12 forming downward directed flow passages 13 between each pair of beams 2. Slats 14 supported by beam 10 form a system resembling a Venetian blind where the said slats form upward directed flow channels having a fixed slope, preferably 60° or somewhat more. Slats 11 with extensions 12 and slats 14 generate now another series of funnel-shaped spaces 15 directed downward.

Beams 1 and 2 form the heart of the apparatus. It is obvious that many other shapes can be presented. The essential general operational features required from the beams are:

- they should be rugged enough to retain their shape and resist wear
- they should offer no undue resistance to air flow
- they should stay clean
- they should be easily replaced by new ones if necessary.

FIG. 2 presents a schematic vertical section of a unit classifier according to this invention. It includes a stationary box-like housing 16, feeding means 17, front grate 18 which carries front beams 1, rear grate 19 which carries rear beams 2, opening 20 to feed and means 21 to regulate gas flow into pressure equalizing space 22, secondary classification space 23, vertical or sloping back wall 24 provided with a discharge opening 25, cyclone means 26 to collect the fine product and receptacles 27 and 28 to collect the coarse and middle products, respectively.

To form a complete operating system the medium discharge pipe 29 from cyclone 26 is connected to the suction side of low-pressure blower 30 and the pressure side of the same blower via opening 20 to space 22 of the classifier box. Means 31, consisting e.g., of a series of baffles with an opening of predetermined diameter in each, is used to regulate the air volume. Outlet 32 is provided for removal of a certain volume of gas medium from circulation by any suitable outside means.

The unit classifier operates as follows:

Material to be classified is introduced at a desired rate via feeder 17 whose height is selected to suit. Low-pressure air from blower 30 is fed via opening 20 into pressure-equalizing space 22 where air distribution is further regulated by plate means 21. From space 22 the air discharges in the form of jets via the long series of

channels 3 in front grate 18. In each base separator the respective air jet crosses the downward flowing curtain of solids. The jet carries a certain quantity of finer material via outlets 4 in rear grate 19 into space 23. The particles not removed proceed downward in funnel-shaped space 5 to the following separation module on a lower level. Extensions 6 and/or wear plates 7 in beams 1 cause forced changes in the vertical flow direction whereby a zig-zag-type flow pattern is obtained. This flow pattern brakes down effectively the downward flow velocity of the material stream, helps further dispersion of the solids and agglomerates, and causes strong rearrangement of the particles within the stream. The coarse fraction retained by the lowermost base separator flows into receptacle 27. In space 23 a second separation of the finer particles removed from the feed stream by the series of air jets takes place because of substantial reduction in the flow velocity of the carrier medium. Only particles finer than a certain maximum size are capable of staying in suspension. With the outflowing air these fine particles are carried away via opening 25 into cyclone 26 where the fine solids separate from the gas. The particles not carried away from space 23 settle into receptacle 28 as a middle product. Air discharged from cyclone 26 is directed back to the suction side of blower 30 whereby a closed medium circuit is formed. The air flow to the classifier is controlled by baffle means 31. To prevent the possibility of partial spreading of dust outside the apparatus it is preferable to remove a certain quantity of air from circulation via opening 32 by any well known means. The removed air is compensated by fresh air flowing into the system with the feed material.

FIG. 3 presents a diagrammatic vertical cross section of a unit classifier constructed e.g., for separation of a very fine cyclone product of given specifications. The additional features included here comprise substantially vertical multiple-channel means 33 placed in space 23. The channels lead into cyclone 26 via opening 25. The uppermost entrance opening 34 of the said channel means is situated nearest to rear grate 19 and the lower entrance openings stepwise further away. In operation the essential difference exists now in the secondary classification step. The air medium has to flow through the channels after a sudden controlled change in the flow direction upward. Particles larger than a certain maximum size separate sharply from the fines, collide to the front surfaces of the channel plates, lose their velocity and start falling downwardly. These and other particles separating inside the channel system settle downward by gravity in the form of curtains and are repeatedly subjected to cleaning by the lower air streams.

According to FIGS. 2 and 3, three separate products are obtained from the system. The apparatus can, however, be provided with simple chute means to combine the products in any desired way.

In studying the performance of the pneumatic classification apparatus as shown by FIGS. 2 and 3 it has been found out that excellent precision separation can be obtained already by a single run through the apparatus in cases where relatively coarse feed materials are treated and the coarse fraction forms the final desired end product. With emphasis on the fine end product such as cement, however, a single run leads to

a partial separation of the fines into the cyclone product only.

It has now been discovered that by sharpening the secondary separation step in space 23 by means of one or more series of inclined flow channels generated by the Venetian blinds already described, the middle product or at least one of the middle products can be obtained already so fine as to be acceptable with the cyclone product as the final fine product. By installing e.g., the rear grate as shown in FIG. 1c into the units shown in FIGS. 2 and 3, the originally horizontal gas jets discharging via openings 4 from the primary separation modules are forced by extensions 12 to make a sharp downward bend along channels 13. The coarsest grains and especially the tramp oversize grains carried over in suspension by the said jets continue their path downward into funnel-shaped spaces 15 formed by slats 11, extensions 12 and slats 14 and are collectively removed via lowermost funnel 15, e.g., into the coarse material stream discharging from the primary separation zone. The gas medium with the still retained finer solids takes a sharp forced upward bend as directed by slats 14 and proceeds into space 23, where separation of the fines into two fractions takes place as already described. The important fact is that no accidental tramp oversize grain can any more find its way into the middle product, that the overall fineness of the middle product so obtained is substantially increased, and that the middle product brings about a big additional recovery of the fines. In all cases where the said combined fine product meets the specifications of the final end product, this treatment materially reduces the number of separations, lowers the number of classification units required and simplifies the classification circuit. Naturally, the said middle product and the said cyclone product can also be removed as two separate end products.

Even in cases where the cyclone product alone meets the specifications for an acceptable final fine product, the sharpening treatment and the respective means explained above allow substantially greater gas flow rate to be applied in the process whereby the fines recovery represented by the said cyclone product can be essentially improved without a detrimental effect on its quality.

Certain finely divided powders are extremely difficult to de-agglomerate for separation. In order to improve dispersion of such feed materials, additional low or high pressure gas jets can be directed when desired to the feed material stream. The nozzles or other means of well known construction to obtain such jets are preferably attached to feeding means 17.

The tendency of fine dust to adhere on some critical surfaces within the apparatus can be effectively controlled, e.g., by vibrating or tapping either or both of the grates formed by front beams 1 and rear beams 2 and the respective supporting means, as well as any slat system that may be installed. In an extreme case the front grate may even be provided with scraper means to keep air channels 3 unblinded under any circumstances.

Characteristic to the multiple unit classification apparatus according to this invention is that in a general case it comprises any desired number of unit classifiers in parallel or in series, feeding means common for the

primary classifiers in parallel, common collecting means of the final fine product, common collecting means of the final coarse product, common closed air circulation means, common dust removal means, and pipes and channels combining operatively the various parts, all of which together with an external size reduction apparatus form a unified system operating in closed circuit.

In smaller industrial classification systems the parallel units are placed into one or more horizontal or vertical rows while in very large systems they are preferably placed into an annulus over 360° area.

FIG. 4 presents a schematic, vertical section of the classification apparatus according to this invention for closed circuit grinding system of cement clinker in large-scale industry. FIG. 5 presents a horizontal cross section of the same apparatus.

With reference to FIGS. 4 and 5, the apparatus comprises a desired number of unit classifiers 35, constructed along the principles already explained. In the case shown, the total number of parallel units is 20. The effective height of the classifiers is selected to meet the product specifications and the desired degree of sharpness of classification.

The closed circuit apparatus includes, as shown in FIG. 4, an essential auxiliary means disc feeder 36 rotated about a vertical axis at a desired speed, distribution channel 37 formed by two cones, distribution tubes 38, feeding means 39, centrally located air reservoir 40, air distribution channels 41 leading from reservoir 40 to units 35, fine product separation cyclones 42, air collector ring 43, air return tubes 44, one or more low pressure blowers 45, feeder tubes 46 leading from blowers 45 to reservoir 40, chute and pipe means 47 to collect all coarse fractions into pocket 48, chute and pipe means 49 for the middle products, discharge pipe 50 for the fine cyclone product, and bin 51 to receive the combined middle and fine products as the final fine product of the system.

Outside the classification apparatus the closed dry grinding circuit still includes as additional essential basic units e.g., a primary grinding mill such as the rod mill, a secondary grinding mill such as the ball mill, an elevator, a feeding conveyor from the elevator to the top section of the classification apparatus and dust removal means, as well as tubes and channels combining the various parts operatively together, all of which together form a unified system operating in closed circuit.

The grinding circuit operates as follows:

The cement clinker is ground first in the rod mill operating in open circuit. The ground product is transferred by an elevator to a desired elevation and then by belt feeder 52 to the top section of the classification apparatus. Disc feeder 36 sprays the material evenly over a 360° area in channel 37. Distribution tubes 39 divide the feed material to the unit classifiers. Air fed by channels 41 from reservoir 40 subdivides in unit classifiers 35 into a long series of air jets crossing the material curtains already explained. The coarse product retained inbetween the grates in all unit classifiers is collected together by chute and pipe means 47 leading into pocket 48, wherefrom the fraction is directed to the ball mill for further size reduction. The ball mill product is combined with the rod mill product and

returns in closed circuit back to classification. The middle product produced in each unit classifier and the cyclone product separated in each cyclone form in the case shown the final cement. The middle products are collected by chute and pipe means 49 and the cyclone products by pipes 50. All these means lead by gravity into bin 51 which receives the cement from all classifiers. In order to keep the apparatus in its entirety as dustfree as possible, part of the circulating air is removed from the system, e.g., by means of outlet 53 leading into any external de-dusting unit.

The apparatus can naturally be designed with means to collect the sharply controlled middle product and the cyclone product as two separate fine products. The former may correspond, e.g., to a low specific surface area cement, the cyclone product to a higher specific surface area cement.

The most essential means of regulation affecting the performance of the classification apparatus at a specified feed rate are the regulation of air and the regulation of flow speed of the material curtain. The former is accomplished on a large scale by regulating the volume and pressure of air produced by one or jointly by several low pressure blowers, and on a small scale by regulating the volume of air introduced into each classification unit. Further, regulation within a unit classifier can be directed to feeding relatively more air via the upper air channels in the front grate than via the lower channels. In general, an increase of the air volume leads to a coarser middle product and to a coarser fine product, a decrease of the same to finer products. The flow speed of the material curtain can be influenced, e.g., by means of braking baffles placed in feed channels, and by forcing the stream to take a zig-zag-type flow pattern.

The ability of the classification apparatus according to this invention to accomplish separations of extreme sharpness will be demonstrated by the following tests carried out on pilot plant scale:

TEST 1

The purpose of classification in this case was to produce a coarse product with the minimum of fines.

The impure sands were fed only once at the rate of 1 t/h into a unit classifier substantially as shown in FIG. 2. In this unit the modular number of unit separators was 20, the modular height 50 mm and the height of air channels 3 mm. The effective width of the box (the length of beams 1 and 2) was 20 cm. The results were:

TABLE 1

Screen, mesh	Screen opening, μ	Percent undersize			
		Feed	Coarse product	Middle product	Fine product
28	589	100.0	100.0	100.0	
35	417	93.9	89.5	99.7	
48	295	65.9	39.7	95.7	
60	208	44.6	12.8	81.2	100.0
100	147	30.7	2.6	53.8	99.5
150	104	20.3	0.4	25.3	95.1
200	74	14.4	0.3	11.2	83.3
Weight distribution		100.0%	56.8 %	29.5%	13.7%

It can be graphically verified that the logarithmic size distribution curve of the coarse product is extremely

steep; this is a measure of the cleanliness of the product. Similarly, the respective curve of the middle product is steep. Thus, it is possible to separate simultaneously two or even more sharply classified coarse products with this apparatus.

With the described small unit the feed rate has been varied from small values up to about 7 t/h. The energy consumption is very low: values even less than 0.2 kWh/t are conventional.

TEST 2

The purpose of classification was now to produce a product at least 80 percent -200 mesh from ground limestone. This product corresponds to the conventional raw material in cement industry.

Ground limestone was fed at the rate of 2 t/h into the unit classifier already described. After a single run the results were:

TABLE 2

Screen mesh	Screen opening, μ	Percent undersize			Fine product
		Feed	Coarse product	Middle product	
35	417	66.0	45.5	100.0	
48	295	60.0	35.7	99.9	
65	208	54.1	26.4	99.8	
100	147	48.1	17.2	98.8	100.0
150	104	41.2	8.0	94.2	99.1
200	74	34.7	3.2	82.6	96.4
Weight distribution		100.0%	62.3%	26.2%	11.5%

The combined final product obtained from the middle product and the fine product carries 86.8 percent -200 mesh material and accordingly it is substantially finer than specified above. The combined final product amounts to 37.7 percent of the feed to the classification process. The recovery of -200 mesh material in the combined final product is 94.1 percent.

TEST 3

The purpose of classification was this time to produce a product corresponding in fineness to the common grade cement.

Ground feldspar was fed at the rate of 2 t/h into the same unit classifier as used before. The coarse products of the first, second and third run were retreated whereby one final coarse product, four middle products and four fine products were obtained. The screen analyses of the feed, final coarse product, combined middle products, and combined fine products were:

TABLE 3

Screen mesh	Screen opening, μ	Percent undersize			Fine product
		Feed	Coarse product	Middle product	
200	74	51.6	9.6	90.9	99.0
400	37	33.4	2.2	59.6	82.6
Weight distribution		100.0%	49.3%	41.9%	8.8%

When combined, the middle product and fine product together assay 92.3 percent -200 and 63.6 percent -400 mesh. The recovery of -200 mesh

material in the final fine product is 90.7 percent and that of -400 mesh material 96.6 percent. The specific surface area on the middle product is 2,930 cm²/g, on the fine product 3,750 cm²/g. and on the final combined material 3,030 cm²/g.

As the test data shown above is based on preliminary investigations, it is obvious that the performance of the classification apparatus according to this invention can still be improved. A comparison with the respective results obtained with conventional industrial classifiers show, however, that the reported results already are of extremely high quality.

I claim as my invention:

1. In an apparatus for classifying finely divided solid materials containing coarse and fine particles including:

- upright front and rear gratings between which a downwardly flowing stream of finely divided solid material is conducted in a zig-zag path,
- each grating including a plurality of vertically spaced horizontal beams alternating with horizontally disposed gas flow channels between adjacent beams of the front grating, said channels being provided by said beams, and a discharge outlet between adjacent beams of the rear grating,
- each beam of the rear grating being located back of a beam of the front grating and spaced therefrom to provide a portion of said zig-zag path,
- means for supplying gas to the channels in the front grating to flow transversely therefrom through the downwardly flowing stream of finely divided material and carry fines thereof through the respective opposite discharge outlets of the rear grating,
- each beam of the rear grating having a surface sloping toward and for directing the stream of finely divided material therefrom toward the beam next below the directly opposite beam of the front grating,
- each beam of the front grating including a portion projecting toward and adapted to direct the stream of finely divided material onto the sloping surface of the beam of the rear grating directly at its back, and
- means for separating fines from the gas flowing from the passageways of the rear grating, the improvements wherein
- oppositely positioned front and rear beams cooperate with each other to define a unit separator in said zig-zag path, the beams of the front grating having horizontal substantially parallel top and bottom surface areas extending toward said opposite discharge outlet of the rear grating, the resulting facing surface areas of adjacent beams of the front grating defining a channel therebetween which is narrow relative to the vertical height of a front beam, said narrow channel adapted to deliver a horizontal rearwardly-directed gas jet across and through said stream of material flowing into the adjacent unit separator and into the discharge outlet opposite said channel,
- the top of each beam of the rear grating is at a substantially lower level than the top surface area of the opposite beam of the front grating,

- j. adjacent beams of the rear grating defining a discharge outlet therebetween for the flow of gas carrying fine particles of the material of said stream and wherein
 - k. the vertical distance between adjacent beams of the rear grating is substantially greater than that between adjacent beams of the front grating, thereby facilitating the flow of the gas of said gas jets through said stream of material and into and through the discharge outlets. 5
2. An apparatus as claimed in claim 1 wherein the free height between adjacent rear beams is at least twice the free height between adjacent front beams. 10
3. In an apparatus for classifying finely divided solid materials containing coarse and fine particles including: 15
- a. upright front and rear gratings between which a downwardly flowing stream of finely divided solid material is conducted in a zig-zag path,
 - b. each grating including a plurality of vertically spaced horizontal beams alternating with horizontally disposed gas flow channels between adjacent beams of the front grating, said channels being provided by said beams, and a discharge outlet between adjacent beams of the rear grating, 20
 - c. each beam of the rear grating being located back of a beam of the front grating and spaced therefrom to provide a portion of said zig-zag path,
 - d. means for supplying gas to the channels in the front grating to flow transversely therefrom through the downwardly flowing stream of finely divided material and carry fines thereof through the respective opposite discharge outlets of the rear grating, 25
 - e. each beam of the rear grating having a surface sloping toward and for directing the stream of finely divided material therefrom toward the beam next below the directly opposite beam of the front 30

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- f. each beam of the front grating including a portion projecting toward and adapted to direct the stream of finely divided material onto the sloping surface of the beam of the rear grating directly at its back, and
- g. means for separating fines from the gas flowing from the passageways of the rear grating,
- h. the beams of the front grating have horizontal substantially parallel top and bottom surface areas, the facing surface areas of adjacent beams of the front grating defining a channel therebetween for the delivery of a horizontally-directed gas jet across and through said stream of material and directly into the opposite discharge outlet,
- i. the top of each beam of the rear grating is at a substantially lower level than the top surface area of the opposite beam of the front grating,
- j. adjacent beams of the rear grating defining a discharge outlet therebetween for the flow of gas carrying fine particles of the material of said stream,
- k. the vertical distance between adjacent beams of the rear grating is substantially greater than that between adjacent beams of the front grating, thereby facilitating the flow of the gas of said gas jets through said stream of material and into and through the discharge outlets and wherein the beams of the rear grating each include a rear portion sloping downwardly and outwardly, and a third upright grating located at the back of the rear grating and including a plurality of vertically spaced beams respectively located opposite the discharge outlets of the rear grating, each beam of the third grating having a front surface sloping downwardly and toward the sloping back portion of a beam of the rear grating. 35

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