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APPARATUS FOR CLASSIFYING PARTICULATE MATERIAL

Filed June 20, 1958

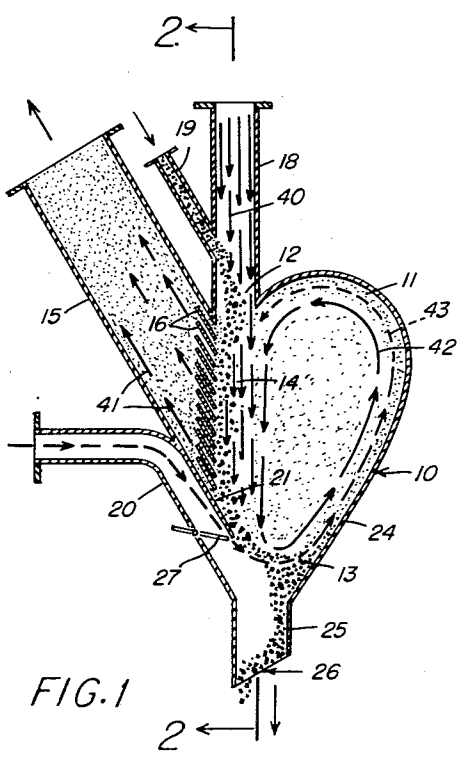


FIG. 1

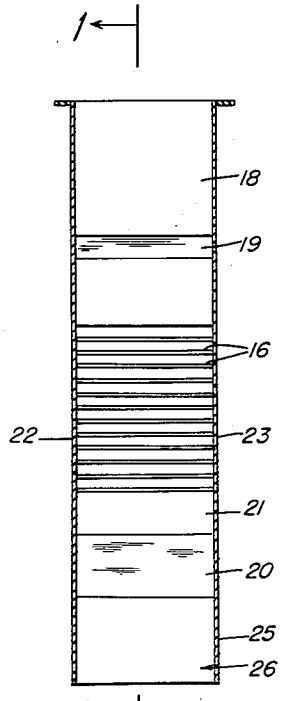


FIG. 2

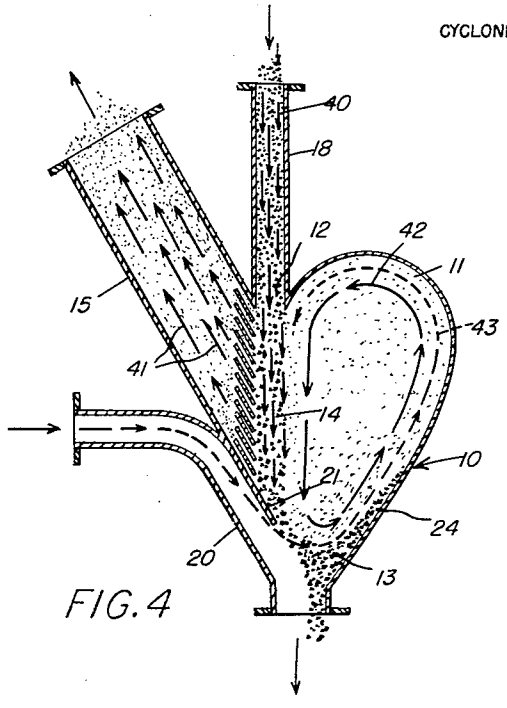


FIG. 4

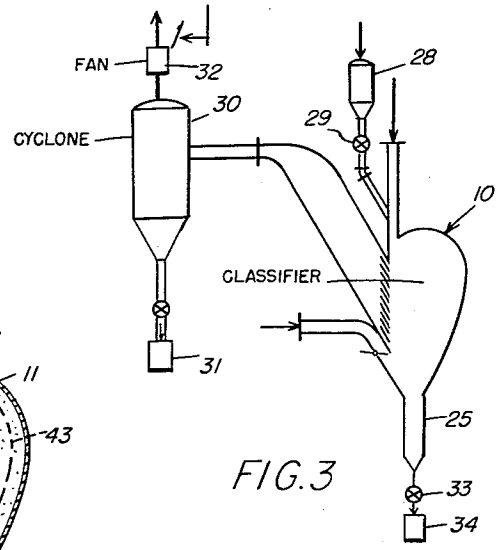


FIG. 3

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APPARATUS FOR CLASSIFYING PARTICULATE MATERIAL

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This invention relates to a method and apparatus for classifying particles or granular material into fractions of different particle size.

It is well known to classify particles according to sizes by the use of screens and the like. However, screens have the disadvantage of clogging and wearing due to the abrasive action on the wires of the screen. It is particularly difficult to effect separation of particles with screens when comparatively small particles are to be separated. For these reasons, various devices have been developed which use aerodynamics to provide the desired separation.

A primary object of the present invention is to provide an improved method and apparatus for classifying particulate material by utilizing a combination of gravitational, inertial, centrifugal and aerodynamic forces.

Another object of this invention is to provide a method and apparatus for classifying materials capable of achieving a sharp division into fractions according to particle size.

These and other objects will become apparent from the description of the drawings in which typical forms of the apparatus are shown and in which like numerals are used to designate like parts throughout.

FIG. 1 is a view in vertical cross section of a preferred embodiment of this invention taken along the line 1—1 in FIG. 2.

FIG. 2 is a cross section taken along the line 2—2 in FIG. 1.

FIG. 3 is a diagram illustrating one manner in which this invention may be utilized.

FIG. 4 is a view similar to FIG. 1 except that it shows an alternative form of this invention.

According to the invention, the classifier comprises a chamber, an exhaust duct communicating with the chamber at a side thereof, a plurality of vanes or slats within the exhaust duct and adjacent the chamber, means for moving particulate material in front of said slats, said slats having spaces therebetween such that the fine particles will be entrained in the air passing out of the exhaust duct, and means for establishing an eddy current flow within said chamber in such a way that the eddy current moves in a direction adjacent to the particulate material moving in front of said slats.

It is known that fine particles may be separated from coarse particles by virtue of the fact that inertial and gravitational forces are proportional to the mass of the particle which in turn is proportional to the cube of a linear dimension of the particle whereas the drag is directly proportional to the linear dimension. This means that where the linear dimensions are relatively large, as they are in the coarse particles, the inertial and gravitational forces dominate and the particles travel downwardly through moving air currents. However, in the fine particles the gravitational and inertial forces are small so that the fine particles are picked up by the air going out the exhaust duct and pass through the slats. It should be mentioned, that the slats do not function as a screen, i.e. the space between the slats is much larger than that of the largest linear dimension of the coarse particles. This has the advantage of preventing the clogging which takes place where screening actions are used when the particles have unusual configurations such as fiber forms.

The use of gravitational forces to separate coarse particles from entrained fines passing between slats is known, but the use of increased inertial forces which is present in the preferred form of this invention is believed to be novel. The increased inertial forces intensify the effect produced by gravity and tend to provide a sharper separation between coarse and fine particles.

However, there are particles which have a size which is very close to the cut size which are not effectively separated and which tend to increase the absolute fault. Absolute fault is expressed as the percentage of material available in the feed which is improperly classified.

As used herein, the term cut point means the particle that has a reference diameter such that the particle has a 50:50 chance of being found in the fines or in the coarse particles after classification.

This invention provides means whereby those particles having a size close to the cut point are subjected to a plurality of passes in front of the slats and pass upwardly from the bottom of the classifier until they finally settle downwardly with the coarse particles or go outwardly in the exhaust air with the fine particles. This is achieved by the formation of an eddy current within the chamber which has a direction of flow such that the downwardly moving air of the eddy current is at the side of the chamber adjacent to the slats and the upwardly moving air currents are between the center of the chamber and the side opposite the slats.

Preferably these eddy currents are formed by passing air adjacent to the eddy current so that the eddy current is formed by frictional drag.

In the drawings the classifier **10** is generally indicated by the reference character **10** ard the word "classifier." There is the chamber **11** (see FIGS. 1 and 4) having two parallel walls **22** and **23** (see FIG. 2) and a partially curved third wall therebetween having a side or portion **24** with a major curve at the top. On the side of the chamber opposite this curved portion **24** of the third wall, there is a substantially vertical side of the chamber, on the left as viewed in FIGS. 1 and 4, containing an exhaust opening **14** and exhaust duct **15** with a series of slats **16**. Each slat has its axis extending substantially horizontally and all the axes lying in a substantially vertical plane at the duct **15** and adjacent the opening **14**. This vertical side of the third wall of the chamber is structurally related to a primary air inlet duct **18** near the top thereof and a coarse solids outlet **25** at the bottom. The primary air inlet is directed substantially vertically downward and has a feed inlet or conduit **19** bringing the particulate material into the air duct **18** as they pass through an opening **12** into the chamber **11**. However, it is important that the particles be in the primary air duct **18** for a length of time sufficient to gain the required increase in velocity. The primary air duct **18** and opening **12** are so positioned that the primary air stream is directed downward in a vertical plane adjacent the opening **14** of chamber **11**. Below the feed inlet **19** the opening **14** communicates with an exhaust duct.

The term "slat" as used herein is intended to include any longitudinal member which presents an inclined surface **17**. Thus, in its generic sense the term "slat" would include rod-shaped or elliptically-shaped members or vanes as well as the preferred flat members shown in the drawing.

In communication with the opening **12** of the chamber **11**, there is the primary air inlet duct **18** which is directed substantially vertically downward. The primary air duct **18** and opening **12** are also positioned so that the primary air stream is directed downward in a vertical plane adjacent to the opening **14** of chamber **11** and to slats **16**.

Thus the primary air passes vertically downward as indicated by the arrows **40** in FIG. 1 and turns angularly

to become exhaust air as indicated by arrows **41** in the exhaust duct **15**. In its preferred form, the exhaust duct **15** is inclined angularly upward so that the primary air turns at an obtuse angle within the chamber. The effect of this primary air current **40** is to cause an eddy current **42** to be formed within the classifier by frictional drag. As shown in FIG. 1, the eddy current **42** has its downwardly moving air between the vertical center line of chamber **11** and the extended axis of the primary air duct **18**, while its upwardly moving air begins near the bottom of the chamber and travels in a position between the center of the chamber and the major curved side **24** of the third wall of the chamber.

The material to be classified is supplied into the primary air duct **18** and accelerated downwardly in front of the slats **16** by the primary air currents. Thus it is seen that the particulate material to be classified is subjected to both gravitational forces and the force of inertia caused by the velocity increase of the particles carried in the air current in the primary air duct **18** as it enters the chamber **11**.

Disposed just below exhaust duct **15**, there is a secondary air inlet duct **20**. Preferably, there is a common wall **21** between exhaust duct **15** and secondary air duct **20** at the ends of each where they communicate with chamber **11**.

The curved portion **24** of the third wall of the chamber is angularly inclined at the lower portion thereof so that coarser particles which are blown on the wall portion **24** will descend downwardly to the bottom of chamber **11**. At the bottom of chamber **11**, there is a collecting section **25** in which coarse particles are collected. The collecting section is preferably closed to prevent air from blowing up into chamber **11** through the collected coarse particles. A valve **26** is provided for removal of the coarse particles.

The air passing through the secondary air duct achieves a double effect as will be apparent by observing its flow. The path of the air is shown by dotted line **43** of FIG. 1. First of all the secondary air passes through the coarse particles to provide a scrubbing action and remove any remaining fine particles which are present on the coarse particles. Then the secondary air continues by its inertia over toward the wall portion **24** of chamber **11** and upwardly between the wall portion **24** and the eddy current **42**. This action provides additional frictional drag on the eddy current **42** and thereby increases the velocity of the eddy current. It is believed that it is novel to provide a clean air current which combines a scrubbing action of the coarse particles with a beneficial effect on the primary classification. In other words, the secondary air current reinforces or increases the effect of the primary air current in providing the desirable eddy current **42** which carries particles close to the cut point to achieve a sharper cut. The fine particles which are picked up in the secondary air current **43** continue with the air current **43** as it passes around the outside of eddy current **42** and then out the exhaust duct **15**. The secondary air current not only carries the entrained fines scrubbed from the coarse particles back to the primary classification, but it also provides means whereby the velocity of air in the exhaust duct may be controlled. This is important because the velocity of air through the exhaust duct will determine the cut point. Thus, by controlling the relative proportions of primary and secondary air entering the classifier, the cut point may be regulated over a comparatively wide range of particle size and still maintain an exceedingly sharp cut.

In order to control the relative proportions of air entering from primary air duct **18** and secondary air duct **20**, a damper valve **27** may be provided in secondary air duct **20**. Alternatively, control means could be provided in primary air duct **18** and the exact location and type of control is not critical. One advantage in using a damper of the type shown in FIG. 1 is to assure concentration of the air stream from the secondary air duct so that it passes in a thin layer adjacent to wall **21**. This causes the secondary air to flow at a high velocity through the particles as they cascade downwardly from wall **21**.

It is also considered desirable to utilize comparatively small proportions of secondary air traveling at relatively high velocity. This is important in order to insure that the secondary air travels in accordance with the path **43** and to prevent substantial proportions of secondary air from going out the lower portion of exhaust duct **15** where it would work against, rather than reinforce, the eddy current. It is also within the scope of this invention to provide additional air ducts which would supply or increase the air current in path **43** to increase the desired eddy current **42** within the chamber **11**.

In the operation of the embodiment shown in FIGS. 1 to 3, the feed particles are allowed to pass through conduit **19** while primary air passes through primary air duct **18** and secondary air passes through secondary air duct **20**. The particles follow a path substantially as illustrated in the drawing, i.e. they pass downwardly through opening **12** and are then directed toward the slats **16** by the passage of air through exhaust duct **15**. At the slats, fine particles are entrained in the exhaust air and pass out through exhaust duct **15**. On the other hand, the intermediate coarse particles impinge against the surfaces **17** of slats **16** and are rejected into the coarse particles moving toward outlet **25**. At this point in the classifier, the slats achieve an excellent classification whereby coarse particles are positively prevented from going out the exhaust duct **15**. However, some of the fine particles are carried by the coarse particles so that as the mass of particles slide off the wall **21** there are still some fine particles remaining in the coarse fraction. At this point, the secondary air stream sweeps through the coarse particles at a comparatively high velocity and removes substantially all of the fine particles so that only the desired coarse fraction drops downwardly into coarse solids outlet **25**.

The secondary air stream also tends to pick up some of the intermediate coarse particles which are in close size relation to the cut point. These intermediate coarse particles tend to settle on wall portion **24** of chamber **11**, and slide by gravity down into coarse solids outlet **25**. The fines entrained in secondary air stream **43** and any smaller coarse particles that may be entrained are carried back into the chamber **11** via air stream **43** and are reintroduced into main particle stream.

Thus, it is seen that the secondary air current provides clean air which sweeps through a curtain of coarse particles to provide excellent removal of the last trace of fines and then passes through the feed material to remove additional fines. In this way the secondary air current sweeps through the coarse particles twice in countercurrent relation for removal of fine particles therefrom as well as increasing eddy current flow.

The fine particles which are not carried out exhaust duct **15** in the first pass are carried in the eddy current. In general, the eddy current will pick up most of these particles at a point where the main particle stream impinges on wall **21**. This will be true regardless of whether there is a secondary air current or not. The particles carried in the eddy current are delivered back to the primary particle stream by centrifugal force at the primary air inlet.

The primary air current serves to increase the downward velocity of the feed material and then executes a turn of say about 120° to carry fine particles out of the exhaust duct. As explained above, the secondary air current generally passes into the chamber **11** and changes direction to move toward the slats so that the secondary air current increases the velocity of the eddy current. By adjusting the control **27** to provide different proportions of controlled primary and secondary air, it is possible to increase or decrease the cut point of the classifier. Thus, when a high proportion of secondary to primary air is provided, more fines are swept out

through the exhaust duct **15** to provide a cut point of a comparatively high particle size; while comparatively smaller proportions of secondary air to primary air reduces the cut point.

In its process aspect, this invention provides a method of classifying particulate material which comprises, passing the particulate material in a primary air stream in a substantially vertically downward direction in front of a series of slats, said slats having substantially horizontally extending axes all of which lie in a substantially vertical plane, providing a reduced pressure on the side of the slats opposite to the side at which the particulate material is conveyed to carry air and fine particles through said slats, providing a closure whereby substantially all of the primary air goes out through said slats and causes an eddy current to be formed within the chamber.

In its preferred form, the process aspect of this invention also includes the step of providing a current of substantially clean air at a point below the slats such that the clean air passes through the particles falling downwardly into the bottom of the classifier and also directing the current of clean air so that it increases the eddy current formed from frictional drag by the primary air flow.

In general, the relative proportions of secondary air to primary air will be between 0 and about 40%. The feed rate is not critical and will depend somewhat on the material being classified. There is no theoretical minimum of feed material to air, but the classifier would be inefficient at low rates. For this reason, it is preferred to pass comparatively large proportions of feed material through the classifier.

In FIG. 3, there is shown a diagrammatic view of one setup utilizing the classifier of FIGS. 1 and 2 of this invention. As shown therein, there is a classifier **10**, a feed hopper **28** and valve **29** for conveying material to be classified into the duct **19** of the classifier. There is also a cyclone **30** in communication with exhaust duct **15** for the separation of fines which are carried out with exhaust air. The fines are removed from the cyclone and collected in fine collector **31** and the clean exhaust air is dragged through a fan **32** and exhausted into the open air. Section **25** of classifier **10** collects the coarse particles and they are withdrawn therefrom by means of valve **26** and/or valve **33** to coarse particle collector **34**. Both the primary air duct **18** and secondary air duct **20** may be open to ambient air pressure and their relative proportions controlled by damper **27** as explained above.

From the above, it is obvious that the only power supply required in this setup is that supplied to the fan **32** and that the system will provide a desired separation of particles into a coarse fraction and a fine fraction. This apparatus achieves an excellent separation when the cut point is selected anywhere from say 50 to 1000 microns.

For example, pulverized limestone was classified utilizing the system illustrated in FIG. 3 with the proportions of primary and secondary air adjusted to provide a cut point of 150 microns. Twenty-five percent of the feed material was collected in the fine fraction and 75 percent of the feed was collected in the coarse fraction or tailings. Both the fine and coarse fractions were analyzed according to size, and it was found that only 5 percent of the fine material consisted of particles larger than 100 microns and that only about 5 percent of the material in the coarse fraction was less than 100 microns. Thus, the absolute fault was only 5%. In addition, it was found that the improperly classified particles were all substantially close to the cut point in size. Therefore, when it is desired to avoid the presence of coarse particles in the fine fraction, the cut point can be shifted so that a somewhat larger fraction of fines will be in the coarse fraction but substantially no coarse particles will be in the fine fraction. Alternatively, if it is desired to avoid fine contamination in the coarse fraction, the cut point may be shifted in the other direction.

Although FIG. 1 shows the primary and secondary air ducts opening to ambient atmosphere, it is also within the scope of this invention to have one or both of these air ducts communicating with a closed system. In fact, as explained above, it is usually preferable to have the air pressure at the secondary air duct higher than that in the primary air duct whereby a comparatively high velocity stream may be provided in the secondary air duct.

In FIG. 4 a modified form of this invention is provided which is particularly useful when the primary air duct communicates with a closed system containing the particles to be classified. As shown therein, the primary air duct carries the particles to be classified throughout its length and vertically downward into the chamber of the classifier. In all other respects, the classifier of FIG. 4 may be similar to the classifier of FIG. 1.

It will be obvious to those skilled in the art that various modifications in form and structure of this apparatus as well as procedural modifications may be made, and it should be understood that the scope of the invention is to be limited only by the scope of the appended claims.

What is claimed is:

1. A classifier comprising walls defining a chamber, a fines exhaust duct connected to said chamber at a side thereof, the lower wall of said exhaust duct being above the bottom of the chamber, an outlet from the chamber below the lower wall of said fines exhaust duct for the coarse fraction, a plurality of slats within said exhaust duct at its opening to the chamber, each of said slats having a substantially horizontal axis and having inclined upper surfaces, a primary air inlet duct positioned at the top of said chamber and at the side of said chamber adjacent to said exhaust duct whereby air flowing through the primary air inlet duct into the chamber and out the exhaust duct causes an eddy current to form within the chamber such that the downwardly flowing portion of the eddy current is on the side of the chamber adjacent the exhaust duct, and means for adding particulate material to be classified to said primary air inlet duct.

2. A classifier for separating particles into fractions having a cut point within the particle size range of from about 50 to 1,000 microns, comprising walls defining a chamber, said chamber having a substantially vertical front side, a rear side wall having its lower portion inclined at an angle, and two substantially vertical side walls, a primary air duct opening into said chamber through the top thereof and adjacent to said vertical front side, means for conveying particulate material into said primary air duct, a fluid exhaust duct communicating with said chamber at said substantially vertical side, a secondary air duct communicating with said chamber just below the fluid exhaust duct and above the bottom of the chamber, there being a common wall therebetween at the end where they communicate with the chamber, means for collecting coarse particulate material at the bottom of said chamber, and a plurality of slats disposed within said fluid exhaust duct at a point adjacent to said chamber, said slats being spaced apart at a distance greater than the diameter of the particles being classified and having substantially horizontal axes, said slats also having upper surfaces which are inclined at an angle.

3. A classifier for the division of particulate material in which there is a chamber comprising two parallel walls and a partially curved and partially flat third wall therebetween completing the chamber, there being an opening at the upper part of the third wall, an exhaust duct for the fines in the third wall below the opening and a plurality of slats arranged one above the other across the entrance to the fines exhaust duct, and an inlet duct connected to the opening in the upper part of the third wall adapted to deliver the material to be classified substantially vertically downwardly directly in front of the slats, the third wall having a major curved portion on the opposite side of the inlet duct from the exhaust duct whereby an eddy current is adapted to be set up within the

chamber moving downwardly on the side of the exhaust duct with some of the gas flowing into the chamber at the inlet duct escaping with a fines fraction at the exhaust duct, and moving upwardly on the side of the major curved portion of the third wall, in combination with an exit at the bottom of the chamber for removal of a coarse fraction; whereby the upward part of the eddy current is adapted to bring any remaining fines around to the slats again for exhaust through the slats after gravity has dropped a coarse fraction at the exit at the bottom of the chamber.

4. A classifier according to claim 3 in which there is a secondary air inlet duct disposed below the fines exhaust duct, being so arranged that the secondary inlet duct is adapted to direct its air supply with momentum across said descending eddy current whereby the eddy flow is strengthened, the coarse particles are subjected to a second scrubbing action and the fines thus obtained

are carried around to the fines exhaust duct by the eddy current.

5. A classifier as defined in claim 3 in which control means are provided to adjust the relative proportion of air entering one of the inlet ducts.

6. A classifier as defined in claim 4 in which there is a damper in the secondary air inlet duct; whereby the air from the secondary inlet duct flows at adjustable high velocity through the coarse particles as they descend below the fines exhaust duct.

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