United States Patent

Donovan

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[54] **APPARATUS AND PROCESS FOR SUSPENDING SOLIDS**

[72] Inventor: **Howard Gleason Donovan,** Westfield, N.J.

[73] Assignee: **Johns-Manville Corporation,** New York, N.Y.

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[52] **U.S. Cl.**.....**241/5,** 241/39

[51] **Int. Cl.**.....**B02c 19/06**

[58] **Field of Search**.....241/4, 5, 39, 40

[56] **References Cited**

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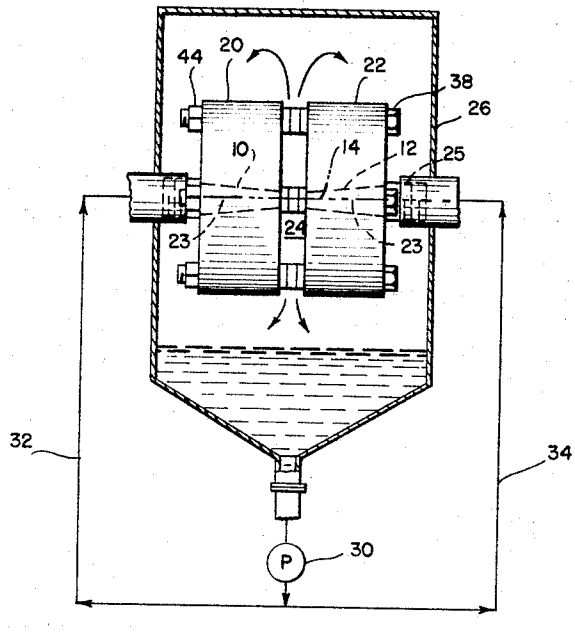
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Primary Examiner—Granville Y. Custer, Jr.
Attorney—John A. McKinney and Robert M. Krone

[57] **ABSTRACT**

A size reduction method and apparatus are provided in which a pair of coaxially aligned opposing nozzles impel liquid streams toward one another between a pair of panels that form a narrow zone that extends radially outwardly from the axis of the nozzles. A plurality of posts protrude into the narrow zone. These posts increase the size reduction capability of the apparatus and are particularly effective in opening (reducing the diameter of) fibers, such as asbestos, and reducing the particle size of particulate materials such as clay, pigments and the like.

12 Claims, 5 Drawing Figures



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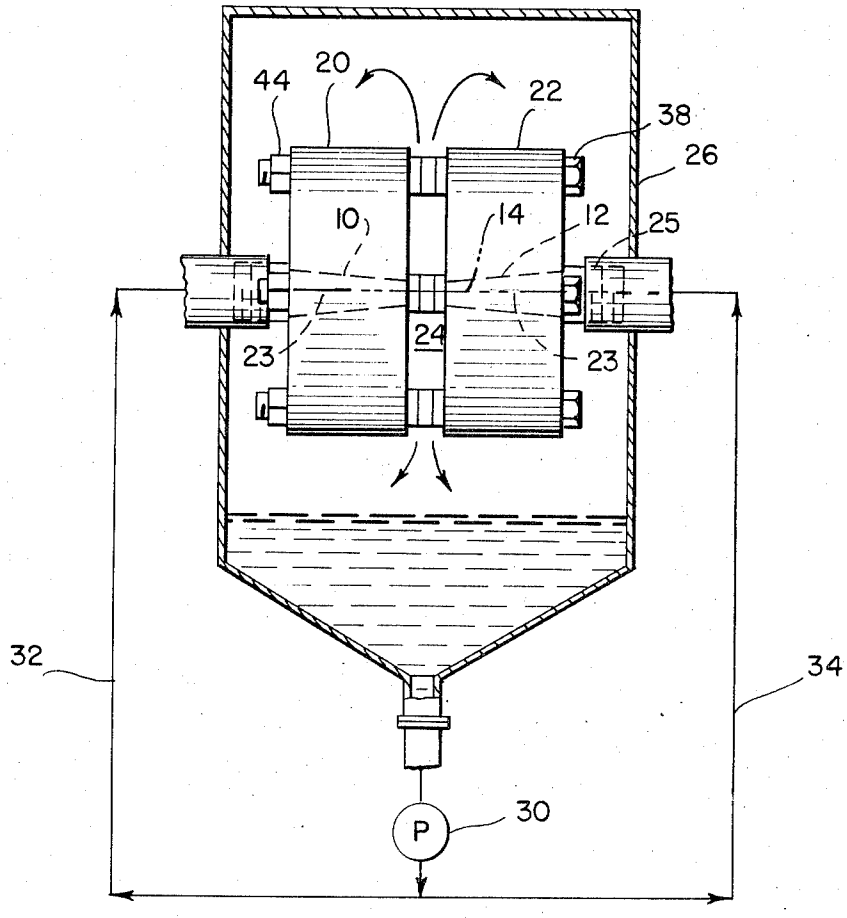


FIG. 1

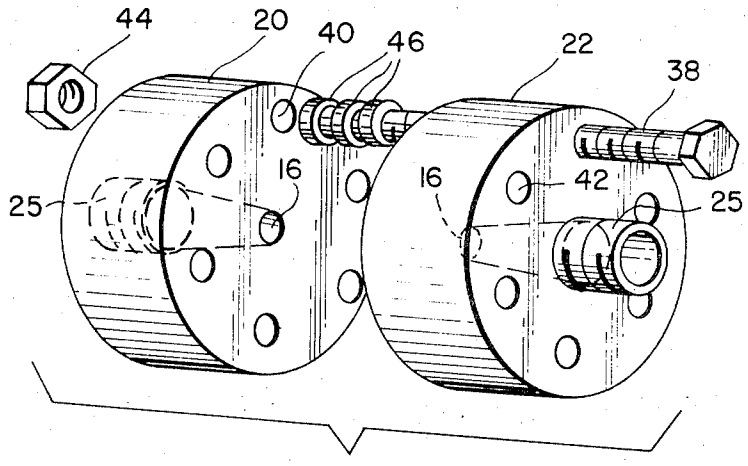


FIG. 2

INVENTOR
HOWARD GLEASON DONOVAN

BY John A. McKinney
ATTORNEY

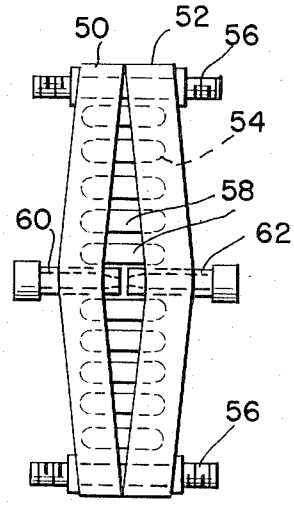


FIG. 3

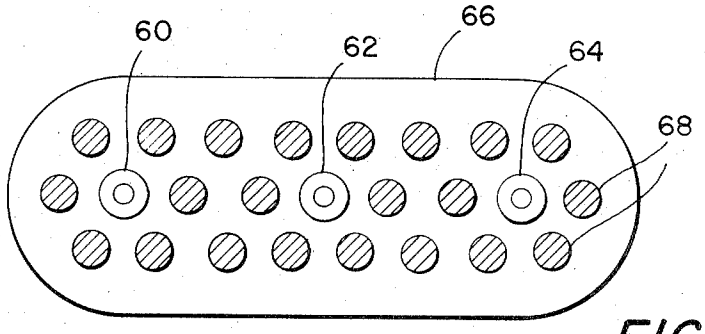


FIG. 4A

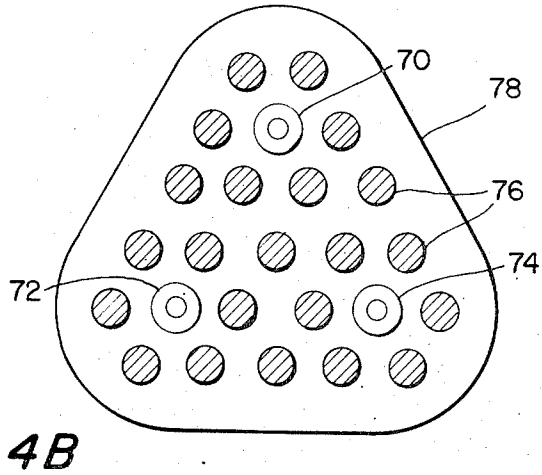


FIG. 4B

INVENTOR
HOWARD GLEASON DONOVAN

BY John A. McKinney

ATTORNEY

APPARATUS AND PROCESS FOR SUSPENDING SOLIDS

FIELD OF THE INVENTION

This invention relates to an improved apparatus and method for reducing the size of solid particles, and more particularly relates to improvements in the size reduction of solids suspended in a slurry.

While the apparatus and method of the invention are particularly described in relation to reducing the size of asbestos tailings and asbestos ore, and possess unique advantages when utilized for this purpose, the invention possesses utility for mixing and reducing the size of any solid that can be suspended in a liquid.

BACKGROUND OF THE INVENTION

There has been a continuing search in connection with a variety of products to find more efficient ways to reduce the size of solid particulate matter and fibers incorporated into liquid slurries. For example, in recent years there has been a trend towards the increased usage of suspension fertilizers. Suspensions offer the advantage of liquid solution fertilizers, such as ease of production and ease of handling and application while at the same time allowing use of low cost raw materials. Accordingly, apparatus for placing fertilizer solids into a suitable suspension have taken on increased commercial importance.

Suspension fertilizers employ a variety of conventional suspending agents, such as clay. Recently, it has been discovered that asbestos fibers having a relatively short fiber length are particularly desirable for use as a suspending agent in view of the low cost of such fibers and the stability of the suspensions they produce. These asbestos fibers can be derived from asbestos ore or even the tailings remaining after a majority of the fiber is removed from asbestos ore.

To create suspension fertilizers, it is desirable to have an inexpensive mixing means which efficiently suspends the suspending agent and other ingredients of the fertilizer in a liquid carrier. The efficiency of the suspending agent in maintaining a suspended composition is normally referred to in terms of buoyancy, which is a measure of the period of time required for settling-out of the suspended solids ingredients of the suspension. For a suspending agent such as clay, buoyancy is related directly to particle size. Accordingly, the mixing means for clay stabilized suspensions should be one which will effectively reduce the particle size of the clay.

For a suspending agent including asbestos fibers, however, buoyancy is not related solely to particle size, and is more directly affected by fiber diameter. For example, for asbestos containing material in which up to about 20 percent by weight of the asbestos fibers normally range in length between about (minus) 14 mesh (McNett standard) down to about 1 micron (equivalent to about 20,000 mesh), buoyancy is not substantially increased by the breaking of the asbestos fibers into shorter lengths. In contrast, buoyancy is substantially increased by further decreasing the average diameter of the fibers.

In the terminology employed in the asbestos fiber industry, when asbestos fibers are further split lengthwise of the fibers, the process is called "opening" the fibers. In this "opening" procedure, the average fiber diameter is decreased.

After a suspension fertilizer has been placed in suspension at a manufacturing facility, the suspension has only a limited storage life. Therefore, there also exists a need for an inexpensive and effective homogenizer which can be operated at relatively low pressures for use in the field to permit users of suspension fertilizers to easily resuspend the solids in suspension fertilizers.

Paper making is another example of a technical area where it is desirable to reduce the size of particulate matter and open fibers. Various size reduction apparatus and methods are used to condition the solids present in the slurries that are fed to the commonly used Fourdrinier and cylinder paper making machines.

OBJECTS OF THE INVENTION

Accordingly, an object of this invention is to provide a process and apparatus that possess improved efficiency in suspending solids in liquids.

A further object of the invention is to provide a process and apparatus that are effective in reducing the fiber diameter of inorganic fibrous material, such as asbestos ore or tailings, while placing the fibrous material in suspension.

Another object of the invention is to provide an improved method and apparatus for reducing the size of particulate matter, such as clay, in a liquid slurry.

Additional objects and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention.

SUMMARY OF THE INVENTION

The invention provides a method for reducing the size of solid particulate matter in a liquid slurry. Two streams of slurry under a pressure of 500 to 2,000 psi are directed towards each other along a common axis at a high velocity to disintegrate the particles. The merged impacted streams of slurry are then passed at a high velocity through a narrow zone extending radially outwardly from the common axis and into contact with solid posts extending into the zone to further disintegrate the particles. The method of the invention is particularly useful in reducing the average diameter of asbestos fiber.

The invention also provides an improvement in apparatus for reducing the size of solid particulate matter in a liquid slurry that is fed to the apparatus under pressure. The apparatus includes a pair of aligned nozzles having a common discharge axis. The nozzles have spaced discharge ends for directing a discharge of slurry toward each other to disintegrate the particulate matter. The improvement comprises the combination of elements described below. A pair of spaced panels extend transversely of the common axis of the nozzles. The panels form a narrow zone which extends radially outwardly from the common axis and is in fluid flow communication with the discharge ends of said nozzles. Frame means are provided for fixing the position of each of the panels with the panels mounted on the frame means. A plurality of posts are connected to at least one of the panels and extend into the narrow zone between the panels. Further disintegration of particulate matter passing outwardly at a high velocity from the discharge nozzles occurs when the particulate matter hits the posts.

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The posts, extending across the narrow zone, are effective to dramatically increase the size reduction capability of the apparatus, with a negligible increase in the power requirements for the increase in size reduction capability that results. The apparatus and method are particularly useful in the opening of asbestos fibers for inclusion in suspension fertilizers, because the diameter of the fibers is efficiently reduced, as is the particle size of other inorganic materials usually present in such fertilizers. The invention also possesses advantages that make its practice useful in manufacturing paper and a variety of other products that have a slurry formed at some stage of their manufacturing process.

DESCRIPTION OF THE DRAWINGS

Of the drawings:

FIG. **1** is a diagrammatic cross-sectional elevation of a typical embodiment of the apparatus of this invention, and also illustrates a container, a pumping means, and conduits for cycling and recycling a slurry through the apparatus.

FIG. **2** is an exploded perspective view of the apparatus of FIG. **1** with only one of the six posts illustrated.

FIG. **3** illustrates another embodiment of the invention; and

FIGS. **4A** and **4B** illustrate the interior faces of the panels of two additional embodiments of the invention and show the posts in cross-section.

DETAILED DESCRIPTION OF THE INVENTION

The apparatus and process of this invention are particularly useful in manufacturing a suspension fertilizer. The process and apparatus of the invention intimately mix a solids-containing slurry, and further reduce the particle size of the suspending agent, such as clay or asbestos fibers. Further, the apparatus and method are unexpectedly effective in obtaining improved suspensions by reducing the diameter of asbestos fibers.

Usually, the asbestos fibers present in a composition to be suspended range in length from −14 mesh (McNett) down to a composition in which about 20 percent of the fibers are 1 micron or less in length. Preferably, the asbestos fibers range in length from about −30 mesh to about +400 mesh. Preferred suspension fertilizers are obtained when the asbestos fibers are present from about 1.5 to about 30 percent by weight of the total weight of the slurry with total solids preferably ranging from about 45 to 60 percent by weight of the slurry.

In measuring the asbestos fiber lengths in terms of McNett mesh size, an attempt is made to cause the fibers to be presented with the length of the fiber aligned in a plane parallel to the plane of the screen so that the fibers of greater length than the particular mesh size do not pass through the mesh. Therefore, although the term "mesh" normally denotes particle size, the expression when used in relation to asbestos fibers relates to fiber length. It should be recognized, however, that as the length of the asbestos fibers being measured becomes shorter it becomes more difficult to align the fibers in a plane parallel to the plane of the screen mesh as the fibers approach the mesh. For example, at about −200 mesh, the McNett measurement of asbestos fibers increasingly reflects particle size, rather than length of fibers because of the increased difficulty in aligning the fibers with the screen.

In accordance with the apparatus of the invention, a pair of aligned nozzles are provided having a common discharge axis. The discharge ends of the nozzles are spaced close together so that the streams of slurry which they emit blast into each other at a high velocity to disintegrate the particulate matter in the stream. As here embodied, and as illustrated in FIG. **1**, a pair of nozzles generally **10** and **12** are formed by openings **23** in a pair of spaced panels **20** and **22**. Nozzles **10** and **12** are coaxially aligned along a common axis **14** and have their discharge ends **16**, illustrated in FIG. **2**, closely spaced for directing a discharge of slurry towards each other.

The pair of spaced panels **20** and **22** extend transversely of the common axis **14**. As illustrated in FIG. **2**, a threaded nipple **25** is welded to the exterior surface of each of panels **20** and **22** to provide a convenient means for introducing slurry to the nozzles, and to permit mounting the panels within a container **26**.

As illustrated in FIG. **1**, panels **20** and **22** form a narrow zone **24** therebetween. Zone **24** is in fluid flow communication with the discharge ends **16** of nozzles **10** and **12** and extends radially outwardly from common axis **14**. Thus, the streams of slurry are free to flow radially outwardly, but in a narrow constricted flow path so that the slurry retains some of its dynamic energy after the discharged streams of slurry impact upon one another.

In the embodiment illustrated in FIG. **1**, the apparatus of the invention is mounted within container **26**. Container **26** functions as both a slurry collection reservoir and also as a shield to prevent loss of slurry as the slurry is moved outwardly from between panels **20** and **22**. A pump means **30** is provided to supply slurry under pressure to each of the nozzles **10** and **12** through supply lines **32** and **34**, respectively. The terminal portions of the supply lines also serve as a means for mounting the apparatus of the invention in container **26**.

The novel apparatus and process of this invention do not require extremely high pump pressures to obtain substantial size reduction and mixing results. However, such high elevated pressures, above 2,000 psi, can be used in the process and apparatus of the invention.

Frame means are provided for fixing the position of the panels with respect to each other. In the embodiment illustrated in FIGS. **1** and **2**, the frame means also function as posts that are impacted by the slurry. The frame means include a plurality of bolts **38** having a threaded end. Bolts **38** extend through holes **40** and **42** in panels **20** and **22**, respectively. A nut **44** is screwed on the threaded end of each bolt to hold the panels together. A plurality of spacing washers **46** are provided which hold the panels at a predetermined distance apart when the nut is adjusted to exert a compressive force on the panels.

In the embodiment illustrated in FIG. **1**, the frame means also form the posts that perform an important impact size reduction and mixing function as described below. However, it should be realized that the frame means do not necessarily have to form the posts and that frame means positioned externally of the panels can be provided.

In accordance with the invention, a plurality of posts are provided which are each fixed to at least one of the panels. Each post extends into the narrow zone between the panels and further disintegrates particulate matter that strikes the post during passage outwardly through the zone. The posts add significantly to the size reduction capability of a pair of opposed nozzles without causing a large increase in power requirements. Further, the posts are unexpectedly efficient in reducing the diameter of short lengths of inorganic fibers, such as asbestos fibers.

In the embodiment of the invention illustrated in FIGS. **1** and **2**, the posts comprise bolts **38** and spacing washers **46** which extend across narrow zone **24** between panels **20** and **22**. Spacing washers **46** preferably are formed of a hard abrasion resistant material, such as tungsten carbide. Washers **46** are removable from bolts **38** when the apparatus is disassembled to permit replacement of the washers after they become excessively abraded during use.

While the surface of the post or spacing washers that is exposed to impact by the slurry is preferably cylindrical, the cross sectional shape of the posts can be varied and may include, square, triangular, hexagonal, or irregular cross sectional shapes.

At least two posts are present in the apparatus of the invention, and the preferred number of posts per pair of nozzles is about **6–12**. More than twelve posts can be utilized, if desired. When very large numbers of posts are used, however, the posts may create an undesirably large pressure drop across the narrow zone.

FIG. **3** illustrates another embodiment of the invention in which a pair of opposing panels **50** and **52** each have concave adjacent faces and include a plurality of openings **54** which do not extend all the way across the panels and a pair of openings which do extend all the way across the thickness of the panels for the insertion of a plurality of bolts **56**. The depth of the openings **54** in the adjacent faces of the panels and the length of posts **58** which are inserted in openings **54** maintain a predetermined amount of spacing between the panels. Nozzles **60** and **62** are each formed by a tubular conduit having walls that converge towards the discharge end. Panels **50** and **52** include threaded openings (not numbered) and nozzle members **60** and **62** include a male threaded portion which permits screwing the nozzles into position for regulating the distance between opposing nozzles. This threaded construction also provides a fluid-sealing relationship between the outer wall of the nozzles and the threaded openings in panels **50** and **52**.

In the embodiment of FIG. **3**, where some of the openings **54** extend merely to a predetermined depth that is less than all the way through the panel, facing washers are not required to maintain the predetermined degree of spacing between opposing faces of the support structure.

The discharge opening of the nozzles, the distance between the opposing nozzles, and the distance between any particular post and the outer diameter of the nozzles must each be sufficiently larger than any particles of the slurry to avoid any significant amount of clogging. On the other hand, it is necessary that these distances and spacings be small enough to create and preferably maximize the impact of the slurry from one nozzle against the slurry from the opposing nozzle, and thereafter against the opposite walls and the posts adjacent to the nozzles.

Normally, the diameter of the conduits and the nozzle apertures, the distance between the ends of the nozzles, the distances between the nozzles and adjacent posts, and the distance between any one or more posts range between about one thirty-second inch up to about three-fourths inch for preferred apparatus which are particularly useful in suspending fertilizers containing clay or asbestos suspending agents. In a particularly preferred embodiment, the outer diameter of the posts is up to about five-eighths inch and the distance between opposing faces of the panels ranges from about three-eighths inch adjacent the nozzles to about one-sixteenth inch at the edges of the panels.

Preferably, a positive-displacement pumping means is provided for producing a liquid slurry pressure ranging from about 500 psi to about 2,000 psi.

FIGS. **4A** and **4B** illustrate respectively the interior faces of the panels of two additional embodiments of the invention. Each panel includes a plurality of pairs of opposing nozzles extending from the interior face of the panel. In the embodiment of FIG. **4A**, there are three opposing nozzles **60**, **62**, and **64** extending from each panel **66** and also a plurality of posts **68**. Similarly in FIG. **4B**, three nozzles **70**, **72**, and **74** and a plurality of posts **76** extend from each panel **78**.

For a clearer understanding of the invention, specific examples of it are set forth below. These examples are illustrative, and are not to be understood as limiting the scope and underlying principles of the invention in any way. All percentages listed in the specification and claims are weight percentages unless otherwise noted.

EXAMPLES 1–3

In a series of tests, asbestos ore tailings, (−66 mesh and −30 mesh) are processed through an apparatus constructed in accordance with the invention. A pump provides a line pressure of 500 psi for all tests, and the solids content of the aqueous slurry is maintained at 9 percent. The apparatus used for these tests utilizes nozzles tapered from three-eighths inch i.d. at the inlet to one-fourth inch i.d. at the discharge end, with the discharge ends spaced approximately one-eighth inch apart. The panels are spaced about one-eighth in. apart.

In the procedure of Example **1**, one bolt clad with two ⅝ inch tungsten carbide washers is positioned with its center line three-fourths inch from the common axis of the nozzles. In the procedure of Example **2**, the general procedure of Example 1 is repeated using an apparatus having three equally spaced bolts with washers and three bolts without washers. The washers are ⅝ inch tungsten carbide washers and the bolts are positioned about three-fourths inch from the axis of the nozzles. Three ¼ inch bolts without washers, in addition to the three bolts described above, are positioned three-sixteenths inch from the center line of the nozzles and equally spaced from each other and from the bolts with washers.

In the procedure of Example **3**, six bolts as described above are utilized with the addition of six 20D nails which are positioned approximately one inch from the center line of the nozzles to give a total of 12 posts on which the slurry impinges.

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In each of the examples, the slurry is fed from a container which is located above the nozzle assembly, and the slurry is permitted to pass through the nozzle assembly only once. The results of the tests run in Examples 1–3 are shown in Table I below, and compared with a control run in which the 9% solids content slurry was run through the same apparatus, except that no posts were provided. In each of the tests, the slurry is fed from a container located above the nozzle apparatus and the apparatus is suspended in a porous plastic bag. During the pumping of the slurry, the apparatus becomes submerged in the liquid slurry within the bag.

TABLE I

	Control	Ex. 1 1 post	Ex. 2 6 posts	Ex. 3 12 posts
% of fibers passing McNett 200 mesh screen	52%	59%	63%	66%
Bulk Density (pcf):				
Loose	31.1	22.7	20.6	19.5
Pressed	33.7	26.3	24.4	22.6
Surface Area (cm2/gm)	5600	8600	9500	11,600

The results tabulated in Table I show that the presence of multiple posts significantly increases the ability of the apparatus to open asbestos fibers. This increased ability to open asbestos fiber is illustrated by each of the three tests; particle size, bulk density, and surface area. Bulk density is generally recognized as one of the most significant and reliable indicators of improved properties for use as a suspending agent with decreases in bulk density providing increases in suspension capabilities.

It should be noted that in the apparatus used in these examples, the suspending apparatus becomes submerged in the slurry during the processing procedure. In an embodiment such as that illustrated in FIG. 1, where the nozzle assembly is maintained at a location above the slurry level, results that are better than those shown in Table I can be expected, because placement of the apparatus below the slurry level creates a back pressure from the surrounding slurry liquid. The back pressure reduces the efficiency of the posts because it reduces the intensity of impact of the slurry against the posts.

It should be recognized that the apparatus and process of this invention can be advantageously practiced at plants manufacturing suspensions, such as fertilizer suspensions, and can also be practiced advantageously at the job site. The apparatus can be compactly constructed and is simple to operate and maintain which permits this wide range of potential usage.

What is claimed is:

1. A method for reducing the size of solid particulate matter in a liquid slurry comprising: directing two streams of slurry under a pressure of 500 to 2,000 psi towards each other along a common axis at a high velocity to disintegrate the particles; and passing the merged impacted streams of slurry at a high velocity through a narrow zone extending radially outwardly from the common axis and into contact with a plurality of solid posts extending into the zone to further disintegrate the particles, at least two of said posts being positioned entirely on the same side of a first plane parallel with and passing through said common axis and at unequal distances therefrom, a portion of each of said two posts lying in a second common plane parallel with and passing through said common axis.

2. The method of claim 1 in which the solid particulate matter includes asbestos fiber.

3. The method of claim 1 in which the flow direction of the merged impacted streams of slurry through the narrow zone is changed by about 90° from the flow path of each of the two streams of slurry before their impact, and this general flow direction is maintained while passing through the narrow zone except in the immediate vicinity of the solid posts.

4. In an apparatus for reducing the size of solid particulate matter in a liquid slurry that is fed to the apparatus under pressure, and including a pair of aligned nozzles having a common discharge axis, said nozzles having spaced discharge ends for directing a discharge of slurry toward each other to disintegrate the particulate matter, the improvement comprising:

a. a pair of spaced panels extending transversely of the common axis of said nozzles, said panels forming a narrow zone in fluid flow communication with the discharge ends of said nozzles, and extending radially outwardly from said common axis;

b. frame means for fixing the position of each of said panels, said panels being mounted on said frame means; and

c. a plurality of posts connected to at least one of said panels and extending into the narrow zone between said panels to further disintegrate particulate matter passing outwardly through said zone at a high velocity from the discharge nozzles, each of said posts comprising a pin connecting said panels and a plurality of abrasion resistant washers concentrically mounted on said pin with one face of one washer abutting the interior face of one of said panels and one face of another washer abutting the interior face of the other panel.

5. The apparatus of claim 4 including a container surrounding said panels for collecting the slurry passing radially outwardly from between said panels; and a high pressure displacement pump having its inlet connected to the interior of said container and its outlet connected to the inlet end of said nozzles for pumping slurry to said nozzles.

6. The apparatus of claim 4 in which said panels are spaced from one thirty-second inch to three-fourths inch apart, and the pair of aligned nozzles are spaced from one thirty-second inch to three-fourths inch apart.

7. The apparatus of claim 4 including a high pressure displacement pump having its discharge outlet connected to the inlet end of said nozzles.

8. The apparatus of claim 4 in which said spaced panels are removably mounted on said frame means to permit periodic replacement of said posts when said posts become eroded by abrasion.

9. In an apparatus for reducing the size of solid particulate matter in a liquid slurry that is fed to the apparatus under pressure, and including a pair of aligned nozzles having a common discharge axis, said nozzles having spaced discharge ends for directing a discharge of slurry toward each other to disintegrate the particulate matter, the improvement comprising:

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a. a pair of spaced panels extending transversely of the common axis of said nozzles, said panels forming a narrow zone in fluid flow communication with the discharge ends of said nozzles, and extending radially outwardly from said common axis, each of said panels being concave to form a zone that decreases in width in a radially outward direction from the common axis,

b. frame means for fixing the position of each of said panels, said panels being mounted on said frame means; and

c. a plurality of posts connected to at least one of said panels and extending into the narrow zone between said panels to further disintegrate particulate matter passing outwardly through said zone at a high velocity from the discharge nozzles.

10. The apparatus of claim **5** in which said posts function as said frame means and connect said panels, and at least one pair of said posts engage said panels to prevent relative movement of said panels.

11. The apparatus of claim **10** in which the end portions of each of said pair of posts extend through said panels, and protrude outwardly from the exterior face of said panel and are threaded to permit nuts to hold the plates together in compression.

12. In an apparatus for reducing the size of solid particulate matter in a liquid slurry that is fed to the apparatus under pressure, and including a pair of aligned nozzles having a common discharge axis, said nozzles having spaced discharge ends for directing a discharge of slurry toward each other to disintegrate the particulate matter, the improvement comprising:

a. a pair of spaced panels extending transversely of the common axis of said nozzles, said panels forming a narrow zone in fluid flow communication with the discharge ends of said nozzles, and extending radially outwardly from said common axis;

b. frame means for fixing the position of each of said panels, said panels being mounted on said frame means; and

c. a plurality of posts connected to at least one of said panels and extending into the narrow zone between said panels to further disintegrate particulate matter passing outwardly through said zone at a high velocity from the discharge nozzles, at least two of said posts being positioned entirely on the same side of a first plane parallel with and passing through said common axis and at unequal distances therefrom, a portion of each of said two posts lying in a second common plane parallel with and passing through said common axis.

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