

[54] **FLUID ENERGY DRYING MILL**

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[58] Field of Search..... **34/57 E, 57 B, 57 R, 10**

[56] **References Cited**

UNITED STATES PATENTS

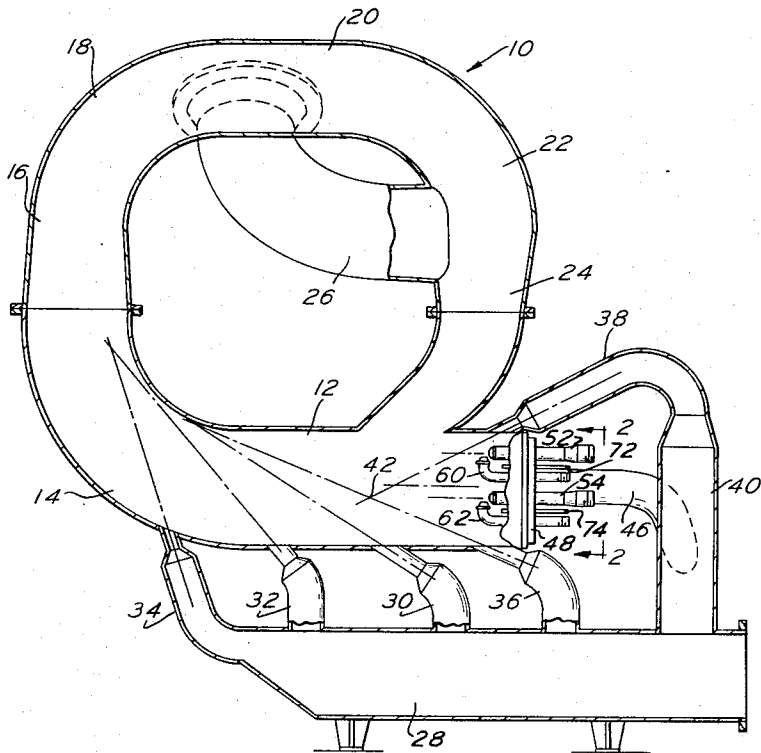
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[57] **ABSTRACT**

A fluid energy drying mill wherein the material to be dried is a liquid slurry of solid particles or of solids in solution. The slurry, upon being fed into the mill is immediately atomized and flash-dried, the atomization being accomplished by high pressure, high velocity gaseous fluid jets, while the flash-drying is effected by very hot, low pressure, gaseous fluid jets. The hot gaseous fluid jets comprise a plurality of gaseous fluid streams which enter from at least four different sides surrounding the feed inlet and converge at a focal point downstream of the inlet whereby the hot gaseous fluid both encompasses the fed material and concentrates its heat energy in the path of the fed material. The flash-dried particles are then centrifugally passed through the curved portion of the mill and centrifugally exhausted from the mill during their passage. Optionally, bypass ducts may be provided between the downstack portion of the mill and the inlet chamber where atomization and flash-drying takes place whereby vapors from the downstack are used to break any vacuum in the inlet chamber and may also be used as a tempering means to avoid case hardening of the particles.

4 Claims, 6 Drawing Figures



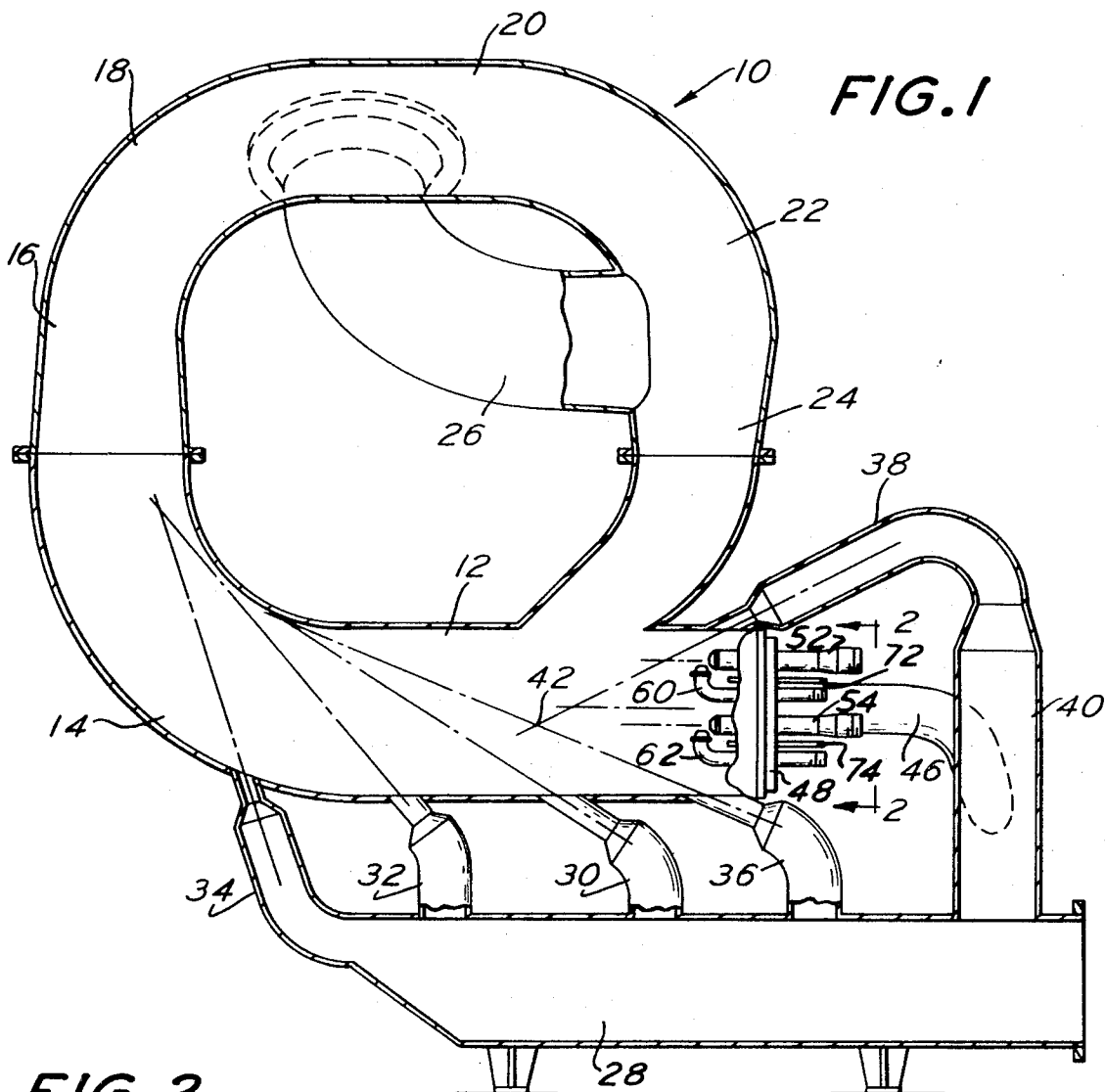


FIG. 2

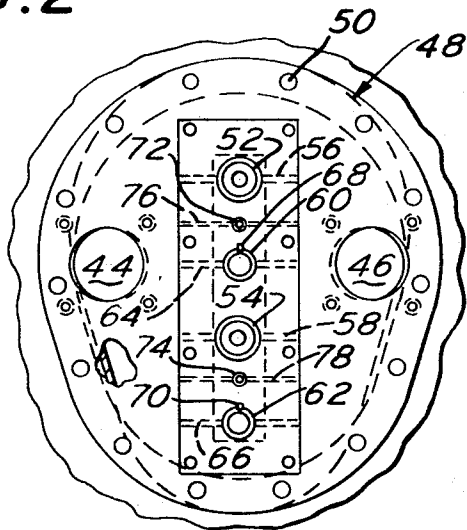
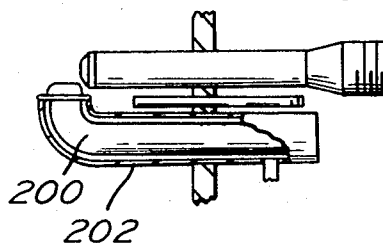


FIG. 6



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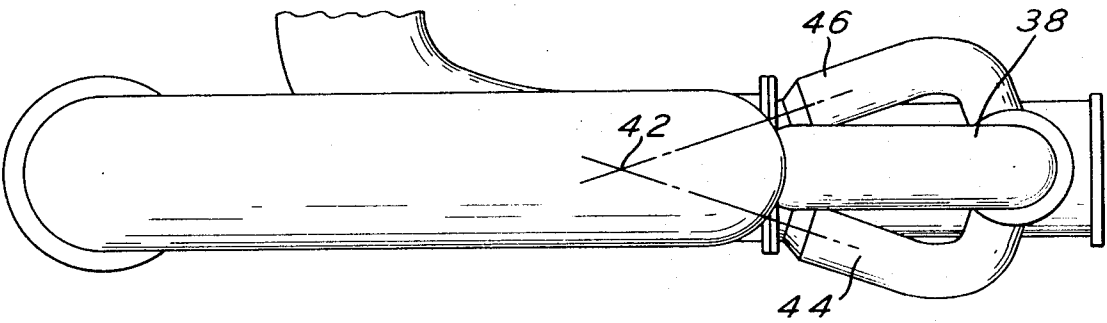


FIG. 3

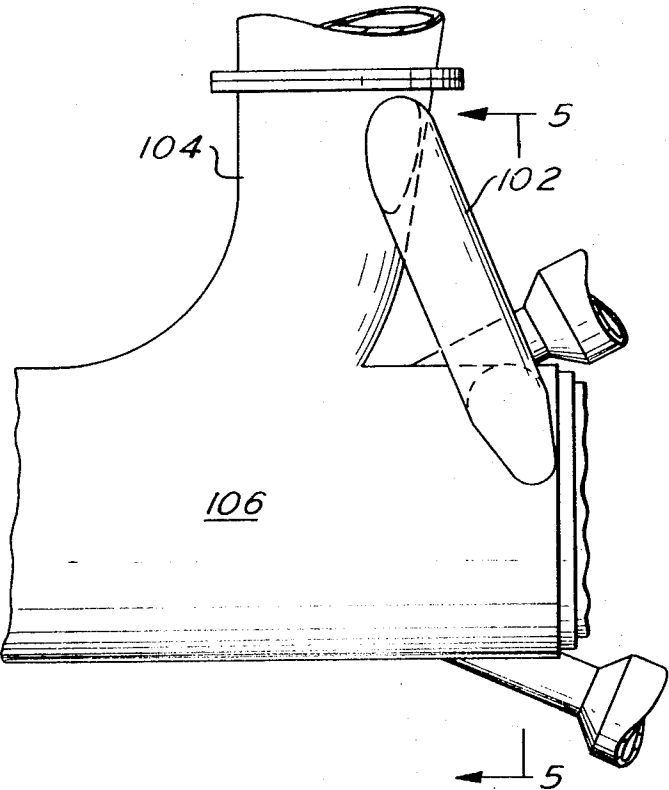


FIG. 4

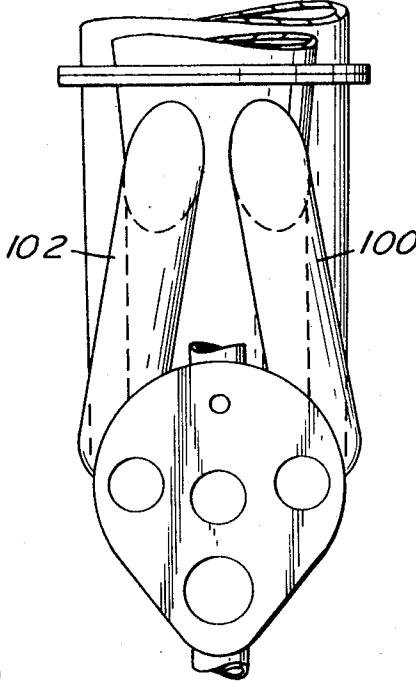


FIG. 5

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FLUID ENERGY DRYING MILL

This invention relates to a fluid energy drying mill, and it particularly relates to a drying mill for liquid slurries and the like.

Fluid energy drying mills have heretofore been used and have proven generally satisfactory for their intended purposes. Mills of this type utilize the system of atomization of the particles in the slurry and very rapid or flash-drying of the particles before they have an opportunity to agglomerate. In these prior mills, the dried particles are then passed through a centrifugally accelerated curved path during which the most completely dried (i.e., the lightest) particles are carried around on the inner periphery of the centrifugal stream while the less completely dried (i.e., the heavier) particles are positioned on the outer periphery of the stream. During the centrifugal motion, the lighter particles on the inner periphery pass through an exhaust duct positioned adjacent the inner periphery, while the heavier particles pass back into the drying area to be mixed with additional raw material for further drying.

However, various problems existed in the mills of this type heretofore used. One highly significant problem was the fact that the initial rapid or flash-drying was not fully effective to completely dry many of the particles. As a result, a large amount of these less dry (heavier) particles had to be recycled back for further drying. This not only decreased the efficiency of the mill but tended to clog the drying chamber and interfere with the atomization and rapid drying of the additional raw material by causing build-up of particle sizes resulting from layering or coating of the recycled material on the raw feed particles, similarly to hail formation while droplets pass through a cloud.

Another problem often heretofore encountered was the formation of a vacuum at the area of where the atomization and drying took place because of the high velocity of the atomizing fluid causing cavitation at the mill walls. This vacuum not only tended to suck material which had already been sufficiently dried away from the exhaust opening and back into the drying chamber, but interfered with the fresh material being fed into the mill.

Yet another problem sometimes encountered in prior mills of this type was that the flash-drying was so rapid that case hardening of the particles occurred, whereby a hard outer shell was formed around an insufficiently dried interior.

It is one object of the present invention to overcome the above-mentioned and other defects of prior fluid energy drying mills by providing a mill apparatus and a method of operating such apparatus whereby substantially all of the particles in a slurry feed are thoroughly dried in a single pass and without the necessity of recycling through the drying area.

Another object of the present invention is to provide a fluid energy drying mill where vacuum conditions at the feed inlet are avoided and where inadvertent case hardening of the particles is obviated without interfering with the total flash-drying effect.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following description when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a sectional view of a mill embodying the present invention.

FIG. 2 is a sectional view taken on line 2—2 of FIG. 1.

FIG. 3 is a fragmentary top plan view of the mill of FIG. 1.

FIG. 4 is a fragmentary side elevational view of a modified form of the mill of FIG. 1.

FIG. 5 is a sectional view taken on line 5—5 of FIG. 4.

FIG. 6 is an enlarged elevational view of a modified form of feed assembly.

Referring now in greater detail to the various figures of the drawings wherein similar reference characters refer to similar parts, there is shown in FIG. 1 a drying mill, generally designated 10, comprising a relatively straight inlet chamber 12 merging into an arcuate elbow section 14 which forms the

lower end of an upstack 16. The upstack 16 is connected by an elbow section 18 to a section 20 which includes an elbow section 22 connecting it to a downstack 24. At the inner periphery of the elbow section 22 is an exhaust duct 26 leading to a collection station (not shown) or to a dust collector (not shown), or to another treating section, all of which form no part of the present invention, in and of themselves.

A manifold 28, supplied with hot low pressure gaseous fluid such as air, steam, or the like, and which may be as high as 3,000° F. or even higher, from a source (not shown), is provided with a plurality of nozzles 30, 32 and 34 which direct such heated gaseous fluid into the inlet 12 at varying angles whereby the fluid streams converge toward the upstack 16.

A similar nozzle is provided at 36, and the fluid stream from nozzle 36 also converges with the other streams. In addition, however, the fluid stream from nozzle 36 converges with a stream of hot, low pressure gaseous fluid from a nozzle 38 which is connected to a standpipe 40 leading from the manifold 28. The intersection of fluid streams from nozzles 36 and 38 takes place at a point designated 42 at the front portion of the inlet chamber 12 just below the downstack 24.

Also converging at point 42 are angularly directed streams of hot, low pressure gaseous fluid from lateral nozzles 44 and 46 (see FIG. 3) which are also connected to the standpipe 40.

By means of the above-described nozzles 36, 38, 44 and 46, a conical hot fluid shield substantially envelops the atomized slurry particles as they are propelled linearly into the inlet chamber so that all the particles are subjected to the heat of the fluid streams. At the same time, the four converging hot fluid streams focus their combined heat energy at one focal area. This results in increased heat energy and a far greater flash-drying effect than if only the hot gaseous fluid from the nozzles 30, 32 and 34 were used, especially since the latter rapidly dissipate some of their heat energy. The fluids from the nozzles 30, 32 and 34, aided by that from the nozzle 36, which is also used for flash-drying, not only provide the primary centrifugal force, but the heat thereof also serves to prevent too rapid a cooling of the flash-dried particles during their centrifugally actuated passage through the mill.

The inlet chamber 12 is closed by a front plate 48 (best seen in FIG. 2) which is connected to a peripheral flange of the open front end of the chamber by means of screws, bolts, or the like indicated at 50. The nozzles 44 and 46 are attached to this plate, as indicated in FIG. 2. Also mounted in this plate are a pair of parallel high pressure nozzles 52 and 54 connected to a source of high pressure gaseous fluid (not shown), by a flexible or adjustable connection. These nozzles 52 and 54 are preferably axially adjustable into the chamber 12. Such adjustment may be accomplished by any desirable means. As illustrated herein, the adjustment is accomplished by permitting the nozzles to move axially through corresponding apertures in the plate and then holding them in fixed adjusted position by means of pins or the like indicated at 56 and 58 respectively.

Each high pressure nozzle 52 and 54 is associated with a slurry feed nozzle, as at 60 and 62 respectively. The nozzles 60 and 62 are connected to a source of slurry (not shown) by a flexible or adjustable connection. The nozzles 60 and 62 each have an upwardly extending outlet portion (as shown in FIG. 1) which is positioned adjacent the outlet of the corresponding high pressure nozzle 52 or 54.

Each feed nozzle 60 and 62 is axially adjustable in the same manner as the nozzles 52 and 54. They are held in adjusted positions by pins or the like indicated at 64 and 66. They are also provided with keys, as at 68 and 70 to prevent rotation.

In operation, the slurry is propelled, under low pressure, from the feed nozzles 60 and 62 in an upward direction. As the slurry issues from the feed nozzles, it is entrained in the jet of high pressure, high velocity gaseous fluid issuing from the corresponding nozzle 52 or 54. The high pressure, high velocity fluid immediately atomizes the slurry and propels it forwardly into the inlet chamber 12. As the atomized material is propelled forwardly, it is acted upon by the very hot gaseous

fluid from the nozzles 36, 38, 44 and 46 which cause instantaneous flashdrying of the atomized particles.

Although there is a very slight clearance between the outlets of feed nozzles 60 and 62 and the outlets of their corresponding high pressure nozzles 52 and 54, there is ordinarily a tendency for a build-up of feed material between them. After a relatively short time, this causes clogging of the nozzles and serious interference with the operation of the mill. In order to overcome this tendency to build up material at the nozzle outlets, there are provided high pressure nozzles 72 and 74 connected to a source of high pressure gaseous fluid (not shown) by flexible or otherwise adjustable connections. These nozzles 72 and 74 are also axially adjustable similarly to nozzles 52 and 54 and nozzles 60 and 62, and are shown held in adjusted positions by pins or the like 76 and 78. By applying a high pressure jet from the nozzles 72 and 74 against their corresponding feed nozzles 60 and 62, the build-up of material on the feed nozzles is obviated so that the nozzle tips are kept clean and full efficiency is maintained. These jets also prevent overheating of the slurry feed lines.

After the fed slurry is atomized and the particles are flash-dried, the particles are whirled through the mill by centrifugal force generated by the jets from nozzles 30, 32, 34 and 36. Unlike other fluid energy drying mills, however, there is little need for centrifugal separation of lighter (more dried) from heavier (less dried) particles because substantially all the particles are completely dried, and are, therefore, extremely fine, often down to $7\frac{1}{2}$ Hegeman. They, therefore, remain on the inner periphery of the centrifugally actuated stream and are almost all exhausted through the exhaust duct 26. This not only avoids any clogging in the inlet chamber because of recycling of particles already sent through the mill but also permits greater efficiency in atomizing and drying fresh material being fed into the mill. In addition, it permits the utilization of vacuum breakers for the inlet chamber as will hereinafter be described.

In FIGS. 4 and 5, there is shown a modified form of the mill shown in FIGS. 1, 2, and 3. This modification takes advantage of the aforementioned characteristic of the mill whereby the return to the inlet chamber is substantially free of solid particles. The return comprises, in effect, only the gaseous fluid used as the centrifugal conveying means. A portion of this fluid is by-passed into the inlet chamber and breaks any vacuum which tends to form therein as a result of the high velocities of the atomization nozzles and as a result of the sudden reduction of space-filling material due to the atomization and flash-drying.

The apparatus for accomplishing this vacuum breaking is shown in FIGS. 4 and 5 and comprises a pair of ducts, designated 100 and 102 extending angularly from the downstack 104, similar to downstack 24, into the inlet chamber 106, similar to inlet chamber 12. As seen in FIG. 5, the ducts 100 and 102 have laterally offset lower portions which extend into opposite sides of the inlet chamber. As the gaseous fluid passes transversely into the inlet chamber 106 from opposite sides thereof, the gaseous fluid envelops the entire area and quickly breaks any vacuum. Since there are little if any solid particles in the by-passed gaseous fluid, there is no possibility of their clogging the area.

In addition to the function of the by-passed fluid to break any possible vacuum, this fluid, which is still hot but which has lost some of its heat during the centrifugal motion, acts to somewhat temper the very hot gases causing the flash-drying, thereby permitting the use of even higher temperatures than would otherwise be feasible. In this respect, if these gases are extremely hot, they may cause case hardening of the particles whereby a hard skin is formed on the outside before the inside is completely dried. This is especially applicable to those processes where solids in solution are being treated. The by-passed fluid is just cool enough to prevent such case hardening but is not cool enough to seriously interfere with the flash-drying. In fact, it causes just enough instantaneous delay in the drying to permit thorough drying before case hardening oc-

curs. For example, calcium stearate, which melts at 300° F. may be dried, utilizing the present invention, at from 650° to 750° F. The end product, however, has a temperature of only about 125° to 135° F.

The material being dried may be of any composition. For example, it may be a solution, either aqueous or utilizing any other diluent. It may be an aqueous slurry of precipitated iron oxide or of white or yellow silica. Instead of an aqueous slurry, it may be a slurry of solid particles in any other liquid diluent such as isopropanol, methanol, perchloroethylene, trichloroethylene, etc. In the case of slurries containing such diluent liquids or others like them which have a definite odor, the present mill is well adapted to aid in the deodorization of the finished products. In this respect, the flash-drying process also causes vaporization of the liquids. Much of these vapors are exhausted from the mill together with the dried particles so that the odor clings to the particles. However, since the diluent is in a vapor state, after the finished product has left the mill, the solids can be readily picked up with an odorless gas such as air, nitrogen, or the like, whereby the odor is completely removed by replacing the diluent vapor with the odorless gas. Furthermore, products in solution, as for example, a solution of aluminum chlorohydrate, are effectively dried in this manner. Other products which may be similarly treated are fruit juices, milk, concentrated coffee, etc.

FIG. 6 shows a modified form of feed means wherein the parts are essentially the same as those shown at 52, 54, 60, 62, 72 and 74 in FIG. 1, except that the feed nozzle 200 is provided with a cooling jacket 202. The jacket 202 is connected to a source of cooling fluid (not shown) by a hose or the like (not shown). The fluid may be either liquid, such as cold water, etc., or gaseous, such as air, Freon gas, etc. This aids in the prevention of crusting of the feed line.

The invention claimed is:

1. A drying mill comprising an inlet chamber having a front end and a rear end, a generally arcuate tubular portion extending from the rear end of said inlet chamber and having an exhaust duct intermediate thereof and a return section connected to said inlet chamber adjacent the front end thereof, at least one conveyor nozzle entering said inlet chamber at an angle tangential to the longitudinal axis of said inlet chamber, said conveyor nozzle being connected to a source of hot, low pressure gaseous fluid, a feed inlet at the front end of said inlet chamber, said feed inlet being connected to a source of solids containing slurry, atomizing means in said inlet chamber for atomizing the slurry issuing from said feed inlet, said atomizing means comprising an atomizing nozzle connected to a source of high pressure gaseous fluid, and a plurality of enveloping nozzles positioned radially outward of said inlet nozzle and atomizing means and inclined toward each other, said enveloping nozzles being connected to a source of hot, low pressure gaseous fluid, whereby they act to direct intersecting streams of said hot, low pressure gaseous fluid within said inlet chamber toward a focal point intermediate the front and rear ends of said inlet chamber and rearwardly of said feed inlet and atomizing means, said feed inlet having an offset nozzle end, the outlet end of said atomizing nozzle being positioned adjacent said offset nozzle end and being constructed and arranged to propel the atomized particles longitudinally through said inlet chamber, and a cleaning nozzle positioned within said inlet chamber between said feed inlet and said atomizing nozzle, said cleaning nozzle being connected to a source of high pressure gaseous fluid and having its outlet end constructed and arranged to direct a jet of high pressure gaseous fluid against the offset nozzle end of said feed inlet.

2. The mill of claim 1 wherein said feed inlet, said atomizing nozzle and said cleaning nozzle are longitudinally adjustable.

3. A drying mill comprising an inlet chamber having a front end and a rear end, a generally arcuate tubular portion extending from the rear end of said inlet chamber and having an exhaust duct intermediate thereof and a return section connected to said inlet chamber adjacent the front end thereof, at least one conveyor nozzle entering said inlet chamber at an

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angle tangential to the longitudinal axis of said inlet chamber, said conveyor nozzle being connected to a source of hot, low pressure gaseous fluid, a feed inlet at the front end of said inlet chamber, said feed inlet being connected to a source of solids containing slurry, atomizing means in said inlet chamber for atomizing the slurry issuing from said feed inlet, and a plurality of enveloping nozzles positioned radially outward of said inlet nozzle and atomizing means and inclined toward each other whereby they act to direct intersecting streams of hot, low pressure gaseous fluid within said inlet chamber toward a focal point intermediate the front and rear ends of said inlet chamber and rearwardly of said feed inlet and atomizing means, said enveloping nozzles being connected to a source of hot, low pressure gaseous fluid, and at least one by-pass duct connected between said return section and said inlet chamber

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at a position adjacent said feed inlet and atomizing means.
4. A method of drying particles in a slurry which comprises passing the slurry into the inlet chamber of a generally arcuate mill, atomizing the slurry as it enters said inlet chamber, enveloping the atomized particles with angularly directed streams of hot gaseous fluid while directing said hot gaseous fluid toward a focal point rearwardly of the entering slurry and while propelling the atomized particles toward said focal point, centrifugally propelling the resultant particles around an arcuate path and through an exhaust duct positioned in said arcuate path, and by-passing gaseous fluid from said arcuate path into a position adjacent the entering slurry as it is atomized.

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