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Coombe et al.

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[54] **FLUID ENERGY DRYING AND GRINDING MILL**

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[52] **U.S. Cl.** **241/39,** 34/10, 241/5

[51] **Int. Cl.** **B02c 21/00**

[58] **Field of Search** 241/5, 19, 23, 39; 34/10, 34/57

[56] **References Cited**

UNITED STATES PATENTS

2,846,150	8/1958	Work	241/5
3,223,333	12/1965	Stephanoff	241/5
3,559,895	2/1971	Fay	241/5
3,667,131	6/1972	Stephanoff	34/10
3,726,483	4/1973	Kometani et al.	241/5
3,726,484	4/1973	Shurr	241/5

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[57] **ABSTRACT**

A fluid energy mill of the confined vortex type is designed to permit the simultaneous drying and grinding of slurries of pulverulent solids, e.g., pigment slurries. The slurry is directed into a passageway leading to the grinding chamber in such a way as to be enveloped and atomized by a flow of gaseous drying fluid, e.g., high pressure steam, of at least sonic velocity. The solids become at least partially dried before entering the grinding chamber but with little or no tendency to adhere to the walls of the passageway leading thereto.

5 Claims, 4 Drawing Figures

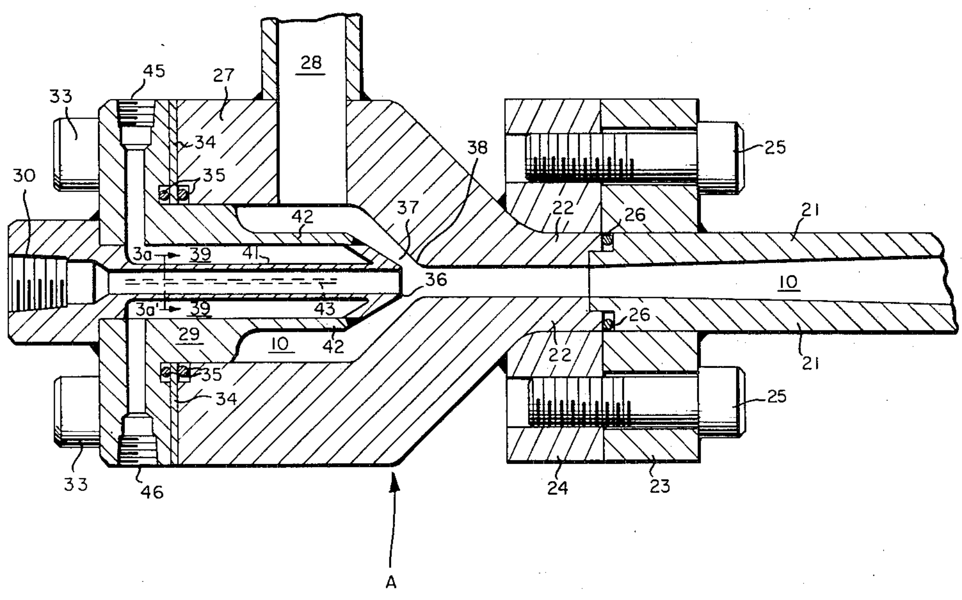


FIG. 1

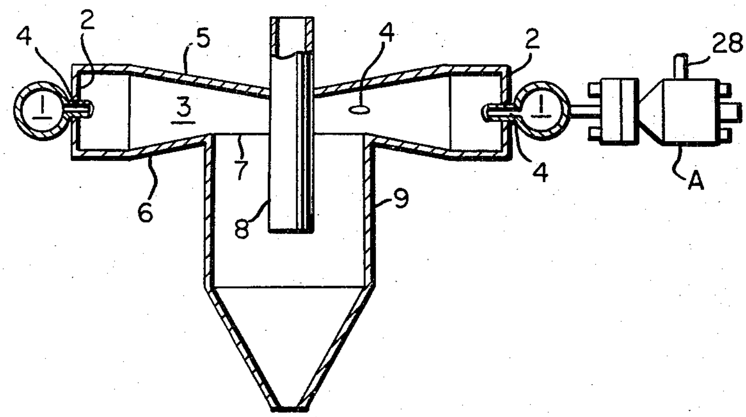
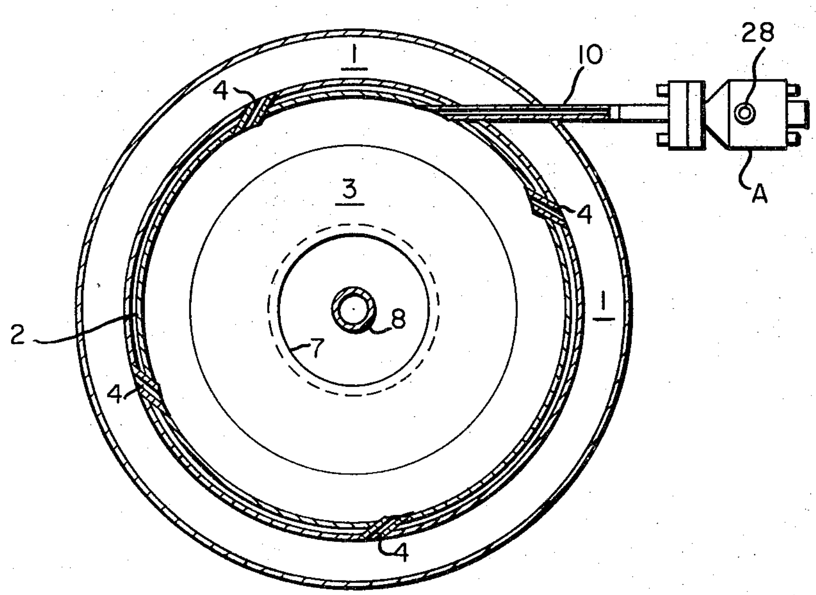


FIG. 2



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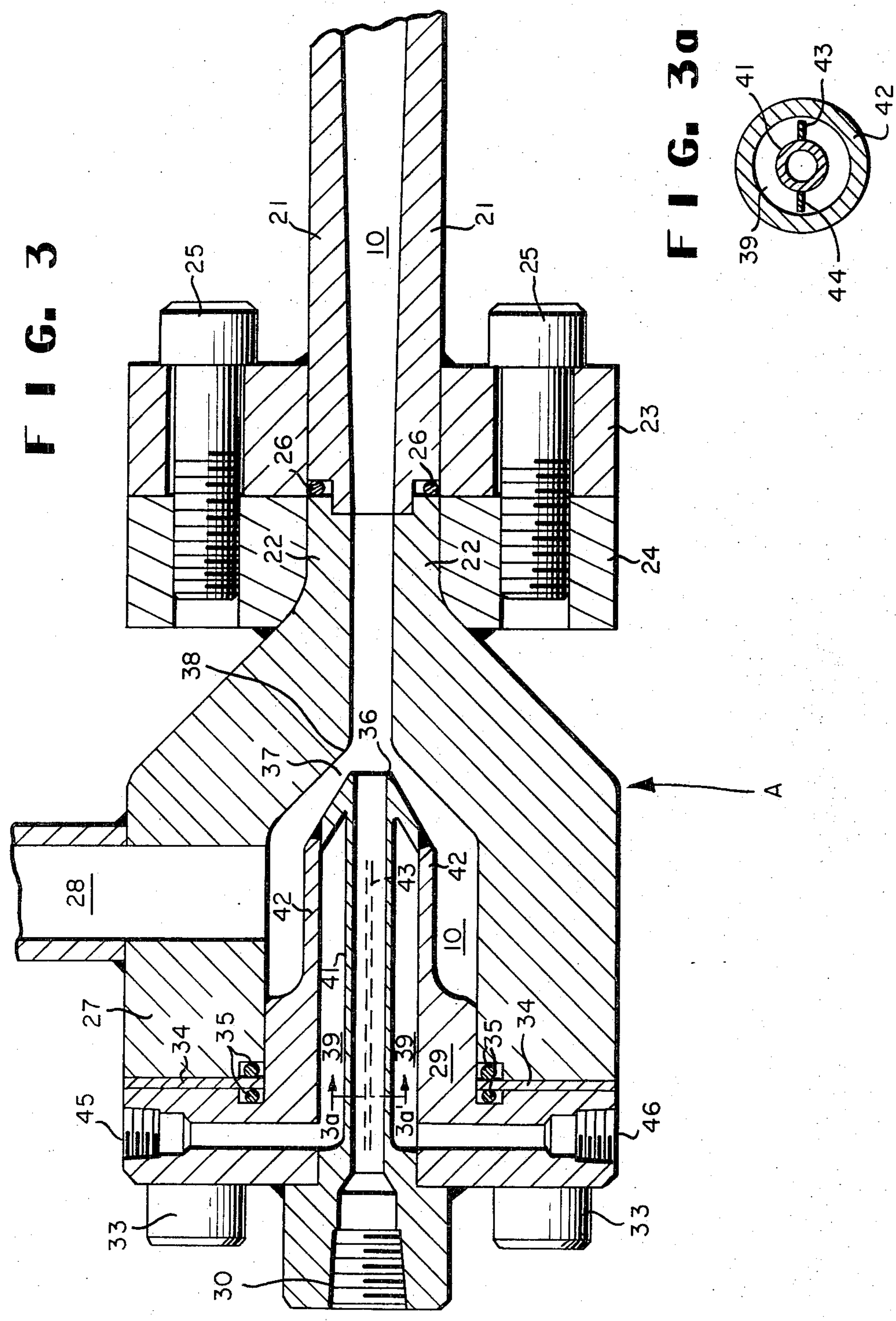

FIG. 3

FIG. 3a

FLUID ENERGY DRYING AND GRINDING MILL

BACKGROUND OF THE INVENTION

Fluid energy mills of the confined vortex type are well known and widely employed in certain industries such as the pigment, cosmetic and plastic industries because of their efficiency and economy in the grinding of pulverulent solids. A number of early designs are described in considerable detail in U.S. Pat. No. 2,032,827.

Most such fluid energy mills are variations on a basic configuration of a generally circular chamber enclosed by a pair of axial walls and a peripheral wall, the axial length or height of the chamber being substantially less than the diameter. At the periphery of the mill there is located at least one inlet for injecting the gaseous grinding fluid which furnishes the energy for grinding the solids, along with one or more feed devices for introducing the pulverulent solids to be ground. Preferably several uniformly spaced apart inlets for gaseous grinding fluid are provided around the circumference of the mill and they are oriented generally tangentially to the chamber. An outlet coaxial to and in direct communication with the grinding chamber is provided for discharge of the ground solids to a cyclone or bag filter for collection.

Fluid energy mills of the foregoing type combine both grinding and classification within a single chamber. As the gaseous grinding fluid is fed tangentially into the periphery of the chamber along with the solids to be ground a vortex is created whereby the particles are swept along in a spiral path to be eventually discharged at the central outlet. By proper selection of operating conditions, such as rate and tangency of fluid injection, particles above a specific size can be kept within the mill until sufficient attrition occurs, whereas other particles are allowed to pass through.

Heretofore such fluid energy mills have not, however, been satisfactorily operable except with pulverulent solids which were in a relatively dry condition. Poor grinding and even clogging of passages could occur if excess liquid were present. This has been a disadvantage in certain areas where the treatment of liquid-laden solids such as slurries would be desirable. For example, in the case of TiO_2 pigments produced by the vapor phase oxidation of $TiCl_4$, the particles as formed are frequently collected as a water slurry. The utilization then of a fluid energy milling step, invariably needed to break up particle agglomerates, has meant that it would first be necessary to dry the particles, e.g., via a costly drying operation.

The desirability of a fluid energy mill permitting drying and grinding functions to be carried out simultaneously will be apparent.

SUMMARY OF THE INVENTION

The present invention relates to a fluid energy mill of the confined vortex type as described above but with a feed device that enables it to be used for the simultaneous drying and grinding of flurries of pulverulent solids. More particularly there is used a slurry feed device formed by

walls defining a generally rectilinear passageway which opens into a peripheral region of the grinding chamber,

a slurry supply conduit having an inlet remote from the passageway and a discharge nozzle positioned in the passageway for directing slurry along the passageway and toward the grinding chamber, the size of the discharge nozzle being small relative to the surrounding passageway to define an annular space therebetween,

means for supplying gaseous drying fluid of at least sonic velocity to the annular space to thereby envelop and atomize within the passageway slurry emerging from the discharge nozzle, and

means for controlling the temperature of the discharge nozzle.

DETAILED DESCRIPTION OF THE DRAWINGS

The invention will be further described with reference to the drawings, not to scale and with the same reference characters used to denote identical parts, wherein:

FIG. 1 shows a side elevational view, partly in cross-section, of an apparatus of the invention, the slurry feed device being shown generally as A,

FIG. 2 is a horizontal view, also partly in cross-section, of the apparatus of FIG. 1 taken normal to the axis at the level of the inlet jets,

FIG. 3 illustrates in greater detail the slurry feed device A, the view being a horizontal cross-sectional view, and

FIG. 3*a* is a cross-sectional view taken across 3*a*—3*a'* of FIG. 3.

In FIG. 1 and FIG. 2, **1** is a header for gaseous grinding fluid and encircles peripheral wall **2** of generally circular grinding chamber **3**. Inlets **4**, of which only four are shown, interconnect the header and the grinding chamber. Axial walls **5** and **6** of the chamber may be relatively parallel but in the preferred embodiment, as shown, come closer to one another as the chamber axis is approached. Circular discharge port **7** and exhaust duct **8** are axially located. Fluid from each inlet **4** enters the peripheral wall **2** generally tangentially of the chamber, i.e., at an angle that is tangent to a circle about the center of the chamber which has a radius smaller than the radius of the chamber. A multiplicity of these inlets for gaseous grinding fluid is advantageously used, twelve being convenient for a chamber of **27** inches diameter.

A slurry feed device shown generally as A, and to be described more fully hereinafter in connection with FIG. **3**, serves to introduce liquid-laden solids, preferably a solids slurry such as a TiO_2 pigment slurry in water, to a peripheral region of the chamber through elongated passageway **10**, the latter being aligned nearly tangentially to peripheral wall **2** to facilitate flow of the solids into the chamber vortex. Passageway **10** preferably opens into the chamber directly through peripheral wall **2**, as shown, but it may alternatively open into the chamber through upper axial wall **5** in close proximity to peripheral wall **2**. The cylindrical discharge opening formed by discharge port **7**, in conjunction with conical enclosure **9**, forms a centrifugal separator into which the ground product settles to be collected while the grinding fluid flows out through exhaust duct **8**.

Referring now to FIG. **3** and to the details of the slurry feed device A for introducing and drying the slurry, elongated passageway **10**, through which the solids ultimately pass into the grinding chamber, is formed by annular walls **21, 22** which abut at flanges

23, 24, are held together by bolts **25**, with an O-ring gasket **26** in position as shown. An extension of wall **22** forms housing **27** which is adapted to accommodate the entry of high velocity gaseous drying fluid, e.g., high pressure steam supplied via pipe **28**, which intersects passageway **10** at a right angle.

Communicating with passageway **10** in axial alignment with the relatively wider upstream portion thereof is a slurry supply conduit shown generally as **29** which is connected at its feed inlet **30** to a source of the slurry to be dried and ground. Conduit **29** is maintained in position against housing **27** by means of bolts **33.** O-rings **35** are in contact with shim plate **34** to assist in preventing leaks of gaseous drying fluid.

Conduit **29** extends into housing **27** and is convergently tapered at its forward extremity to form discharge nozzle **36.** The latter is centered within the wider portion of passageway **10** leaving a small annular space **37** between passageway lip **38** and discharge nozzle **36** for flow of gaseous drying fluid so as to envelop the stream of slurry emerging from the discharge nozzle and passing into the narrower portion of passageway **10.**

By varying the thickness of shim plate **34** the size of annular space **37** is varied.

As shown more clearly in FIG. 3*a*, slurry conduit **29** is composed of inner cylindrical element **41** and outer cylindrical element **42,** the two bewng welded at each end. Hence, essentially fully along the length of conduit **29** is channel **39** for flow of heat exchange fluid, e.g., cold water, therethrough. Elongated baffles **43** and **44** are welded to cylinder **41** and extend nearly the entire length of channel **39.** Thus the heat exchange fluid will for the most part enter at threaded connection **45,** traverse the length of conduit **29** through channel **39,** return and finally exit at threaded connection **46.** It is especially desirable that the portion of conduit **29** which is exposed to the high velocity gaseous drying fluid from pipe **28** be able to have its temperature appropriately controlled by the heat exchange fluid.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Insofar as the grinding function is concerned, the operation of the fluid energy mill of the invention follows that of similar devices of the prior art. In this respect reference is made to the aforementioned U.S. Pat. No. 2,032,827 to Andrews and additionally to U.S. Pat. No. 3,462,086 to Bertrand et al., the disclosures of which are incorporated herein by reference.

With respect to the improvement according to the present invention, gaseous drying fluid, preferably steam, flowing through pipe **28** at a relatively low velocity and high pressure, undergoes a marked increase in velocity, to at least sonic velocity, as it emerges from what amounts to a converging-diverging nozzle at annular space **37** and comes in contact with slurry passing through discharge nozzle **36** at a relatively low velocity. Mass and heat transfer in the region of the discharge nozzle is extremely rapid. Desirably, enough heat will be supplied by the gaseous drying fluid to permit the temperature of the resulting mixture to remain above saturation temperature. The pulverulent solids will hence be at least surface dry before entering the grinding chamber where they are subjected to the action of a gaseous grinding fluid, which like the gaseous drying fluid is also preferably steam.

The envelope of gaseous drying fluid about the stream of slurry issuing from discharge nozzle **36** serves not only in the drying function but also in preventing a buildup of solids along the walls of passageway **10.** Likewise, a flow of a cooling liquid such as chilled water through channel **39** of slurry supply conduit **29** aids in preventing premature drying of the slurry on the inner walls of the conduit or on discharge nozzle **36.** It is particularly important at start-up that the discharge nozzle temperature not become excessively high before the slurry flow is commenced in order that solids do not bake out on the inner conduit wall.

While it is preferred to employ a multiplicity of inlets **4** for gaseous grinding fluid, as shown in FIGS. **1** and **2,** it is also practical to omit them under certain circumstances. For example where the grinding function is only of secondary importance as compared to the drying function, the gaseous drying fluid supplied to chamber **3** via passageway **10** can be adequate to serve as grinding fluid as well.

While the present invention is particularly described with reference to the treatment of aqueous TiO_2 slurries, it will be apparent that it is also applicable to use with various other materials as well.

EXAMPLE

The material to be dried and ground is a slurry in water of uncoated rutile TiO_2 particles having an average particle size of about 0.22 micron. The solids content of the slurry is 64% by weight and its feed rate is 6100 pounds per hour.

The fluid energy mill is that described in connection with the drawings. The axial walls converge from a height of 3⅜ inch at the periphery to 2¼ inch at the discharge port. The grinding chamber is 27 inches in diameter. There is a series of 12 tangential ring jets as inlets for flow of 518°F., and 150 psig steam at the rate of 3200 pounds per hour into the grinding chamber.

The drying fluid is 800°F. steam fed to a 2⅞ inch internal diameter supply pipe at 450 psig and at the rate of 8000 pounds per hours. The annular clearance aurrounding the discharge nozzle of the slurry supply conduit is 0.070 inch. The passageway is 1⅞ inches in diameter at the narrowest portion just beyond the discharge nozzle; and expands to 2⅞ inches in diameter its length from the nozzle to the grinding chamber is 19⅝ inches.

The temperature of the steam discharged from the grinding chamber is 338°F. The overall steam to pigment ratio is 3.0.

The quality of the product is rated equivalent to the same TiO_2 dried separately and ground in a conventional manner. No pluggage of the slurry feed device is encountered throughout an extended run.

What is claimed is:

1. A fluid energy mill of the confined vortex type for drying and grinding a slurry of pulverulent solids, said mill comprising:

a generally circular grinding chamber defined by a pair of opposing axial walls and a peripheral wall,

a slurry feed device formed by

walls defining a generally rectilinear passageway which opens into a peripheral region of said chamber,

a slurry supply conduit having an inlet remote from said passageway and a discharge nozzle positioned in said passageway for directing slurry along the passageway and toward said chamber, the size of discharge nozzle being small relative to the surrounding passageway to define an annular space therebetween,

means for supplying gaseous drying fluid of at least sonic velocity to said annular space to thereby envelop and atomize within the passageway slurry emerging from said discharge nozzle,

means for controlling the temperature of said discharge nozzle, and

discharge means for withdrawing pulverulent solids and gaseous grinding fluid along the axis of the chamber.

2. Mill according to claim 1 wherein the passageway of said slurry feed device opens into the peripheral wall of said grinding chamber.

3. Mill according to claim 1 wherein the passageway of said slurry feed device opens generally tangentially into the peripheral wall of said grinding chamber.

4. Mill according to claim 1 wherein the means for controlling the temperature of the discharge nozzle comprises a channel inside the walls of the slurry supply conduit for flow of a heat exchange medium therethrough.

5. Mill according to claim 1 wherein the discharge nozzle forms a converging-diverging nozzle with the adjacent portion the passageway.

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