

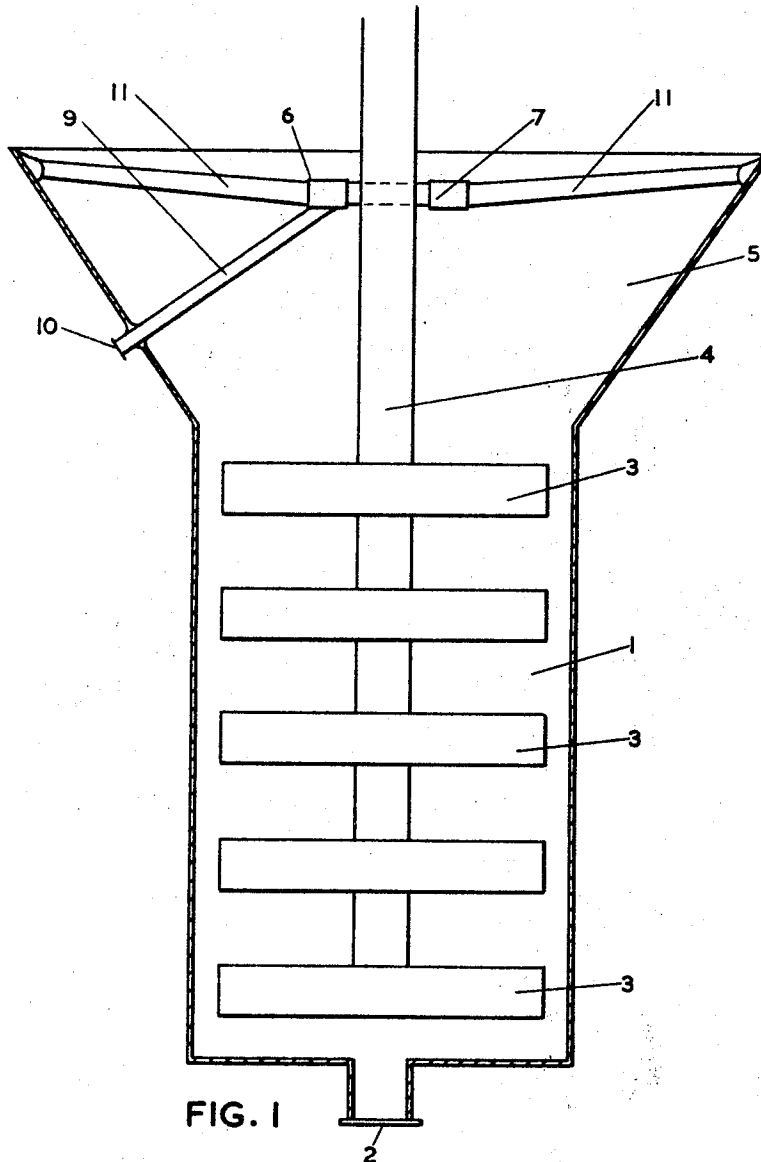
June 10, 1969

J. K. MYATT
MILLING PROCESS

3,448,931

Filed July 14, 1966

Sheet 1 of 2



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Sheet 2 of 2

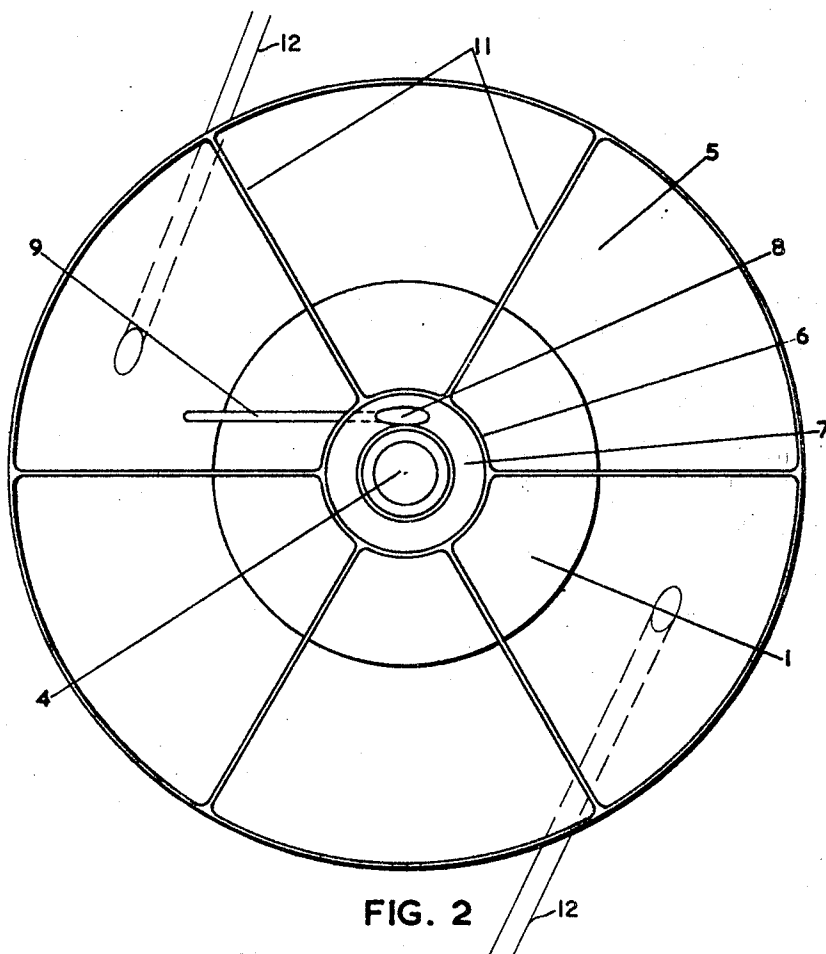


FIG. 2

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3,448,931

MILLING PROCESS

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Filed July 14, 1966, Ser. No. 565,256

Claims priority, application Great Britain, July 31, 1965, 32,882/65

Int. Cl. B02c 7/08, 13/18, 19/00

U.S. Cl. 241—20

10 Claims

ABSTRACT OF THE DISCLOSURE

A process and apparatus for grinding of solids in liquids is disclosed. The process and apparatus provide for the recovery of the ground solids with a significantly reduced content of grinding medium.

The present invention relates to improved apparatus and processes for grinding particulate solids.

In our U.S. Patent 3,185,398, there is described and claimed an apparatus and process for the grinding of solids in liquid wherein a slurry of solid particles to be ground and a liquid is supplied to a first zone containing an agitated particulate grinding medium, a slurry of liquid, ground particles and particulate grinding medium thus formed passes into a second zone situated above the first zone and the vertical rate at which the slurry rises in the second zone is such that the particulate grinding medium settles out preferentially to the ground solid particles in the second zone and falls into the first zone. The ground solid particles, free from at least most of the particulate grinding medium are recovered from the periphery of the upper portion of the second zone, for example by means of a collecting channel around the upper edge of the second zone.

In a preferred embodiment of the invention there are baffles placed at the junction of the first and second zones which reduce the rotating motion imparted to the slurry by the agitation in the first zone as it passes into the second zone. These are provided in order to assist in the preferential settling out of the particulate grinding medium in the second zone.

It is an object of the present invention to provide an improvement in, or modification of, the apparatus and process for grinding particulate solids which is described and claimed in U.S. Patent 3,185,398. Accordingly, the present invention is a process for the grinding of solids in liquid comprising continuously supplying solid particles to be ground and a liquid to a first zone containing agitated particulate grinding medium, passing the slurry of liquid, ground particles and particulate grinding medium thus produced into a second zone located above the first zone wherein particulate grinding material is separated from the slurry of ground particles and is returned to the first zone characterised in that the agitation in the first zone imparts a rotating motion to the slurry of liquid, particulate grinding medium and ground particles in the second zone which preferentially projects particles of particulate grinding medium in the slurry toward the periphery of the second zone from which they are returned to the first zone and a slurry of ground particles and liquid free from at least the greater part of the particulate grinding medium is recovered from the second zone at a point remote from the periphery of this zone.

The first zone is preferably similar to that shown in U.S. Patent 3,185,398, consisting of a hollow cylinder which is closed at the lower end with the exception of an inlet port for the slurry of liquid and particles to be ground.

The first zone contains an agitator preferably consisting

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of a rotatable impeller shaft driven by mechanical means such as an electric motor and carrying at least one impeller (and preferably more) of larger diameter than that of the impeller shaft.

The impellers (of which there are preferably up to 10) are generally discs or of spoked annular form and they may have projections on their upper and/or lower surfaces, as desired. They are preferably made from or covered with, material which resists abrasion and/or reduces discolouration of the ground solid, particularly when this is to be used as a white pigment, for example in the case of pigmentary titanium dioxide.

Materials which may be used in the construction or covering of the impellers to prevent or minimise discolouration of the ground product are, for example, polyurethane rubber, glass and titanium metal.

If desired, the wall of at least the first zone may also be made from, or internally covered with, a similar material to prevent or minimise abrasion and/or discolouration of the ground product.

The interior of the wall of the first zone can be provided with inwardly projecting baffles to improve grinding. These may project between adjacent impellers and/or they may be placed opposite the periphery of one or more of the impellers to reduce the space between the impeller and zone wall at that point.

As previously mentioned, the inlet port for the liquid and particles to be ground is preferably in the base of the first zone although, if desired, this material can be supplied at any other point, for example through side walls or through the upper end of the first zone.

Convenient methods of forming the first zone, particularly when baffles are provided, are either to build the walls in the form of a cylinder from circular sections (when the baffles may be formed from annular plates bolted between sections) or to split the walls (and baffles) longitudinally and to bolt or otherwise fix together the component parts when the impeller shaft and impellers are in position. The latter method is particularly suitable for assembly when the baffles project between the impellers.

The dimensions in the first zone, for example the distance between the impellers and between the periphery of the impellers and the wall of this zone may be similar to those described in U.S. Patent 3,185,398.

The second zone is normally placed above the first zone and is preferably a continuation thereof into which the slurry of liquid, particulate grinding medium and ground solid can rise as it is displaced by the introduction of more liquid and solid to be ground into the first zone.

As described in U.S. Patent 3,185,398, the second zone may comprise, for example, a cylindrical vessel of similar diameter to that of the first zone or it may be in the form of an inverted frusto-cone, the lower (and narrower) end of which is similar diameter to that of the first zone and which is attached to the open top of that zone.

Alternatively, in the present invention the second zone may have any other suitable form, for example, the form of a frusto-cone, the lower end (and larger end) of which is of similar diameter to that of the open end of the first zone and which coincides therewith, or it may have the form of a sphere or ovoid truncated top and bottom, the lower end of which coincides with the upper open end of the first zone.

In short, the second zone should be of such a shape that when a rotating motion is imparted to the slurry in the first zone by the agitation therein, this is maintained with as little loss in velocity as possible in the second zone and particulate grinding medium is preferentially projected by this rotating motion away from the volume of slurry in the centre of the second zone and towards the periphery thereof, thus leaving sufficient volume of slurry

in the centre from which to withdraw liquid and ground particles which are free from at least most of the grinding medium and which is preferably substantially completely free from grinding medium.

In order that the rotating motion applied to the slurry in the first zone shall be maintained in the second zone, baffles situated at the junction of the first and second zones should not be provided and the orifice between the first and second zones should be as free as possible from any obstructions which reduces the rotating motion of the slurry in the second zone.

It may be advisable, however, to provide channels, baffles, perforations or the like in or on the internal face of the wall of the lower part of the second zone and/or in or on the upper part of the internal face of the wall of the first zone to assist in the return of particulate grinding medium which has been projected to the periphery of the second zone back to the first zone. Such devices should preferably be so designed to cause the minimum obstruction to the rotating motion of the slurry.

If desired, additional liquid, for example water, can be added to the second zone to improve the separation of the particulate grinding medium and the ground particles. The addition of liquid may also reduce the viscosity and density of the slurry, thereby increasing the rate of movement of the particulate grinding medium and/or the speed of rotation of the slurry in the second zone. If desired, the additional water may be introduced tangentially to the wall of the second zone through one or more orifices in such a manner as to assist the rotary motion of the slurry in this zone.

When the process of the present invention is to be carried out it has been found advisable to add the particulate grinding medium to the first zone and to rotate the impellers while continuously introducing into the zone a slurry of liquid (preferably water) and the particulate solid to be ground, for example titanium dioxide.

The slurry supplied to the first zone, particularly in the case of titanium dioxide, preferably contains an amount of solid in the range 200 to 1400 and preferably an amount in the range 700 to 1000 grams/litre.

As particulate grinding medium there may be used any particles which are small enough to provide adequate grinding of the solid and which do not have a deleterious effect upon the solid to be ground. Where titanium dioxide is to be ground, for example, particles of silica (e.g. Ottawa sand), glass ballotini, alumina, hard titanium dioxide or zircon sand have been found suitable. Particle sizes in the range 150 to 3000 μ and preferably in the range 250 to 2500 μ and particularly 400 to 700 μ are preferred.

In order to provide good grinding conditions and to provide a rotary motion of adequate velocity to the slurry of liquid, particulate grinding medium and ground solid in the second zone, it has been found that the peripheral speed of the impellers should preferably be at least 2000 ft./sec. and particularly at least 3000 ft./sec.

Any suitable method may be utilised for the recovery of the slurry of liquid and ground solid (free from at least most of the particulate grinding medium) from a point remote from the periphery of the second zone, for example from the central volume of the zone. For example, the slurry may be removed through an appropriately placed conduit to which suction is applied or, alternatively, a trough may be provided in the centre of the second zone and so positioned that the slurry overflows into the trough, from which it is led to recovery. It has been found convenient to place such a trough around the impeller shaft (but preferably not rotating therewith) and to provide a conduit from the trough through the wall of the second zone to convey the slurry to a recovery process for the ground solid.

The ground solid, e.g. titanium dioxide, may be recovered by any suitable process, for example by filtration or by the use of a centrifuge. If any particulate grinding medium is carried over in the slurry this may be first

removed, for example by preferential settling or by passing the slurry through an appropriately sized sieve. Generally, however, it has been found that very little particulate grinding medium is present in the slurry recovered from the second zone by the process of the present invention.

In the accompanying drawings, FIGURE 1 is a vertical section through an apparatus according to the present invention and FIGURE 2 is a plan view.

Where appropriate the same integers are used to indicate the same structures in both figures.

When the apparatus is in use, a slurry of particles to be ground and liquid is generally continuously supplied to the milling zone 1 via the inlet port 2.

The milling zone contains particulate milling medium which is agitated by impellers 3 which rotate with the impeller shaft 4.

A slurry of milling medium, ground particles and liquid rises into the settling zone 5 as it is displaced by the incoming slurry into the milling zone. The slurry retains the rotating motion imparted to it by the impellers and under the influence of this motion the heavier particles of grinding medium are projected towards the sides of the settling zone.

The upper level of the slurry rises in the settling zone until slurry, free from at least most of the grinding medium, overflows the upper lip 6 of the launder or annular channel 7, collects momentarily in the channel before being discharged through orifice 8, pipe 9 and outlet port 10.

The grinding medium which has been projected towards the sides of the settling zone settles down the sides of this zone and thus returns to the milling zone.

The launder or annular channel is supported in position by means of supports 11 fixed between brackets on the interior of the wall of the settling zone and on the exterior wall of the launder.

As shown in FIG. 2, settling zone 5 may be provided with tangentially directed conduits 12 for the addition of liquid to this zone if desired.

The following examples show various embodiments of the present invention.

Example 1

The apparatus was similar to that described in the accompanying drawings (except that additional conduits 12 were not utilized) comprising a cylindrical mild steel milling zone and this was surmounted by a settling zone in the form of an inverted frusto-cone.

The internal diameter of the milling zone was 19½" and it was 4'3" in height. The lower end of the settling zone also had an internal diameter of 19½". The internal diameter of the upper end was 6'6" and the vertical height of the settling zone 2'6".

A 4" diameter pipe was provided in the base of the milling zone for the introduction of a slurry of water and solid to be ground.

The impeller shaft projecting into the milling zone was 5" in diameter and carried five polyurethane rubber discs 17½" diameter and 1½" in thickness (as impellers). The lower impeller was 4" above the base of the milling zone and the remaining impellers were spaced 4" apart by means of spacers.

Provision was made to drive the impeller shaft (through a belt drive) by a 47.5 H.P. electric motor.

Around the impeller shaft (but not fixed thereto) and slightly below the upper edge of the settling zone was placed an annular trough 4" in depth and 18" outside diameter which was connected to a delivery pipe passing downwardly through the wall of the second zone and which directed the slurry passing through the pipe over a 325 B.S.S. mesh sieve (having an aperture width of 19 microns).

No vertical baffles and collar surrounding the impeller shaft or collecting channel around the periphery of the

top of the settling zone were provided (cf. U.S. Patent 3,185,398).

In operation, 2,200 lbs. of Ottawa sand having a particle size in the range 400μ to 650μ were placed in the milling zone and the impellers rotated at a peripheral speed of 2,500 ft./min. while a slurry of unmilled rutile titanium dioxide calciner discharge and water (at a concentration of about 850 g./litre) was supplied to the base of the milling zone. The slurry was supplied at a rate of about 0.3 cu. metre/hour. When the level of slurry in the settling zone reached the outer edge of the annular trough the slurry overflowed into the trough and passed down the delivery pipe to the sieve.

The solid residue retained on the sieve, consisting substantially of grinding medium, was removed from time to time and weighed.

Samples of slurry were also taken at the periphery of the top of the settling zone at the same level as that of the annular trough and these were passed through a sieve (325 B.S.S. mesh). The residue on the sieve was recovered and weighed.

The results, expressed as percentages of solid to slurry (by weight) retained on the sieve in each case were as follows:

- | | |
|--|------|
| (1) From annular trough at centre of settling zone | 0.01 |
| (2) From periphery of settling zone | 0.26 |

Example 2

An apparatus similar to that described in the drawings (except that additional conduits 12 were not utilized) was set up having the following dimensions

Internal diameter of milling zone	3 ft. 10½ in.
Height of milling zone	4 ft. 9 in.
Greatest internal diameter of settling zone	6 ft. 9 in.
Height of settling zone	2 ft. 10 in.
No. of impellers	6.
Diameter of impellers	3 ft. 3½ in.
Thickness of impellers	3 in.
Vertical distance between horizontal centre lines of the impellers	10 in.

An annular trough, 9" internal diameter and 18" external diameter and 3 in. deep was supported around the impeller shaft, the upper edge being slightly below the level of the upper edge of the settling zone and from it a pipe was passed downwardly through the wall of the settling zone to discharge over a 325 B.S.S. mesh sieve (having an aperture width of 19 microns).

In the milling zone was placed 3,400 pounds of Ottawa sand of particle size in the range 450-700 microns and to the inlet orifice in the base of the milling zone was supplied, at a rate of 1 cu. metre per hour, an aqueous slurry of titanium dioxide particles at a concentration of about 700 grams/litre.

The impellers were rotated at 340 r.p.m. by means of an electric motor.

When the level of slurry in the settling zone rose to the top of the annular trough surrounding the impeller shaft, a slurry of liquid and ground particles overflowed into the trough and was discharged via the pipe into the sieve.

A sample of slurry was also taken from the upper level of the liquid at the periphery of the settling zone and this sample was also passed through a 325 B.S.S. mesh sieve.

The results, expressed as percentage of solid to slurry (by weight) retained on the sieve in each case are given below.

- | | |
|--|-------|
| (1) From the annular trough at the centre of the settling zone | 0.003 |
| (2) From the periphery of the settling zone | 0.408 |

What is claimed is:

1. A process for the grinding of solids in liquid comprising the steps of:

- (a) supplying solid particles to be ground and a liquid to a grinding zone containing particulate grinding medium;
- (b) mechanically agitating said solid particles, liquid and grinding medium in said grinding zone to impart thereto a rotating motion and to effect grinding action between said solid particles and said grinding medium;
- (c) continuing steps (a) and (b) whereby slurry resulting from step (b) comprising ground solid particles, particulate grinding medium and liquid is caused to flow upwardly, with substantially unimpeded flow, into a separating zone above said grinding zone whereby said slurry substantially retains said rotating motion from step (b) in said separating zone without further mechanical agitation;
- (d) withdrawing liquid, including suspended, ground particles from said separating zone at a rate to establish a maximum, predetermined liquid level in said separating zone, said withdrawn liquid being withdrawn at a point in said separating zone below the liquid level in said separating zone and remote from the periphery of said separating zone; and
- (e) controlling the liquid level in said separating zone at a level not exceeding said maximum, predetermined liquid level solely by the rate of withdrawal of liquid from said separating zone relative to the rate of liquid fed thereto, whereby the major proportion of particulate grinding medium in slurry flowing into said separating zone from said grinding zone is projected toward the periphery of said separating zone and returned to said grinding zone, and ground particles are recovered from said separating zone together with the liquid withdrawn in step (d), with the weight ratio of ground particles to particulate grinding medium mixed with the recovered particles substantially greater than in the slurry of step (c).

2. A process as claimed in claim 1 wherein liquid is added to the separating zone to reduce the viscosity and density of the slurry therein.

3. A process as claimed in claim 2 wherein the liquid is introduced in such a manner as to assist the rotary motion of the slurry in the separating zone.

4. A process as claimed in claim 1 wherein an aqueous slurry of titanium dioxide is supplied to the grinding zone at a concentration in the range 700 to 1000 grams/litre.

5. A process as claimed in claim 1 wherein the grinding medium has an average particle size in the range 400 to 700 microns.

6. A process in accordance with claim 1 wherein said mechanical agitation is effected by impellers rotated with a peripheral speed of at least 2,000 feet/second.

7. A process in accordance with claim 6 wherein said impellers are rotated with a peripheral speed of at least 3,000 feet/second.

8. An apparatus for grinding particles in a liquid comprising, in combination, a grinding zone defined by a first chamber having an inlet and an exit and a rotatable agitation means disposed in said chamber adapted to provide rotational motion to liquid contained in said chamber; a separating zone defined by a second chamber disposed above said grinding zone and contiguous thereto, said second chamber provided with an inlet means connected to said exit of said first chamber and adapted to provide substantially unimpeded flow of liquid from said grinding zone upward into said separating zone without substantial impediment to rotational motion of said liquid; said second chamber further provided with means for withdrawing a slurry of liquid and solid particles from said separating zone and adapted to control the level of liquid in said second chamber, said means for withdrawal of slurry positioned in said second chamber at a point remote from the periphery of said second chamber and

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below the surface of liquid contained in said second chamber, said second chamber being free of mechanical agitation means and substantially free of mechanical impediments to rotational movement and upward flow of liquid in said separating zone.

9. An apparatus as claimed in claim 8 wherein the means to recover a slurry of liquid and solid particles from a point remote from the periphery of the separating zone is an annular trough surrounding the impeller shaft, but not attached thereto and an outlet conduit from the interior of the trough to the exterior of the separating zone.

10. An apparatus as claimed in claim 8 wherein the separating zone is provided with means to introduce a liquid tangentially to the interior wall of the separating zone.

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U.S. Cl. X.R.

209—211; 241—30, 46.15, 171, 172