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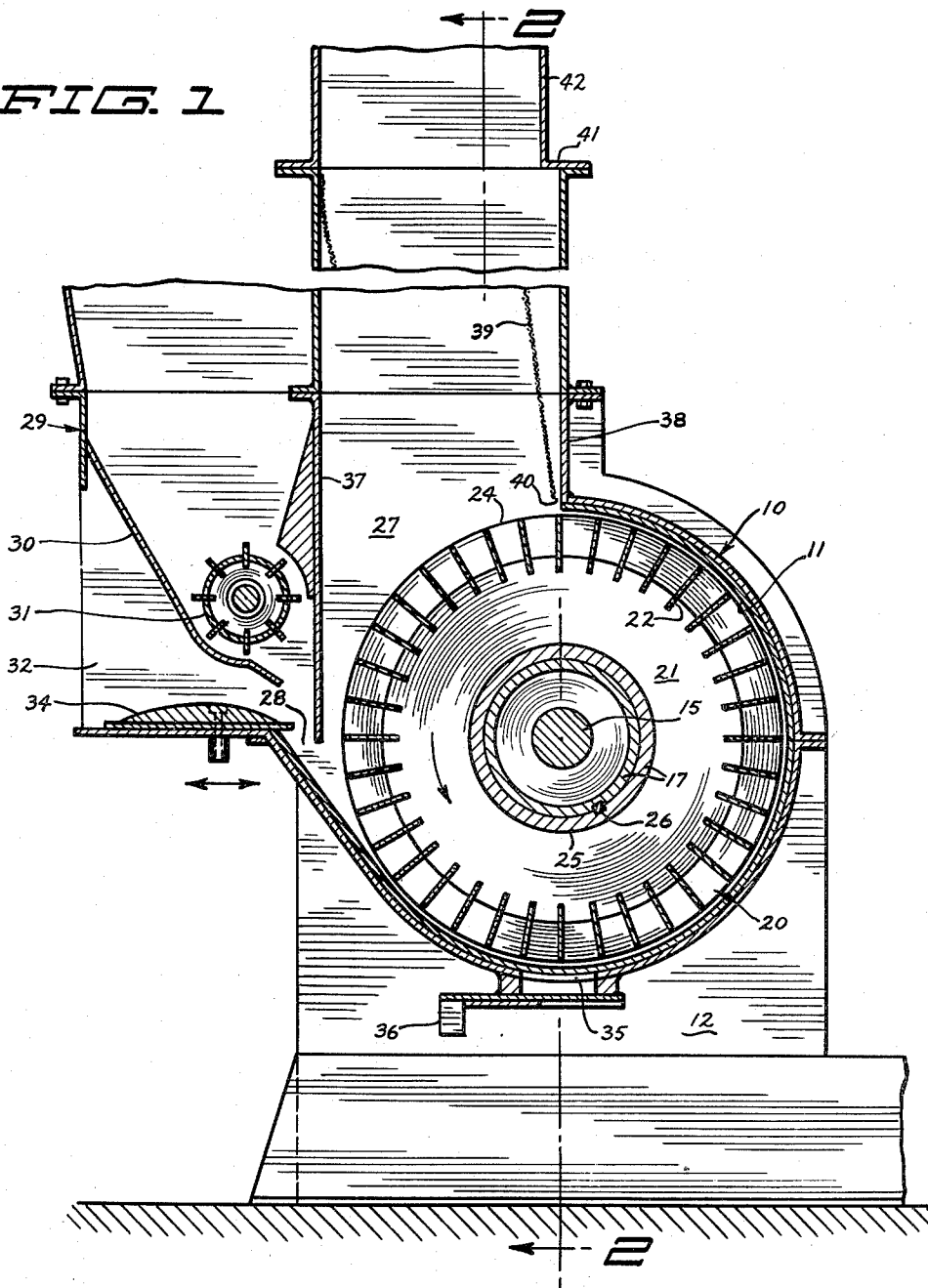
H. G. LYKKEN ET AL
PRECISION GRINDER

2,941,731

Filed March 28, 1955

4 Sheets-Sheet 1

FIG. 1

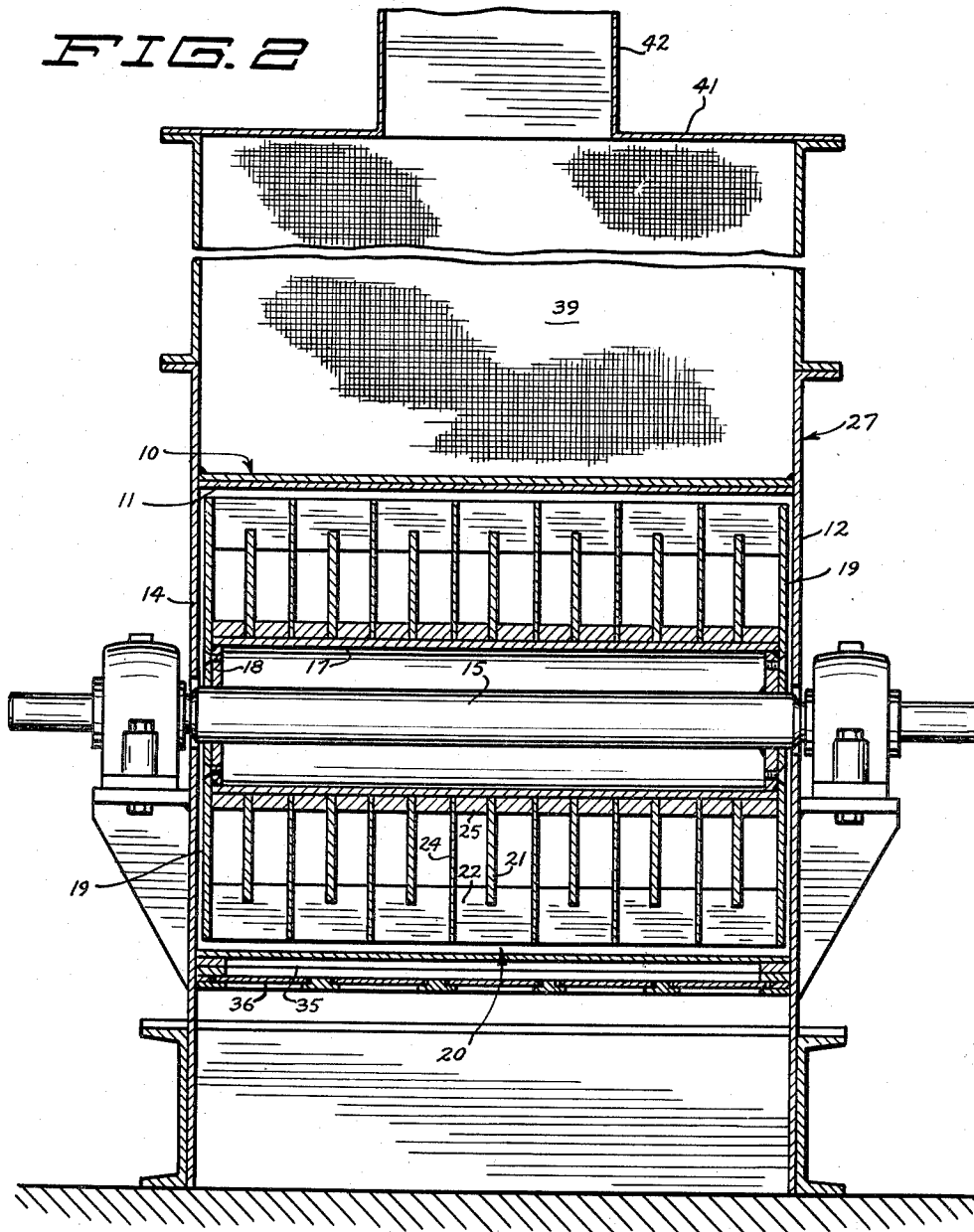


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FIG. 2



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PRECISION GRINDER

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12 Claims. (Cl. 241—10)

This invention relates to means for reducing dry granular and pulverulent material to a desired mesh or particle size range. The apparatus of this invention is adapted to grind a great variety and diversity of materials effectively and efficiently due to its principle of reduction with effective scavenging of the mill load and immediate removal of the finished product as it is produced to avoid overgrinding, production of excessive superfines and the cushioning effect of fines in the mill load. The result is maximum milling efficiency, increasing the mill capacity while appreciably reducing power needs.

The pulverizer of this invention is particularly adapted for grinding materials such as talc, clays, kaolins, graphites, earth pigments and the like that are always more or less contaminated with crystalline material such as sand and grit. This may be designated as differential grinding. The foreign material that must be removed is harder, denser and heavier than the wanted product. It is generally exceedingly hard to reduce and accumulates in the circulating mill load. The wanted product is generally much softer and reduces readily to a high degree of fineness.

A major object of this invention is to provide a precision grinder having means for progressive removal of the harder and heavier material in the grinding process and having means for immediate removal of fines as they are produced.

Other objects of this invention will become apparent as the description proceeds.

To the accomplishment of the foregoing and related ends, this invention then comprises the features herein-after fully described and particularly pointed out in the claims, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principles of the invention may be employed.

This invention is related to our copending applications Serial No. 434,468, filed on June 4, 1954 now Patent No. 2,821,344 and Serial No. 468,764 filed on November 15, 1954, now Patent No. 2,875,956, and embodies features of those inventions in combination with other novel features improving and simplifying construction and operation to effect specific novel results.

The invention is illustrated by the drawings in which the same numerals refer to corresponding parts and in which:

Figure 1 is an end elevation in section of the grinder of this invention;

Figure 2 is an elevation in section taken along the line 2—2 and in the direction of the arrows of Figure 1;

Figure 3 is an end elevation in section, similar to Figure 1, showing a modified form of construction;

Figure 4 is a longitudinal sectional view of the modified form of grinder taken along the line 4—4 and in the direction of the arrows of Figure 3;

Figure 5 is a vertical section through the lower part

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of a grinder showing an alternative form of grit removal means; and

Figure 6 is a vertical section through the upper part of a grinder showing an optional extension of the mill liner or housing.

Broadly stated, the invention comprises apparatus for reducing and classifying dry solid material which includes the steps of feeding a controlled supply of dry solid material and a carrying gas tangentially downward along the entire length of a horizontally disposed generally cylindrical milling area comprised of a plurality of adjacent independent annular grinding zones; maintaining a fluidal suspension of the solid material in the gas; continuously grinding the solid material at least in part by attrition of particle against particle and particle against gas stream by whirling the fluidal stream of particles of the solid material entrained in the gas at high speed in an arcuate path around the outer perimeter of the annular grinding zones, setting up an outer vortex action and whirling a plurality of smaller fluidal streams of particles of the solid material entrained in the gas at high speed around the inner periphery of the annular grinding zones setting up a plurality of inner vortex actions; centrifugally throwing out at least part of the particles, including the desired fines, through one quadrant of the cylindrical milling area; continuously and immediately separating the desired higher falling fine particles from the lower falling coarser particles and withdrawing the fines from the milling area by entraining them in a gas flow through the centrifugal throw-out area while permitting the coarser particles to return to the grinding zone for further reduction.

Referring now to the drawings, and particularly to Figures 1 and 2, there is here shown the precision grinder of this invention. The grinder comprises a generally cylindrical horizontal housing 10, preferably provided with a liner 11, which may be smooth or corrugated. Housing 10 is enclosed between two end plates 12 and 14. It will be noted that this mill is characterized by the absence of a self-contained fan. End plates 12 and 14 extend to a base or floor and are affixed by floor flanges.

A suitable bearing structure is mounted at each end of the mill outside of the end plates. The details of construction of the bearings are within the province of mechanical design and need not be further explained here except to state that the bearings are preferably of the roll or ball bearing type and they are adequately sized to carry the rotor of the mill at the speeds desired and are adequately protected against the entrance of abrasive material into the bearings. Upon the bearings there is mounted a shaft 15 extending through the end plates and running the length of the entire mill forming the axis thereof. The shaft may be rotated by means of a pulley (not shown) mounted on the projecting end of the shaft and belted to any suitable motor. Alternatively, the shaft may be driven directly by direct connection to a motor of suitable design.

The shaft 15 is enlarged and reinforced through part of its length by a tube 17 supported by annular rings 18 welded or otherwise secured to the shaft. The shaft, tube and annular rings form a rigid unitary structure upon which the grinding rotor units are mounted.

A rotor end disk 19 is mounted on each end of the tube secured to annular ring 18. Mounted in series between the rotor end disks 19 are a plurality of individual independent closed end radial blade grinding or pulverizing units 20. In the form shown in Figures 1 and 2 each unit comprises an annular disk 21 perpendicular to the shaft carrying in radial slots around its periphery a plurality of flat radial blades 22 enclosed between a pair of disks 24. Radial blades 22 are positioned perpendicular to the slotted disk 21 so as to lie in spaced longitudi-

nal planes radiating from the axis of the rotor. Disks 24 have a diameter reaching to the periphery of blades 22. The slotted disks 21 and disks 24 are held spaced apart by annular spacer rings 25 of appropriate length keyed at 26 to tube 17. Instead of being in the form of flat plates as illustrated, radial blades 22 may likewise be in the form of rods mounted perpendicular to the rotor disks, as shown in Figures 3 and 4, this alternative form of construction being preferred for some purposes as will be explained in detail hereinafter.

The upper forward quadrant of the cylindrical housing 10 is cut away and replaced by a rectangular section extending upwardly to form an expansion chamber and mill outlet 27. Below this expansion chamber along the center line of the housing is a lip forming a tangential inlet 28 extending the length of the housing for both air and the material to be reduced.

A material and gas inlet means indicated generally at 29 is provided along the full length of the mill for controllably feeding the material to be reduced to the inlet opening 28. In the form here illustrated the material feeder comprises an elongated hopper 30 provided with a rotary metering gate 31 which is preferably driven by a variable speed drive for precise feed rate control.

An air inlet chamber 32 is provided below the feed hopper. The air inlet has a sliding gate 34 in the form of an air foil section associated with the tangential inlet 28 for precise inlet air control. By these means the material as fed is drawn into the mill with the air.

The bottom of the grinder housing is provided with an opening 35 or a plurality of openings along the length of the mill, connected with an outlet gate or duct having slide dampers 36 or similar means for progressively withdrawing bits of sand, stone, metal and like extraneous heavier material from the mill load. Initially this grit trap will become filled with the material to be reduced but as grit and like material is introduced into the mill, it will, because of its greater density, drop to the bottom of the trap.

The expansion chamber 27 extending along the grinder housing over the upper forward quadrant of the circumference of the rotor comprises a front wall 37 which extends vertically upward from the air and material inlet 28 and generally tangential to the rotor circumference and a back wall 38 extending radially outward and upward from the top of the cylindrical housing.

The upper section of the expansion chamber 27 is designed to act as a primary separating chamber and extends vertically upward from the mill housing. Means, such as a screen 39, are provided in the expansion chamber to unify air through the chamber and to restrain oversize and cause it to drop back into the grinding zone by gravity while allowing the wanted particle sizes to be withdrawn with the air. The screen 39, according to one form of the invention as shown in Figure 1, is disposed diagonally in the expansion chamber leaving a narrow open throat 40 at the lower edge. The flow of air accompanying the moving rotor past the throat will create a slight negative pressure sufficient to prevent accumulation of material at the lower end of the screen.

The expansion chamber 27 is provided with a top wall 41 through which the chamber connects with an outlet duct 42, in turn connected (when needed) with an individually driven exhaust fan or equivalent suction inducing means (not shown) to move the air flow into and through the grinder and out through the expansion chamber to withdraw the ground product.

In some cases means are provided within the expansion chamber, such as screen 39, for progressively classifying the withdrawn product allowing the oversize to drop directly back into the grinder for further reduction and the finished product to go out with the air. In other cases all of the ground product is withdrawn and an independently driven classifier operating in series with the mill separates the oversize and returns it to the feed hopper.

The specially designed rotor comprises in effect a series of independently acting closed end rotor units each having its own air and feed inlet. These rotor units when rotated at relatively high speed have a high centrifugal discharge effect on the forward or leading face of each rotor blade and a correspondingly high centripetal or suction effect on the back or trailing side of the blade. This produces a high intensity suction and inrush of air at the back of each blade and a corresponding outrush on the face of the following blade, setting up an intense intrablade vortex action between each pair of blades.

Since the incoming air draws material into the intrablade vortex action, it becomes a major part of the grinding action of such a rotor. In addition, it produces in effect a bound high velocity air flow around the rotor due to its intensified forward suction greater than the peripheral velocity of the rotor. This latter characteristic is utilized in this invention in connection with a properly designed tangential air inlet, air inlet control, material inlet and material inlet control serving as a new and novel means to induce the air and material into the mill, to circulate it in the mill and to produce a static pressure in the mill for discharging the finished material out of the mill with the air (in most cases) in lieu of an auxiliary mill fan. Only when the material and air must be discharged at high pressure is such a fan needed.

A rotor such as is used in the grinder of this invention provides an effective particle size classification within the rotor chamber itself so that in many cases no other classification is required. The coarser material affected by gravity and high directional velocity is directed downwardly and hence back into the rotor. The lighter material is carried up and out by the regulated air flow.

For a wide variety of products and particle size requirements this provides adequate classification, obviating auxiliary classifying means. To fully utilize the self-classifying characteristics of the rotor it is often desirable to provide a mill housing wall or liner extension such as is shown in Figure 6. The extension comprises an arcuate plate 60 which serves as a continuation of housing wall 10 or liner 11 and extends out into the expansion chamber along the entire length of the rotor. Plate 60 is supported from a vertical member 61 adapted to be fastened, as by bolts 62, to the back wall 38 of the expansion chamber. The extension structure is preferably reinforced by a sloping bracing and deflecting plate 64.

This liner extension serves to deflect the rotor discharge downward. Its width can be varied to meet varying requirements. By this means only the smallest and lightest wanted particles are entrained in the controlled air flow and carried up and out of the grinder.

The mill of this invention is designed to operate on the principle of complete and constant scavenging of the mill load, the removal of all of the finished product and finer every revolution of the rotor to provide the greatest possible grinding efficiency. It is designed to reduce material to a precise mesh or specific top size particles and finer in conjunction with a classification means, such as a classification device associated with the grinder to permit only the wanted sizes to escape with the air or an independently driven classifier operated in series with the mill.

The air flow through the mill is regulated to continuously withdraw the wanted particle size and finer immediately as it is produced, with minimum fine left in the mill load. An approximate particle size may be obtained by merely regulating the air flow since the velocity of the air flow determines the particle size lifted out of the mill by the air flow.

In the modified form of construction shown in Figures 3 and 4, the flat radial rotor blades 22 are replaced by rod 45, carried between disks 24A held properly spaced apart by spacer rings 25A. This form of construction is especially adapted for situations wherein division by impact without abrasion is desired, such as, for example, the first break of cereals wherein it is desired to free most of

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the fiber jacket or bran and the germ from the endosperm with a minimum reduction of the fiber jacket or bran, preferably no reduction of the germ and minimum reduction of the wanted material, the endosperm.

In this modified form of construction, the expansion chamber 27A is of reduced height. The top plate 41A is provided with a narrow slot or opening 46 adjacent the front wall of the expansion chamber and extending the length of the mill. An elongated duct 47 connects opening 46 with a material outlet duct 48 which, in turn, is connected to a suitable exhaust means not shown. An external suction fan is required when the peg type rotor is used since this rotor does not produce static pressure sufficient to discharge the product from the mill. Spacers 49 in duct 47 extending through opening 46 and down into the expansion chamber provide a venturi-like throat for increasing the flow velocity through the duct enabling easy removal of relatively coarse ground material from the first break of cereal product in the described desired manner according to this invention. A plurality of vertical vanes 50 assist in directing and unifying the flow through duct 47.

An alternative form of grit remover is shown in Figure 5, adapted for use where the initial feed contains a considerable amount of dense material. A moving member such as a slotted belt 51 carried by rollers 52 and 53 is positioned under the duct connecting with openings 35 in the bottom of the mill housing. The material as fed tends to drop by gravity into this space. Because the feed is in a highly fluidal state and this bed is likewise fluidal, the coarse dense contaminants are readily separated and sink to the bottom of the duct. Rollers 52 and 53 are preferably driven by a variable drive to permit controlled continuous removal of the grit as rapidly as it is separated.

In the operation of the improved precision grinder of this invention the material to be reduced is fed into hopper 30 and introduced at a controllable rate into inlet 28. At the same time air or other gaseous fluid is introduced through chamber 32 at a controllable rate governed by damper 34 into inlet 28. The grinding load is maintained in a highly fluidal state, usually containing not more than about 10 percent solids. As the material enters it falls and is drawn by air flow against the rotating blades of the rotor. Any fines in the feed material are entrained in the air stream and immediately removed.

As the material to be reduced is carried at high speed around the periphery of the rotor reduction takes place by means of a vortex of the fluid suspension of material in which reduction is principally by impact and attrition of particle upon particle, as described in United States Patent 2,294,920 issued September 8, 1942. In that patent it is explained in detail how an outer vortex is set up beyond the tips of the radial blades of the rotor by the action of the blades taking up the air and whirling it around the inside of the cylindrical housing. As the material is fed it is picked up in the whirling air in the grinding chamber and caused to circulate around with the rotor, the material being entrained and conveyed in the air currents. The particles of material entering the pulverizer are picked up by this outer vortex. Milling action occurs due to the inertia of the particles in the air moving at high speed in the vortex. The particles are constantly eroded by the high speed air currents and reduced in size by collision with other particles in its path.

By proper spacing of the radial blades 22 and 45 of the rotor intra-blade vortices are also set up. The forward travel of each blade creates a vacuum. Immediately behind the blade there is an inrush of air to fill the vacuum. That air is taken in part from the inner edge of the outer vortex which is laden with fine pulverized material. Air to fill the vacuum is also partly obtained from about the tip of the next following blade, which air slips from in front of that blade, around its tip and back into the vacuum created behind the leading blade. The following blade advancing toward the vacuum compresses and expels the air directly in front of it and this air also rushes in to fill

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the vacuum at very high speed due to its increased pressure. The result of these several forces will be to produce a somewhat circular high speed vortice movement between each set of opposing faces of the radial blades or rods. The inrush of the material-laden air to fill the vacuum created behind each blade causes innumerable high speed impacts and collisions of the particles upon each other which together with the pull against the inertia of the particles in the vortices and the very high speed of the vortical air currents result in a rapid attrition of the particles to rapidly produce large quantities of very small particles. Each rotor stage in this pulverizer is an individual grinding unit and operates individually as if each unit were enclosed in a housing of its own.

When the invention is utilized as a first break mill with the modified form of construction illustrated in Figures 3 and 4 in which rod-shaped blades 45 replace flat radial blades 22 it may be desirable to operate the rotor at somewhat lower speeds so that the intra-blade vortices are incomplete as shown diagrammatically in Figure 3. In this manner the number of impacts of the particles against the side walls is increased while at the same time reduction by abrasion is substantially reduced.

For efficient operation of any pulverizer it is desirable that the finely reduced material of desired size be removed from the attrition zone as rapidly as possible. Each rotor stage operating as an individual grinding unit discharges its load tangentially at the top of the grinding chamber into the expansion chamber and picks it up again at the bottom of the expansion chamber. The centrifugal throw-out effect of the rotor upon the particles of greatest mass tends to throw these particles tangentially downwardly against the inner surface of wall 37 of the expansion chamber. The more finely ground particles of desired size and finer, which due to their lesser mass are less subject to this throw-out effect, are thrown out at a higher level. These fine particles are entrained in an air flow entering the air flow inlet in a regulatable amount and for the most part being carried about the rotor and upwardly out through the expansion chamber and out through the discharge outlet. The desired fines are immediately removed from the mill load and the coarser particles are returned for further reduction. In this way the burden of overgrinding is eliminated, along with the cushioning and dampening effect of fines in the grinding load, greatly increasing grinding efficiency.

One type of separation chamber with means for separating out oversize, allowing them to drop back into the grinding zone, is shown particularly in Figure 1. This separator consists of a vertical extension of the expansion chamber and the positioning of a diagonally mounted air flow equalizing or baffle screen within the chamber, the openings of the screen being of such area that only the wanted particle size and finer will be drawn out by the air velocity through the screen. This form of separator is especially adapted for most materials in the range greater than 10 microns.

All air and material flows in the grinder are at right angles to the axis. Each individual rotor unit operates independently as if each unit were enclosed in a housing of its own. Each gets its air and material load from the bottom of the expansion chamber and discharges tangentially at the top of the rotor chamber into the same expansion chamber. Apart from incidental equalizing of the loads there is no axial movement of air, feed or product in the mill.

The mill housing is preferably split horizontally so the top half may be lifted off and the rotor removed for cleaning, servicing, replacing or interchanging parts. The rotor is likewise designed so that the rotor units may readily be turned over to reverse their direction of rotation to provide self-sharpening where cutting edge rotors are desired.

The circular part of the housing is preferably provided with replaceable liners, smooth, corrugated or with a

cutting edge as required by the materials and desired product.

Since the mill load is calculated at less than about 10 percent solids, when the mill is fully loaded the solids make a layer on the peripheral wall considerably less than the running clearance. Since this is a fluid energy mill the individual particles must be free to attain and maintain high velocities of impact.

It will be observed that a large volume of air circulates in the grinding chamber but only a relatively small amount of air is drawn through the mill, only enough to remove the finished product, thereby conserving air handling. The humidity of the air entering the mill is controlled by conventional means to provide and maintain the best conditions and temper for grinding and right moisture content in the product. Although the invention is described with air as the processing gas it will be apparent that for some purposes it may be desirable to utilize other inert gases such as carbon dioxide, helium, nitrogen or the like or even more reactive gases such as chlorine, oxygen, hydrogen or the like or mixtures of such gases.

The pulverizer of this invention is especially adapted to the progressive reduction of wheat and other cereals to fiber-free flour. Production of fiber-free flour requires a series of progressive reductions and a series of grinding units.

In the first stage of flour production the whole wheat is only partially reduced or granulated to free most of the fiber jacket or bran and the germ from the wanted material, the endosperm. This husking must be done with minimum reduction of the fiber, preferably with no reduction of the germ and with a minimum reduction of the endosperm finer than about 8 to 10 mesh. The modified form of apparatus shown in Figures 3 and 4 is especially adapted for this purpose. This makes possible the separating out of most of the fiber and the germ from the granulated endosperm by present flour milling methods and means.

The mill illustrated in Figures 3 and 4, fitted with round rods instead of flat blades, is adapted to reduce the grain by velocity impact with no cutting edges, no abrading surface and no mass rubbing of material on material. For this purpose the mill is preferably fitted with a smooth liner having a few widely spaced rounded ribs. The feed is highly fluidal containing about one part by volume of solids to ten parts air. The rotor is preferably operated at a speed to produce incomplete intra-blade vortices, as illustrated diagrammatically, in Figure 3, to provide maximum impact. The narrow throated exhaust duct permits ready removal by adjustable suction air flow of the relatively coarse bran, germ and endosperm particles for segregation by conventional flour mill separating means. The bran and germ is removed full size as soon as it is freed. The oversize feeds back into the rotor.

The object of the first break operation is primarily to free most of the fiber and the germ with the least possible reduction of the endosperm beyond the granular stage. Even after the first break there will be considerable adhering fiber on the endosperm, on the larger particles in particular. Removal of this residual fiber requires two or more progressive reductions, each followed by size segregation and fiber removal. These subsequent progressive reductions are carried out in the same type mill employing a modified rotor and fluidal load with as little attrition as possible. The object of these reductions is merely to break the larger particles into two or three segments in a trip or two around the rotor to free more fiber with minimum reduction of the endosperm followed by immediate removal of the freed fiber. The process is repeated with minimum reduction each time. The relatively low rotor speeds used in these operations require relatively little power.

After each reduction, including the first break, a percentage of endosperm will clean up fiber-free. This

material is fed directly to a high-speed flour grinding and sizing mill, such as the mill illustrated in Figures 1 and 2, preferably fitted with a corrugated liner. This mill is arranged for efficient grinding to the desired top size, such as all through 325 mesh or all the dimensions of the individual starch cell without material breakdown of the starch cell. The flour will be ground and finished to any desired mesh without the waste of overgrinding, heating or power loss due to the cushioning or dampening effect of fines in the mill load. The mill remains constantly free of reduced material. Any fines in the feed are removed instantly as they enter the grinding chamber. All fines or finished product are removed the instant they are produced.

Instant removal of fines and finished product insures up to several hundred percent increase in mill efficiency as increased mill capacity and reduction in power requirements.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that we do not limit ourselves to the specific embodiments herein.

What we claim is:

1. A precision grinder for dry solid material comprising a substantially cylindrical horizontal mill housing, a rotor journaled for rotation horizontally in said mill housing and a plurality of relatively narrow individual independent closed end radial blade vortex action grinding units mounted on said rotor within the mill housing, the blades of said grinding units lying in spaced longitudinal planes radiating from the axis of said rotor and confined between pairs of spaced parallel discs normal to said axis, a generally rectangular expansion chamber mounted in said cylindrical mill housing over approximately one quadrant thereof, said expansion chamber being in direct fluid communication with the interior of the housing over that quadrant to serve as a tangential material discharge from said rotor, a tangential gas and material inlet to said mill housing extending along the full length of said mill housing at the juncture of the front wall of said expansion chamber and the mill housing, feeder means extending the full length of said mill housing adjacent to said tangential inlet for controlling the rate of feed to the inlet, damper means extending the full length of said mill housing below the feeder means for regulating the flow of gas to said inlet, the top of said expansion chamber being open to form a material discharge outlet the full length of said mill housing at the upper part of said expansion chamber.

2. The grinder according to claim 1 further characterized in that a diagonal flow unifying screen baffle is positioned in said expansion chamber between the mill housing and the discharge outlet, said screen sloping upwardly and forwardly from the back wall of the expansion chamber adjacent to the top of the cylindrical mill housing, the lower edge of said screen being spaced from the wall of said expansion chamber to define a narrow open throat between said screen and said wall.

3. The combination of a substantially cylindrical horizontal mill housing, a generally tangential material and gas inlet to said housing extending the length of said housing, a vortex action grinding rotor journaled for rotation horizontally in said housing, a generally rectangular expansion chamber mounted in said cylindrical mill housing over about one quadrant thereof and a discharge outlet at the upper end of said expansion chamber.

4. A precision grinder for dry solid material comprising a substantially cylindrical horizontal mill housing; a tangential gas and material inlet extending along the length of said housing in the forward wall thereof, feeder means along the length of said housing adjacent to said tangential inlet for controlling the rate of feed of solid material to said inlet, a gas inlet chamber extending the length of said housing below said feeder for admitting

and regulating flow of air to said inlet; a rotor journaled for horizontal rotation in the housing, a plurality of relatively narrow individual independent closed end radial blade vortex action grinding units spaced along said rotor within said housing, the blades of said grinding units lying in spaced longitudinal planes radiating from the axis of said rotor and confined between pairs of spaced parallel discs normal to said axis; a generally rectangular expansion chamber mounted in the wall of said cylindrical mill housing over approximately the upper forward quadrant thereof, intersecting said wall and in direct communication with the interior of said mill housing over that quadrant to serve as a tangential material discharge from said rotor, the top of said expansion chamber being open to form a material discharge outlet in the upper portion of said expansion chamber.

5. The grinder according to claim 4 further characterized in that a grit trap is provided in the bottom wall of the mill housing along the length thereof.

6. The grinder according to claim 4 further characterized in that a diagonal flow unifying screen is positioned in said expansion chamber between the mill housing and discharge outlet, said screen sloping upwardly and forwardly from the back wall of the expansion chamber adjacent to the top of the cylindrical mill housing, the lower edge of said screen being spaced from the wall of said expansion chamber to define a narrow throat between said screen and said wall.

7. The grinder according to claim 4 further characterized in that the blades of the radial blade grinding units are in the form of rods.

8. The grinder according to claim 4 further characterized in that a cylindrical extension is provided as a continuation of the cylindrical mill housing extending out from the top of the mill housing and projecting into the expansion chamber along the entire length of the rotor.

9. A method of precisely grinding and classifying dry solid material which comprises feeding a controlled supply of dry solid material and a carrying gas tangentially along the length of a horizontally disposed generally cylindrical milling area comprised of a plurality of adjacent independent annular grinding zones, maintaining a fluidal suspension of the solid material in the gas, continuously grinding the solid material at least in part by attrition of particle against particle and particle against gas stream by whirling the fluidal stream of particles of the solid material entrained in the gas at high speed in an arcuate path around the outer perimeter of the cylindrical milling area setting up an outer vortex action and whirling a plurality of smaller fluidal streams of particles of the solid material entrained in the gas at high speed around the inner periphery of the cylindrical milling area setting up a plurality of inner vortex actions, continuously centrifugally throwing at least part of the particles including the desired fines out through one quadrant of the cylindrical milling area, immediately and continuously separating the desired higher falling fine particles and withdrawing these fines from the cylindrical milling area by entraining them in a gas flow through the centrifugal throw-out area while permitting the coarse particles to return to the milling area for further reduction.

10. An improved method of producing fiber free flour by progressively reducing and classifying dry cereal material which comprises feeding a controlled supply of dry grain and a regulated supply of air tangentially downwardly into a horizontally disposed generally cylindrical milling area comprised of a plurality of adjacent independent annular grinding zones along the length thereof, maintaining a fluidal suspension of the grain in the gas, continually breaking the grain to free substantial portions of the bran and germ and granulate the endosperm at least in part by velocity impact by whirling the suspension of grain in an arcuate path around the outer periphery of the cylindrical milling area setting up an

outer vortex action and whirling a plurality of smaller fluidal streams of the suspension of grain around the inner periphery of the cylindrical milling area setting up a plurality of inner vortex actions, said inner vortices being incomplete to increase velocity impact of the grain against the outer periphery of the cylindrical grinding area, continuously throwing out centrifugally at least part of the grain particles, including the freed bran, freed fibers, germ and reduced endosperm, through the upper forward quadrant of the cylindrical milling area, immediately and continuously entraining the higher falling freed bran, freed fiber, germ and reduced endosperm in a gas stream and withdrawing them from the grinding area, segregating the freed bran, freed fiber germ and fiber-free endosperm from the endosperm having residual clinging fibers, progressively reducing this fibrous endosperm by repeating the milling and segregation process until all of the endosperm is free from adhering fiber and then reducing the fiber-free endosperm to the desired particle size.

11. A precision grinder comprising a generally cylindrical horizontal mill housing enclosing a grinding chamber, a rotor journaled for rotation horizontally and substantially coaxially within said chamber, said rotor comprising a plurality of individual independent closed end radial blade vortex action grinding units, the blades of said grinding units lying in spaced longitudinal planes radiating from the axis of said rotor and confined between pairs of spaced parallel disks normal to said axis, a tangential material and air inlet extending along the full length of said grinding chamber, said rotor being associated with the tangential inlet to said chamber and being positioned within said chamber to constitute a peripheral fan unit having a peripheral discharge above the rotor, an expansion chamber mounted on the mill housing over one quadrant thereof forming the outlet of the grinding chamber, said expansion chamber being in direct fluid communication with the grinding chamber to receive the peripheral discharge from the rotor, and a material discharge at the upper part of the expansion chamber.

12. A precision grinder for dry solid material comprising a substantially cylindrical horizontal mill housing; a tangential gas and material inlet extending along the length of said housing in the forward wall thereof, feeder means along the length of said housing adjacent to said tangential inlet for controlling the rate of feed of solid material to said inlet; a gas inlet chamber extending the full length of said housing below said feeder for admitting and regulating flow of air to said inlet; a rotor journaled for horizontal rotation in the housing; a plurality of radial blade grinding units spaced along said rotor within said housing, the blades of said grinding units lying in spaced longitudinal planes radiating from the axis of said rotor; a grit trap in the bottom of the mill housing along the length thereof, a movable belt member under said grit trap for continuous removal of grit from said housing; a generally rectangular expansion chamber mounted in the wall of said cylindrical mill housing over approximately the upper forward quadrant thereof, intersecting said wall and in direct communication with the interior of said mill housing over that quadrant; and a material discharge outlet in the upper portion of said expansion chamber.

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