(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 194 242 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
17.12.2008 Bulletin 2008/51

(21) Application number: **00916384.1**

(22) Date of filing: **16.03.2000**

(51) Int Cl.:
B02C 19/06 *(2006.01)*

(86) International application number:
PCT/US2000/006853

(87) International publication number:
WO 2000/056460 (28.09.2000 Gazette 2000/39)

(54) **APPARATUS AND METHOD FOR CIRCULAR VORTEX AIR FLOW MATERIAL GRINDING**

VORRICHTUNG UND VERFAHREN ZUR ZERKLEINERUNG VON MATERIAL MITTELS TURBULENTER LUFTSTRÖMUNG

INSTALLATION ET METHODE DE BROYAGE DE MATERIAUX AVEC ECOULEMENT TOURBILLONNAIRE DE L'AIR

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority: **23.03.1999 US 125570 P**

(43) Date of publication of application:
10.04.2002 Bulletin 2002/15

(73) Proprietor: **Vortex Dehydration Technology, LLC**
Reeds Spring, MO 65737 (US)

(72) Inventor: **Polifka, Francis D.**
Hays, KS 67601 (US)

(74) Representative: **Strehl Schübel-Hopf & Partner**
Maximilianstrasse 54
80538 München (DE)

(56) References cited:
WO-A-93/19848
US-A- 2 316 207
US-A- 2 474 314
US-A- 2 958 472
US-A- 5 236 132
DE-C- 517 225
US-A- 2 390 678
US-A- 2 846 151
US-A- 3 726 484

EP 1 194 242 B1

Description

Technical Field

[0001] The present invention generally relates to material grinding and, more particularly, is concerned with an apparatus and method for circular vortex air flow material grinding.

Background Art

[0002] Landfills often have limited space. In order to reduce the volume of space which discarded materials occupy in landfills, it is generally desirable to have an apparatus capable of grinding diverse materials typically disposed of in landfills. Two approaches have employed air in the grinding process. One approach involves the use of a large volume of air which is generated by a fan. The other approach involves the use of air at high velocity instead of large volume. A variety of grinding devices using air have been developed over the years. Representative examples of such prior art grinding devices and the like are disclosed in U.S. Pat. No. 1,123,033 to Stobie, U.S. Pat. No. 2,362,351 to Burmeister et al., U.S. Pat. No. 2,562,753 to Trost, U.S. Pat. No. 2,690,880 to Chatelain, U.S. Pat. No. 3,058,674 to Kocher, U.S. Pat. No. 4,248,387 to Andrews, U.S. Pat. No. 4,280,664 to Jackson et al., U.S. Pat. No. 5,012,619 to Knepprath et al., French Pat. No. 778,415 to International Pulverizing Corporation. The Trost patent uses air velocity in the grinding process. The Trost patent discloses an anvil grinder which includes a cyclone chamber in communication with a grinding chamber. An upper portion of the cyclone chamber extends upwardly through the grinding chamber such that the grinding chamber surrounds an upper end of the cyclone chamber but is separated therefrom. Only the upper ends of the grinding and cyclone chamber are in communication along an upper passageway extending around and above the entrance to an air offtake stack. Problems exist with this arrangement in that the upper portion of the cyclone chamber is cylindrical shaped and separated from the grinding chamber so it does not augment a vortex air flow created in the grinding chamber. The ground material must drastically change its direction of movement and be entrained in the air flow to go from the grinding chamber to the cyclone chamber in order to rise over the upper end of the cyclone chamber.

[0003] Consequently, a need remains for a material grinding apparatus which overcomes the aforementioned problems associated with the prior art design without introducing any new problems in place thereof.

[0004] WO 93/19848 A discloses an apparatus for comminuting material in a vortex air flow. Present claim 1 has been drafted in the two-part form in view of this document.

[0005] Another prior art example of a material grinding apparatus is disclosed in US-A-2,958,472.

SUMMARY OF THE INVENTION

[0006] The object of the invention is to provide a material grinding apparatus which allows to improve the vortex air flow in the grinding chamber in an efficient and cost-effective manner.

[0007] The present invention provides an apparatus and method for compressed air vortex flow material grinding as defined in claims 1 and 12 designed to satisfy the aforementioned need. The grinding apparatus uses high velocity compressed air in the grinding process for grinding, and also drying, diverse materials including by way of examples, but not limited to, glass, grain, paper, plastic, aluminum and granite. The grinding apparatus includes an annular upper enclosure defining an upper chamber into which material to be ground is introduced, a conical lower enclosure defining a lower chamber provided in tandem with the upper enclosure and one or more holes defined in the upper enclosure for introducing compressed air that generates a relatively high velocity vortex flow of air and material in the upper enclosure for grinding and drying to take place. The conical lower enclosure is a downward continuation and extension of the annular upper enclosure. The lower enclosure does not extend upwardly into nor past the upper chamber of the upper enclosure.

[0008] The subclaims relate to preferred modifications therof.

[0009] Accordingly, the material grinding apparatus comprises: (a) an upper enclosure including an upper annular sidewall, an supper end, open lower end and opposite exterior and interior sides, the upper annular sidewall defining an upper interior chamber at the interior side of the upper enclosure and having at least one hole of a predetermined size formed therethrough between the exterior and interior sides thereof providing flow communication between the exterior side of the upper enclosure and the upper interior chamber thereof; (b) a lower enclosure disposed below and in tandem with the upper enclosure, the lower enclosure including a lower annular sidewall having a substantially inverted conical configuration and open upper and lower ends and defining a lower interior chamber, the lower annular sidewall of the lower enclosure being mounted at the open upper end thereof to the open lower end of the upper enclosure such that the lower annular sidewall and lower interior chamber of the lower enclosure is substantially continuous from and in flow communication with the upper annular sidewall and upper interior chamber of the upper enclosure; (c) means for delivering material to be ground into the upper interior chamber of the upper enclosure through the upper end thereof; (d) means for supplying a flow of air, such as in a compressed state, through the hole in the upper annular sidewall of the upper enclosure into the upper interior chamber thereof to along a flow path extending about the interior side of the upper annular sidewall of the upper enclosure; and (e) means for exhausting air from the upper interior chamber of the upper

enclosure through the upper end thereof such that the means for supplying air and the means for exhausting air coact with the hole in the upper annular sidewall and with the upper and interior chambers to create a circular vortex flow of air within the upper and lower interior chambers of the upper and lower enclosures that causes grinding and drying of material substantially in the upper interior chamber of the upper enclosure, exhausting of air from the upper interior chamber of the upper enclosure through the upper end thereof, downward travel of ground material through the lower interior chamber of the lower enclosure and downward discharge of the ground material from the lower interior chamber through the open lower end of the lower enclosure, the lower interior chamber of the lower enclosure having an inverted conical shape which augments the circular vortex flow of air and material in the upper and lower interior chambers of the upper and lower enclosures. The apparatus also comprises a support structure supporting the upper and lower enclosures in an upright orientation with the upper enclosure above the lower enclosure such that the upper and lower enclosures and their upper and lower interior chambers are in a tandem orientation with one another.

[0010] More particularly, the hole through the upper annular sidewall of the upper enclosure is a slot having a height oriented so as to extend between and in a generally transverse relationship to the upper and lower ends of the upper enclosure and a length oriented so as to extend between and at an acute angle relative to the exterior and interior sides of the upper enclosure. The upper enclosure further includes means disposed along the exterior side thereof for adjusting the width of the vertical slot. The slot width adjusting means includes a plate and a releasable fastening arrangement mounting the plate to the upper annular sidewall at the exterior side of the upper enclosure adjacent to the hole for undergoing slidable movement in relation to the upper annular sidewall and the hole therethrough for varying the effective width of the hole through which the flow of air can pass. The upper enclosure further includes a deflection plate mounted to the upper annular sidewall at the interior side of the upper enclosure adjacent to the hole through the upper annular sidewall and defining an angular configuration relative to the upper annular sidewall for deflecting air away from the hole so as to not disrupt the air flowing from the hole into the upper interior chamber of the upper enclosure. The means for supplying air includes a manifold mounted to the upper annular sidewall of the upper enclosure on the exterior side thereof and defining an air collection cavity enclosing and disposed in flow communication with the hole through the upper annular sidewall of the upper enclosure. The manifold has an air supply inlet. At least one tube extends from an external source of compressed air and is connected to and in flow communication with the air supply inlet of the manifold such that air in the compressed state passes through the tube, through the air supply inlet of the manifold, into and through the air collection cavity of the manifold, through the hole of the upper enclosure and into the upper interior chamber of the upper enclosure.

[0011] The means for exhausting air from the upper interior chamber of the upper enclosure includes an exhaust pipe having an open upper end and an open lower end and being mounted to and disposed through the upper end of the upper enclosure such that the open upper end of the exhaust pipe is disposed externally of and above the upper enclosure and the open lower end of the exhaust pipe is disposed within and in flow communication with the upper interior chamber of the upper enclosure. The open lower end of the exhaust pipe is located closer to the open lower end of the upper enclosure than to the upper end thereof. The exhaust pipe also has an upper side opening disposed externally of and above the upper enclosure and a lower side opening disposed within and in flow communication with the upper interior chamber of the upper enclosure. The means for delivering material to be ground into the upper interior chamber of the upper enclosure includes a feed tube having an open upper end and an open lower end and being mounted to and disposed through the upper and lower sides openings of the exhaust pipe such that the open upper end of the feed tube is disposed externally of the upper enclosure and adjacent to a side of the exhaust pipe and the open lower end of the feed tube is disposed internally of the upper enclosure and adjacent to an opposite side of the exhaust pipe and within and in flow communication with the upper interior chamber of the upper enclosure such that material to be ground can be fed via the feed tube across the exhaust pipe from exteriorly of the upper enclosure into the circular vortex flow of air in the upper interior chamber of the upper enclosure.

[0012] The material grinding method comprises the steps of: (a) providing an upper enclosure with at least one hole of a predetermined size formed therethrough between exterior and interior sides thereof and oriented so as to extend between and at an acute angle relative to the exterior and interior side so as to provide flow communication between the exterior side thereof and an upper interior chamber thereof; (b) providing a lower enclosure below and in tandem with the upper enclosure and having an inverted conical configuration such that an lower interior chamber of the lower enclosure is substantially continuous and in flow communication with the upper interior chamber of the upper enclosure; (c) delivering material to be ground into the upper interior chamber of the upper enclosure through an upper end thereof; (d) supplying a flow of air, such as in a compressed state, through the hole in the upper enclosure into the upper interior chamber thereof to along a flow path extending about the interior side of the upper enclosure; and (e) exhausting air from the upper interior chamber of the upper enclosure through the upper end thereof such that the supplying of air and the exhausting of air coact with the hole in the upper enclosure and with the upper and interior chambers to create a circular vortex flow of air within the upper and lower interior chambers of the upper

and lower enclosures that causes grinding and drying of material substantially in the upper interior chamber of the upper enclosure, downward travel of ground material through the lower interior chamber of the lower enclosure and downward discharge of the ground material from the lower interior chamber of the lower enclosure through an open lower end thereof, the lower interior chamber of the lower enclosure being provided with an inverted conical shape which augments the circular vortex flow of air and material in the upper and lower interior chambers of the upper and lower enclosures.

[0013] These and other features and advantages of the present invention will become apparent to those skilled in the art upon a reading of the following detailed description when taken in conjunction with the drawings wherein there is shown and described an illustrative embodiment of the invention.

Brief Description of the Drawings

[0014] In the following detailed description, reference will be made to the attached drawings in which:

FIG. 1 is a perspective view of a material grinding apparatus of the present invention.

FIG. 2 is a vertical sectional view of the grinding apparatus with arrows indicating the flow of air.

FIG. 3 is a horizontal sectional view of the grinding apparatus taken along line 3--3 of FIG. 2 with arrows indicating the flow of air.

FIG. 4 is an enlarged detailed view of a manifold and an air tube of an air supplying means of the grinding apparatus enclosed by circle 4 of FIG. 3 with arrows indicating the flow of air.

FIG. 5 is a side elevational view of an air hole width adjusting means as seen along line 5--5 of FIG. 4 with a front cover of the manifold of the air supplying means removed.

Best Mode for Carrying Out the Invention

[0015] Referring to the drawings, and particularly to FIGS. 1 to 3, there is illustrated a material grinding apparatus, generally designated 10, of the present invention. The grinding apparatus 10 basically includes an upper enclosure 12, a lower enclosure 14, an air supplying means 16, an air exhausting means 18 and a material delivering means 20. The grinding apparatus 10 also includes a support structure 22 supporting the upper and lower enclosures 12, 14 in an upright tandem orientation.

[0016] Referring to FIGS. 1 to 5, the upper enclosure 12 includes a continuous upper annular sidewall 24 and has opposite exterior and interior sides 12A, 12B, an open lower end 12C and a closed upper end 12D. Its closed upper end 12D is provided preferably in the form of a top cover 26 removably mounted on and overlying the upper annular sidewall 24. The upper annular side wall 24 has a main annular wall portion 24A of substantially cylindrical configuration and upper and lower annular lip portions 24B, 24C being substantially identical to one another. The upper and lower annular lip portions 24B, 24C are rigidly fixed to upper and lower opposite open ends of the main annular wall portion 24A and extending substantially perpendicularly and outwardly therefrom. The top cover 26 has a substantially rigid flat disc-like configuration and is supported at its peripheral edge portion 26A upon the upper annular lip portion 24B of the upper annular sidewall 24 so as to overlie and close the open upper end of the main annular wall portion 24A of the upper annular sidewall 24 and thus the upper end 12D of the upper enclosure 12. The top cover 26 has defined therethrough a central opening 28 of a substantially circular configuration.

[0017] Referring now to FIGS. 1 to 3, the lower enclosure 14 in the form of a continuous lower annular sidewall 30. The lower annular sidewall 30 has a substantially inverted truncated conical configuration and opposite open upper and lower ends 30A, 30B. The open upper end 30A of the lower annular sidewall 30 has a diameter which is substantially greater than the diameter of the open lower end 30B thereof and substantially the same as the diameter of the upper annular sidewall 24 at the lower end 12C of the upper enclosure 12. The lower annular sidewall 30 has an upper annular lip 32 which is rigidly fixed to the open upper end 30A of the lower annular sidewall 30 and extends substantially perpendicularly and outwardly therefrom. The lower annular sidewall 30 at the upper annular lip 32 thereof is mounted to the lower annular lip portion 24C of the upper annular sidewall 24 such that the upper annular sidewall 24 of the upper enclosure 12 and the lower annular side wall 30 of the lower enclosure 14 are substantially continuous with one another.

[0018] The upper enclosure 12 at the interior side 12B thereof defines an upper interior chamber 34 within the upper annular sidewall 24, below the top cover 24 and above the open lower end 12C of the upper enclosure 12. The lower enclosure 14 defines a lower interior chamber 36 within the lower annular sidewall 30 and between the open upper and lower ends 30A, 30B thereof. The lower interior chamber 36 of the lower enclosure 14 is disposed substantially continuous from and in flow communication with the upper interior chamber 34 of the upper enclosure 12. The upper annular sidewall 24 and the top cover 26 of the upper enclosure 12 and the lower annular sidewall 30 of the lower enclosure 14 are made of the same heavy metal material to ensure a relatively long wear life for the upper and lower enclosures 12, 14.

[0019] The upper annular sidewall 24 and top cover 26 of the upper enclosure 12 at their respective upper annular lip portion 24B and peripheral edge portion 26A are sealably secured together by an upper annular seal 38 clamped therebetween and a plurality of fasteners extending between and interconnecting the upper annular lip portion 24B and the peripheral edge portion 26A at locations circumferentially spaced apart about the up-

per enclosure 12. The upper annular sidewall 24 and lower annular sidewall 30 at their respective lower annular lip portion 24C and upper annular lip portion 32 are sealably secured together by a lower annular seal 40 clamped therebetween and a plurality of fasteners extending between and interconnecting the lower annular lip portion 24C and upper annular lip portion 32 at locations spaced apart circumferentially about the upper and lower enclosures 12, 14. The upper and lower annular seals 38, 40 are substantially identical to one another and have substantially circular configurations. They provide respective air-tight seals between the upper annular sidewall 24 and top cover 26 of the upper enclosure 12 and the upper and lower annular sidewalls 24, 30 of the upper and lower enclosures 12, 14. Each fastener can be of any conventional form per se, such as a bolt 42 as seen in FIG. 1, or, alternatively, an overcenter toggle clamp 44 as seen in FIGS. 2 and 3. The overcenter toggle clamps 44 function in a manner that is well-known to releasably clamp and lock the upper annular sidewall 24 and top cover 26 together and the upper and lower annular sidewalls 24, 30 together. Each overcenter toggle clamp 44 includes a lever 46 pivotally mounted at one end 46A to an outer end 48A of a bracket 48 fixedly attached on respective ones of the peripheral edge portion 26A of the top cover and upper annular lip portion 32 of the lower annular sidewall 30, a bolt 50 pivotally mounted at one end to the lever 46 between the opposite ends 46A, 46B thereof and having a nut 52 applied on the other end of the bolt 50. When the lever 46 is pivoted to an overcenter locked vertical position, as seen in solid line form in FIG. 2, the bolt 50 extends through a notch in another bracket 54 attached to and projecting outwardly from respective ones of the upper and lower lip portions 24B, 24C of the upper annular sidewall 24 and the nut 52 on the bolt 50 is disposed on an opposite side of the bracket 54 from the lever 46. When the lever 46 is pivoted outwardly from the overcenter locked position to a released position, as seen in dashed line form in FIG. 2, the bolt and its nut (not shown) are released from engagement with the bracket 54.

[0020] Referring again to FIGS. 1 to 5, the upper enclosure 12 has at least one and, preferably, a plurality of air holes 56, such as three in number, formed through the main annular wall portion 24A of the upper annular side wall 24 of the upper enclosure 12 and open at each of the exterior and interior sides 12A, 12B thereof. The number of air holes 56 is determined by the desired diameter of the upper enclosure 12. The air holes 56 can be substantially identical to one another, although they need not be so. The air holes 56 are circumferentially spaced apart, such as through equal distances, from one another. Each air hole 56 preferably is in the form of a vertical slot having a vertical height H (FIG. 2) oriented so as to extend between and in a generally transverse relationship to the upper and lower ends 12D, 12C of the upper enclosure 12 and a length L (FIG. 3) oriented so as to extend between and at an acute angle relative to the exterior and interior sides 12A, 12B of the upper enclosure 12. The height H of each hole 56 is substantially greater than the length L and a width W thereof. The formation of each air hole 56 so as to extend at the acute angle through the upper annular sidewall 24 creates a substantially tangential circular flow pattern in the upper interior chamber 34 of the upper enclosure 12, as depicted by the arrows A in FIGS 1 and 3.

[0021] The upper enclosure 12 also includes a plurality of means 58 for adjusting the effective width W of each air holes 56. The width adjusting means 58 includes a pair of plates 60, 62 and a plurality of fasteners 64, such as bolts. More particularly, there is one adjustable plate 60, one stationary plate 62 and four fasteners 64 for each air hole 56, as shown in FIGS. 4 and 5. The adjustable and stationary plates 60, 62 have the same size. The stationary plate 62 is fixedly mounted to the upper annular sidewall 24 of the upper enclosure 12 at the exterior side 12A thereof on one side of the adjacent air hole 56. The adjustable plate 60 is slidably mounted to the upper annular sidewall 24 on an opposite side of the adjacent air hole 56 and, upon loosening of two of bolts 64, can undergo slidable movement toward and away from the stationary plate 62 relative to the upper annular sidewall 24 and the hole 56 therethrough to vary the effective width W of the adjacent air hole 56. The movement of the adjustable plate 60 in the opposite directions causes the orifice or spacing between the adjustable and stationary plates 60, 62 aligned with the hole 56 to correspondingly increase or decrease in size and thereby expose more or less of the adjacent air hole 56 so as to vary the effective width of the air hole 56 between facing edges 60A, 62A of the plates 60, 62 which are angled in a direction consistent with the angle of the adjacent air hole 56. The adjustable plate 60 has a pair of spaced apart slots 66 formed therethrough which are identical and parallel to one another. The two fasteners 64 are received through the slots 66 and threadable into the upper annular sidewall 24. The two fasteners 64 may be tightened or loosened in relation to the adjustable plate 60 and the upper annular sidewall 24 for holding the plate 60 in place or for allowing the plate 60 to be moved along the lengths of the slots 66 through the desired amount before retightening of the fasteners 64.

[0022] The air supplying means 16 of the apparatus 10 delivers air, preferably in a compressed state, through each of the air holes 56 in the upper annular sidewall 24 and into the upper interior chamber 34 of the upper enclosure 12. The air supplying means 16 includes at least one and, preferably, a plurality of manifolds 68 and at least one and, preferably, a plurality of air tubes 70. One manifold 68 and one air tube 70 are used in conjunction with each of the air hole 56 of the upper enclosure 12. Where there are three holes 56, there will be three manifolds 68. Each manifold 68 is attached to the upper annular sidewall 24 of the upper enclosure 12 on the exterior side 12A thereof. The manifolds 68 are preferably spaced apart from one another through equal distances along

the upper annular sidewall 24 of the upper enclosure 12. Each manifold 68 has a pair of opposite side walls 72, a top wall 74, a bottom wall 76, an annular seal 78, a front cover 80 and a plurality of fasteners 82, such as bolts. The side walls 72 are substantially identical to and mirror images of one another, having substantially slanted L-shaped transverse configurations. The top and bottom walls 74, 76 are substantially identical to and mirror images of one another and extend between and rigidly interconnected opposite upper and lower edges of the side walls 72. The annular seal 78 and front cover 80 have substantially rectangular configurations. The annular seal 78 is disposed and provides an air-tight seal between the periphery of the front cover 80 and adjoining edge portions of the side walls 72, top wall 74 and bottom wall 76. The front cover 80 has a plurality of spaced apart holes at the corners thereof, such as six in number, that receive the fasteners 82 which, in turn, are removably threaded into a plurality of corresponding holes 84 in the manifold 68. The front cover 80 is thereby removable for providing access to the width adjusting means 58 of the upper enclosure 12.

[0023] Each manifold 68 defines an air collection cavity 86 therein and an air supply inlet 88. The air collection cavity 86 is disposed between the upper annular sidewall 24 and the side walls 72, top wall 74, bottom wall 76 and front cover 80. The air collection cavity 86 thus encloses, overlies and is disposed in flow communication with the one adjacent air hole 56 of the upper enclosure 12. The air supply inlet 88 of the manifold 68 is circular in shape and formed through one of the side walls 72. The air supply inlet 88 also is in flow communication with the air collection cavity 86. Each air tube 70 of the air supplying means 16 has a cylindrical shape. There are three air tubes 70 matching the number of manifolds 68. Each air tube 70 extends from an external source of compressed air (not shown), such as a conventional air compressor, and is connected to and in flow communication with the air supply inlet 88 of one of the manifolds 68 such that air in a compressed state may pass through the air tube 70, through the air supply inlet 88 of the respective one manifold 68, into and through the air collection cavity 86 of the one manifold 68, through the adjacent air hole 56 of the upper enclosure 12 and into the upper interior chamber 34 of the upper enclosure 12, as shown in Fig. 4.

[0024] The upper enclosure 12 also includes at least one and, preferably, a plurality of deflection plates 90. Each deflection plate 90 has a substantially angular configuration and is mounted to the upper annular sidewall 24 of the upper enclosure 12 at the interior side 12B thereof and adjacent to a respective one of the air holes 56 of the upper enclosure 12. Each deflection plate 90 functions to slightly deflect the flow of air circulating within the upper interior chamber away from the air hole 56 as it passes the air hole 56 so as to not disrupt the incoming air flow from the hole 56 into the upper interior chamber 34 of the upper enclosure 12. The angular configuration of the deflection plate 90 provides a gap between it and the upper annular sidewall 24 to allow the maximum amount of air to flow unrestricted into the upper interior chamber 34.

[0025] Referring to FIGS. 1 to 3, the air exhausting means 18 of the apparatus 10 is provided for exhausting air from the flow thereof circulating in the upper interior chamber 34 of the upper enclosure 12. The air exhausting means 18 includes an exhaust pipe 92. The exhaust pipe 92 has a cylindrical configuration and opposite open upper and lower end 92A, 92B. The exhaust pipe 92 also has upper and lower side openings 94, 96 of substantially circular configurations disposed on opposite sides of the exhaust pipe 92. The cross-sectional size of the exhaust pipe 92 is generally determined by the combined sizes of the upper and lower interior chambers 34, 36 of the respective upper and lower enclosures 12, 14. The exhaust pipe 92 snugly fits through and is mounted to and disposed through the central opening 28 of the top cover 26 of the upper enclosure 12 such that the open upper end 92A and the upper side opening 94 of the exhaust pipe 92 are disposed externally above the upper enclosure 12 and the open lower end 92B and the lower side opening 96 of the exhaust pipe 98 are disposed within and in flow communication with the upper interior chamber 34 of the upper enclosure 12. Thus, air in the upper interior chamber 34 of the upper enclosure 12 can be exhausted into and upwardly through the exhaust pipe 92 in the direction indicated by arrows B in FIG. 2. The open lower end 92B of the exhaust pipe 92 is disposed closer to the open lower end 12B than to the closed upper end 12A of the upper enclosure 12. The open upper end 92A of the exhaust pipe 92 is disposed from the top cover 26 of the upper enclosure 12 at a distance substantially greater than the distance the open lower end 92B of the exhaust pipe 92 is disposed from the top cover 26.

[0026] The upper enclosure 12 also includes a top annular seal 98, a top annular seal cover 100 and fasteners 102. The top annular seal 98 and top annular seal cover 100 both have a substantially circular configuration. The top annular seal 98 is disposed on top of the top cover 26 around the central opening 28 therethrough, the top annular seal cover 100 is disposed on and overlies the top annular seal 100 and the fasteners 102 secure both to the top cover 26 about the central opening 28. The top annular seal 98 of the upper enclosure 12 provides an air-tight seal between the exhaust pipe 92 and the top cover 26 of the upper enclosure 12.

[0027] The apparatus 10 also includes a damper 104 mounted on the open upper end 92A of the exhaust pipe 92 and an actuator 106. The damper 104 has two half portions 104A, 104B substantially identical to and mirror images of one another. The actuator 106 interconnects the half portions 104A, 104B and is operable for moving them toward or away from one another so as to decrease or increase the size of a central space 108 therebetween. The damper 104 has an actuator 116 for causing movement of the half portions 104A, 104B. The actuator 106, which can be hydraulic or electric, is manually operated

remotely. The damper 104 is thereby mounted upon the exhaust pipe 92 at the upper end 92A thereof and operable for regulating the flow of air from the upper and lower interior chambers 34, 36 of the respective upper and lower enclosures 12, 20 through the exhaust pipe 98 of the air exhausting means 16 and thereby for regulating the size to which the material is ground in the upper and lower chambers 34, 36 of the upper and lower enclosures 12, 14, as shown diagrammatically in FIG. 1. The damper 104 can be adjusted to permit lighter material to be retained longer in the upper and lower interior chambers 34, 36 of the upper and lower enclosures 12, 14 for more complete grinding of the material.

[0028] Referring to FIGS. 1 and 2, the material delivering means 20 of the apparatus 10 is for delivering material to be ground to the upper interior chamber 34 of the upper enclosure 12. The material delivering means 20 includes a feed tube 110 of a substantially cylindrical configuration. The feed tube 110 has opposite open upper and lower ends 110A, 110B. The upper end 110A of the feed tube 110 can be in the form of a hopper or the like for receiving the material to be ground feed thereto by any suitable means, such as manually, by vacuum or the discharge end of a material elevator or auger. The feed tube 110 is mounted to the exhaust tube 92 and disposed through the upper and lower side openings 94, 96 of the exhaust pipe 92 such that the open upper end 110A of the feed tube 110 is disposed externally to the upper enclosure 12 and the exhaust pipe 92 whereas the open lower end 110B of the feed tube 110 is disposed in and in flow communication with the upper interior chamber 34 of the upper enclosure 12 such that material to be ground can be fed via the feed tube 110 across the exhaust pipe 92 from exteriorly of the upper enclosure 12 into the circular vortex flow of air in the upper interior chamber 34 of the upper enclosure 12. The feed tube 110 is disposed at an acute angle relative to the top cover 26 of the upper enclosure 12. The material to be ground is fed into the feed tube 110 after the compressed air is delivered into the upper interior chamber 34 of the upper enclosure 12 via the angled air holes 56. Alternatively, instead of through the exhaust pipe 92, the feed tube 110 can be inserted through the top cover 26 adjacent to the peripheral edge portion 26A thereof, such as at the location 112 shown in dashed outline in FIG. 1.

[0029] The support structure 22 of the apparatus 10, which supports the upper and lower enclosures 12, 14 in the upright tandem orientation as seen in FIGS. 1 and 2, includes a plurality of mounting braces 114, a support platform 116, a plurality of elongated leg members 118 and support actuators 120. The mounting braces 114 have substantially triangular shapes and are circumferentially spaced apart from one another. The mounting braces 114 are fixedly mounted in vertical orientations to upper annular sidewall 24 of the upper enclosure 12 at the exterior side 12A thereof and extend radially outwardly therefrom so as to overlie the support platform 116. The support platform 116 has a generally flat configuration and a central opening 116A. The attached upper and lower enclosures 12, 14 are received through the central opening 116A of the support platform 116 and the mounting braces 114 by resting upon the support platform 116 about its central opening 116A thereby support and retain the attached upper and lower enclosures 12, 14 in the upright tandem orientation. The leg members 118 having top and bottom ends 118A, 118B and are rigidly connected at their upper ends 118A to the support platform 116 at the respective corners 116B thereof so as to dispose the platform in a horizontal orientation and at a desired height above a support surface, such as the ground. Pairs of the leg members 118 at their bottom ends 118B may be interconnected by horizontal brace members 122 and rest on the support surface. Each of the support actuators 120 can be any suitable conventional type, such as ones manually, mechanically, pneumatically or hydraulically operated. Each actuator 120 is mounted to the top cover 26 of the upper enclosure 12 and extends upright therefrom and is connected at corners of a bracket arrangement 124 surrounding and extending outwardly from the exhaust pipe 92. The actuators 120 can be actuated so as to selectively raise and lower the exhaust pipe 92, via the bracket arrangement 124, relative to the top cover 26 to different positions relative to the upper enclosure 12 and thus to extend to different depths within the upper interior chamber 34 of the upper enclosure 12.

[0030] The upper interior chamber 34 of the upper enclosure 12 receives from a suitable external source, via the feed tube 110, diverse materials to be ground, such as glass, grain, paper, plastic, aluminum, granite and the like. The upper interior chamber 34 also receives, via the angled air holes 56 in the upper annular sidewall 24, the flow of air in compressed state that interacts with the material as the latter is received in the upper interior chamber 34 of the upper enclosure 12. The angle of each of the air holes 30 is selected to cause the compressed air to flow at high velocity in one of a clockwise or counterclockwise direction in the upper interior chamber 34 such that the compressed air, by its high velocity, causes forceful impacts on the material which result in the reduction and grinding of the material into small sizes within the upper interior chamber 34. The lower interior chamber 36 of the lower enclosure 14 which is continuous and in flow communication with the upper interior chamber 34 of the upper enclosure 12 has a substantially inverted conical configuration that augments the creation and maintenance of the circular vortex flow of air within the upper and lower interior chambers 34, 36 of the upper and lower enclosures 12, 20 that facilitates the grinding of the material therein. The material ground in the upper interior chamber 34 falls or descends into the lower interior chamber 36 and downward therethrough along the lower annular sidewall 30 of the lower enclosures 14 toward and out the open lower end 30B thereof, as shown in FIG. 2. The circular vortex flow creates a vacuum in the center of each of the upper and lower interior cham-

bers 34, 36 of the upper and lower enclosures 12, 14 which allows the ground material to fall downward through the lower interior chamber 36 and out the lower end 30B of the lower annular sidewall 30 of the lower enclosure 14 while excess air flows from the upper and lower interior chambers 34, 36 upward through the exhaust pipe 92. A vacuum condition is also present in the feed tube 110 which tends to draw the material to be processed into the upper interior chamber 34 of the upper enclosures 12. Concurrently, with the grinding of the material by the apparatus 10 it is also dried therein. The sizes of the upper and lower enclosures 12, 14 as well as the other components of the apparatus 10 can vary depending upon the type of material to be ground and the capacity needed. The apparatus 10 illustrated in the drawings is but one exemplary embodiment.

[0031] The compressed air introduced into the upper interior chamber 34 of the upper enclosure 12 may have a preselected pressure that falls within a wide range of from about 1.5 mPa to about 90 mPa (about 10 to about 600 pounds per square inch (psi)). The compressed air may have a velocity that falls within a wide range of from about 0.1 to about 320 m^3/min (about 5 to about 12,00 cubic feet per minute (cfm)). The compressed air also may have a temperature which may be varied. The temperature of the compressed air may be raised, such as by use of a heat exchanger unit (not shown) or the like, to enhance the grinding and drying of the material. The temperature of the air may fall within a wide range of about 4°C (40°F) to about 500°C (900°F). Steam can also be used to heat the compressed air. The steam may be at a temperature falling within a wide range of about 100°C (212°F) to 1100° (2000°F). This will greatly enhance the drying process as well as increase the shearing force of the compressed air. Steam may also be used to operate the apparatus 10 at a specific pressure, temperature and cubic metre (cubic feet) per minute.

[0032] It is also possible to use cooled air, such as air which has been cooled to below freezing temperatures, to retain certain elements in the finished product. For example, liquid nitrogen, carbon dioxide, cooling vortex tubes, refrigeration equipment and/or underground or surface water could be used to cool the air. Also a suitable flow of air can be delivered at the velocity, pressure and temperature required, by other known techniques than compression of the air, to operate the apparatus 10. The variation of the air in terms of its velocity, pressure and temperature depends on the type of material being processed and size of the apparatus 10.

[0033] The exact mechanism that causes the grinding and reduction of the material within the apparatus 10 is not known. Several different theories of its operation are that the grinding results from the pieces of material forcefully colliding with each other or the centrifugal force of the vortex moving the material forcefully against the upper and lower annular sidewalls 24, 30 of the upper and lower enclosures 12, 14 or the difference of pressure and vacuum causing the material to loose unity or integrity or to implode. It has been noted that when the apparatus 10 is in operation, the center of the vortex has dead air (low pressure) space from the lower end 92B of the exhaust pipe 92 to the exit or lower end 30B of the lower annular sidewall 30 of the lower enclosure 14. Another dead air (low pressure) space is found along the interior of the sidewall 30 of the lower enclosure 14 allowing the processed material to drop down to the bottom of the lower interior chamber 36 and exit the lower enclosure 14. A vacuum is formed between the dead air in the center of the apparatus 10 and the dead air space along the perimeter of the lower enclosure 14.

Industrial Applicability

[0034] The apparatus 10 is designed to efficiently and easily grind, dry and dehydrate diverse materials. As described in more detail below, the apparatus 10 has many practical applications which include, but are not limited to, the grinding, drying and pasteurization of animal or agricultural products, the grinding of industrial waste cleanup, the recycling of consumer waste, desalination of salt water, the grinding of fuels for more efficient burning, and the grinding of medical products for more efficient delivery. The drying, dehydrating and grinding characteristics of the apparatus 10 appears to be a cost-effective supplement or replacement of conventional spray drying operations. The apparatus 10 also appears capable of being downsized to provide small grinders and dryers for use in a household with consumer products.

[0035] Pasteurization. The temperature of the air at 66°C (150°F) or higher and the pulverizing effect of the colliding particles combine to produce a uniquely efficient pasteurization process. Liquid egg, a byproduct of the hatchery and egg breaking industry, can be reduced to a powder, even though the solid content of the liquid egg is only about 18% to 20%. The powder seems to have a pleasant odor and good shelf life. The moisture content of the powder averages from 1% to 4%.

[0036] Agricultural Products. All types of grains can be ground into flour and dried in the same operation. The mill wastes from the grain can then be ground into a fine powder, making more of the nutrients available so it can then be utilized in feed products. Water plants, such as algae, seaweed, duckweed and other plant life, can be dried and ground at low temperatures thereby preserving their nutritional value. Herbs can be ground into a fine powder potentially increasing their potency.

[0037] Animal Product. Many shellfish and marine life products, such as crab, lobster, shrimp, oyster, etc., can be ground and dried to better utilize the byproducts of processing plants. The shells, a byproduct of processing, can be dried and ground into a fine powder that makes extraction of products such as chitin more feasible. Most of the shellfish shells can be ground to the micron size desired enhancing the interaction with different elements.

[0038] Various animal wastes as well as byproducts

from animal processing plants can be ground and dried. Animal wastes, such as hen manure from commercial layer houses, can be dried and ground to produce a fertilizer-grade product. D.A.F., a waste product from animal processing plants, can be dried and ground. This material has good protein content and can be used in animal feeds. D.A.F. contains a high bacteria content, but through the use of the apparatus 10, the bacteria reproduction in some cases was reduced or eliminated. Poultry products such as eggshells from hatcheries and egg breaking plants can be ground and dried. Eggshell can be better utilized by grinding the shell into a fine powder. The membranes from the inside of the shell having a high content of collagen will remain in large particles. These can then be easily removed from the calcium with the use of a screen. Both membrane and calcium can be dried and ground to the desired size.

[0039] Industrial Waste Cleanup. The apparatus 10 can be used to grind high fracture materials such as coal, concrete, aluminum, glass, wood, paper, hard plastics, rock, limestone, mineral ores, etc. Its grinding-drying motion and dehydrating can be used on contaminated soils as well as industrial and hazardous wastes. Pollution prevention and waste reduction goals of EPA regulations can be addressed by this apparatus.

[0040] Moreover, certain materials may be rendered more valuable, effectuated by the reduction of volume. For example, filter cakes are mostly water. If the water is removed, the remaining materials, chromium, nickel, tin, iron, etc., effectively become more concentrated and thus have value. The process of extracting and recycling them, then, may become more economically feasible.

[0041] Further, the possibility for element extraction exists, even with the simultaneous application of this technology. Element extraction is based on specific atomic gravity of each element found in its own strata in the vortex after the initial grinding has taken place. Extraction should be relatively simple once the elements are located.

[0042] Industrial byproducts can be reduced in volume and moisture content, reducing freight costs and storage requirements. Sewage waste and sludge can be dried, reducing the volume. The technology's characteristics of heated air and vortex air velocity will likely prove to be very effective in remediating hydrocarbon contaminated soils (halogenated and non-halogenated), especially those that are regulated via the Resource Recovery Act (RCRA). Through an accelerated volatilization of the hydrocarbons they may be recovered in another stage, condensed into pure products and sold as such. The remediated soil may then be back-filled.

[0043] Consumer Waste Recycling. Many consumer products can be separated into their components, ground and dried, and then recycled. Glass can be processed into a fine powder or silica. Glass products having labeling on them can be processed without removing the labels. The paper or labels will remain in larger pieces and can be easily removed from the silica with the use of a screen. Other products, for example baby diapers, can be separated and dried, enabling the recycling of the components that can be recycled, and reducing the volume of the wastes that must be deposited in landfills.

[0044] Freshwater Creation. The apparatus 10 has the potential to desalinate seawater. Ionization is possible for use of separation and processing of materials.

[0045] Cleaner Burning Fuels. The apparatus 10 may have the ability to grind fuels such as coal into micro particles that may be burned more efficiently, with reduced pollution.

[0046] Medical and Pharmaceuticals. The ability to grind particles to microscopic sizes may have the ability to render drugs, vitamins and minerals more available to humans and animals.

[0047] It is thought that the present invention and its advantages will be understood from the foregoing description and it will be apparent that various changes may be made thereto without departing from the scope of the invention or sacrificing all of its material advantages, the form hereinbefore described being merely preferred or exemplary embodiment thereof.

Claims

1. A material grinding apparatus, comprising:

an upper enclosure (12) including an upper annular sidewall (24) and having an upper end (12D), an open lower end (12C) and opposite exterior and interior sides (12A, 12B), said upper annular sidewall (24) defining an upper interior chamber (34) at said interior side of said upper enclosure (12) and having at least one hole (56) of a predetermined size formed through said upper annular sidewall (24) between said exterior and interior sides (12A, 12B) of said upper enclosure (12) so as to provide flow communication between said exterior side of said upper enclosure (12) and said upper interior chamber (34) thereof;

a lower enclosure (14) disposed below and in a tandem arrangement with said upper enclosure (12), said lower enclosure (14) including a lower annular sidewall (30) having a substantially inverted conical configuration and open upper and lower ends (30A, 30B) and defining a lower interior chamber (36), said lower annular sidewall (30) of said lower enclosure (14) being mounted at said open upper end (30A) thereof to said upper annular sidewall (24) at said open lower end (30B) of said upper enclosure (12) such that said lower annular sidewall (30) and said lower interior chamber (36) are substantially continuous and in flow communication with said upper annular sidewall (24) and upper interior chamber (34);

means (20) for delivering material to be ground into said upper interior chamber (34) of said upper enclosure (12) through said upper end (12D) thereof;
means (16) for supplying a flow of air through said hole (56) in said upper annular sidewall (24) into said upper interior chamber (34) to along a flow path extending about said interior side of said upper enclosure (12); and
means (18) for exhausting air from said upper interior chamber (34) of said upper enclosure (12) through said upper end (12D) thereof such that said means (16) for supplying air and said means (18) for exhausting air coact with said hole (56) in said upper annular sidewall (24) and with said upper and lower interior chambers (34, 36) to create a circular vortex flow of air within said upper and lower interior chambers (34, 36) that causes grinding and drying of material substantially in said upper interior chamber (34), upward discharge of air from said upper interior chamber (34) through said upper end thereof, downward travel of ground material through said lower interior chamber (36) and downward discharge of the ground material from said lower interior chamber (36) through said open lower end (30B) of said lower enclosure (14), said lower interior chamber (36) having an inverted conical shape which augments said circular vortex flow of air and material in said upper and lower interior chambers (34, 36),

characterized by at least one deflection plate (90) mounted to said upper annular sidewall (24) at said interior side of said upper enclosure (12) adjacent to said hole (56) and defining an angular configuration relative to said upper annular sidewall (24) for defecting air away from said hole (56) so as to not disrupt the air flowing from said means (16) for supplying a flow of air through said hole (56) into said upper interior chamber (34).

2. The apparatus of claim 1, wherein said hole (56) through said upper annular sidewall (24) is a slot having
a height oriented so as to extend between and in a generally transverse relationship to said upper and lower ends of said upper enclosure (12), and/or a length oriented so as to extend between and at an acute angle relative to said exterior and interior sides (12A, 12B) of said upper enclosure (12).

3. The apparatus of any preceding claim, further comprising a support structure supporting said upper and lower enclosures (12, 14) in an upright orientation with said upper enclosure (12) above said lower enclosure (14) such that said upper and lower enclosures (12, 14) and said upper and lower interior chambers (34, 36) thereof are in a tandem orientation with one another.

4. The apparatus of any preceding claim, wherein said upper enclosure (12) further includes means (58) for adjusting said size of said hole (56) through said upper annular sidewall (24).

5. The apparatus of claim 4, wherein said means (58) for adjusting said size of said hole (56) includes a plate (60) and a releasable fastening arrangement (64) mounting said plate (60) to said upper annular sidewall (24) at said exterior side of said upper enclosure (12) adjacent to said hole (56) through said upper annular sidewall (24) for undergoing slidable movement in relation to said upper annular sidewall (24) and said hole (56) therethrough for varying the effective size of said hole (56) through which said flow of air can pass.

6. The apparatus of any preceding claim, wherein said means (16) for supplying air provides the air in a compressed state.

7. The apparatus of any preceding claim, wherein said means (16) for supplying air includes:

at least one manifold (68) mounted to said upper annular sidewall (24) of said upper enclosure (12) on said exterior side thereof and defining an air collection cavity (86) enclosing and disposed in flow communication with said hole (56) through said upper annular sidewall (24), said manifold (68) having an air supply inlet (88); and
at least one tube (70) extending from an external source of preferably compressed air and being connected to and in flow communication with said air supply inlet (88) of said manifold (68) such that the flow of air passes through said tube (70), through said air supply inlet (88) of said manifold (68), into and through said air collection cavity of said manifold (68), through said hole (56) of said upper enclosure (12) and into said upper interior chamber (34).

8. The apparatus of claim 7, wherein said means (18) for exhausting air from said upper interior chamber (34) includes an exhaust pipe (92) having an open upper end (92A) and an open lower end (92B) and being mounted to and disposed through said upper end (12D) of said upper enclosure (12) such that said open upper end (92A) of said exhaust pipe (92) is disposed externally of and above said upper enclosure (12) and said open lower end (92B) of said exhaust pipe (92) is disposed within and in flow communication with said upper interior chamber (34), said open lower end (92B) of said exhaust pipe (92) being located closer to said open lower end (12C)

of said upper enclosure (12) than to said upper end (12D) thereof.

9. The apparatus of claim 8, wherein said upper end (12D) of said upper enclosure (12) includes a top cover (26) having a substantially central opening (28).

10. The apparatus of claim 8 or 9, wherein:

said exhaust pipe (92) also has an upper side opening (94) disposed externally of and above said upper enclosure (12) and a lower side opening (96) disposed within and in flow communication with said upper interior chamber (34) of said upper enclosure (12); and
said means (20) for delivering material to be ground into said upper interior chamber (34) includes a feed tube (110) having an open upper end (110A) and an open lower end (110B) and being mounted to and disposed through said upper and lower sides openings (94, 96) of said exhaust pipe (92) such that said open upper end (110A) of said feed tube (110) is disposed externally of said upper enclosure (12) and adjacent to a side of said exhaust pipe (92) and said open lower end (110B) of said feed tube (110) is disposed internally of said upper enclosure (12) and adjacent to an opposite side of said exhaust pipe (92) and within and in flow communication with said upper interior chamber (34) such that material to be ground can be fed via said feed tube (110) across said exhaust pipe (92) from exteriorly of said upper enclosure (12) into said circular vortex flow of air in said upper interior chamber (34) of said upper enclosure (12).

11. The apparatus of claim 9 or 10, further comprising a damper (104) movably mounted to said exhaust pipe (92) and being adjustable to regulate the flow of air from said upper interior chamber (34) through said exhaust pipe (92) and thereby regulate the size to which the material is ground in said upper interior chamber (34).

12. A material grinding method, comprising the steps of:

providing an upper enclosure (12) with an interior side and an exterior side, said interior side defining an interior chamber, with at least one hole (56) of a predetermined size formed between the exterior and interior sides (12A, 12B) thereof and oriented so as to extend between and at an acute angle relative to the exterior and interior sides (12A, 12B) so as to provide flow communication between said exterior side and an upper interior chamber (34) thereof;
providing a lower enclosure (14) below and in a tandem arrangement with the upper enclosure (12) and having an inverted conical configuration such that a lower interior chamber (36) of the lower enclosure (14) is substantially continuous and in flow communication with the upper interior chamber (34) of the upper enclosure (12);
delivering material to be ground into the upper interior chamber (34) through an upper end (12D) of the upper enclosure (12);
supplying a flow of air through the hole (56) in the upper enclosure (12) into the upper interior chamber (34) thereof to along a flow path extending about the interior side of the upper enclosure (12);
deflecting the flow of air circulating within the upper enclosure (12) away from said hole (56) so that air circulating within the upper enclosure (12) does not disrupt air flowing from said hole (56) into said upper interior chamber (34), using at least one deflection plate (90) mounted to said interior side of said upper enclosure (12) adjacent to.said hole (56) and defining an angular configuration relative to said interior side of said upper enclosure (12); and
exhausting air from the upper interior chamber (34) of the upper enclosure (12) through the upper end (12D) thereof such that the supplying and the exhausting of air coact with the hole (56) in the upper enclosure (12) and the upper and lower interior chambers to create a circular vortex flow of air within the upper and lower interior chambers (34, 36) that causes grinding and drying of material substantially in the upper interior chamber (34), downward travel of ground material through the lower interior chamber (36) and downward discharge of the ground material from the lower interior chamber (36) of the lower enclosure (14) through an open lower end (30B) thereof, the lower interior chamber (36) being provided with an inverted conical shape which augments the circular vortex flow of air and material in the upper and lower interior chambers (34, 36).

13. The method of claim 12, wherein the air being supplied
is in a compressed state, and/or
is at a temperature within the range of about 4°C (40°F) to about 500°C (900°F), and/or
is at a pressure within the range of from about 1.5 mPa (10 psi) to about 90 mPa (600 psi), and/or
is at a velocity within the range of from about 0.1 m^3/min (5 cubic feet per minute) to about 320 m^3/min (12,000 cubic feet per minute), and/or
contains steam having a temperature within the range of from about 100°C (212°F) to about 1100°C

(2000°F).

14. The method of claim 12, further including the step of adjusting said size of said hole (56) of said upper enclosure (12).

Patentansprüche

1. Materialzerkleinerungsgerät mit:

einem oberen Gehäuse (12) mit einer oberen ringförmigen Seitenwand (24) und einem oberen Ende (12D), einem offenen unteren Ende (12C) und entgegengesetzten äußeren und inneren Seiten (12A, 12B), wobei die obere ringförmige Seitenwand (24) eine obere Innenkammer (34) an der Innenseite des oberen Gehäuses (12) eingrenzt und wenigstens ein Loch (56) vorbestimmter Größe aufweist, das durch die obere ringförmige Seitenwand (24) zwischen der äußeren und der inneren Seite (12A, 12B) des oberen Gehäuses (12) gebildet ist, um eine Strömungskommunikation zwischen der Außenseite des oberen Gehäuses (12) und dessen oberer Innenkammer (34) zu ermöglichen;
einem unteren Gehäuse (14), das unterhalb und in einer Tandemanordnung mit dem oberen Gehäuse (12) angeordnet ist, wobei das untere Gehäuse (14) eine untere ringförmige Seitenwand (30) mit im Wesentlichen umgekehrter konischer Konfiguration und offenen oberen und unteren Enden (30A, 30B) aufweist und eine untere Innenkammer (36) eingrenzt, wobei die untere ringförmige Seitenwand (30) des unteren Gehäuses (14) an deren offenem unteren Ende (30A) an der oberen ringförmigen Seitenwand (24) an dem offenen unteren Ende (30B) des oberen Gehäuses (12) befestigt ist, so dass die untere ringförmige Seitenwand (30) und die untere Innenkammer (36) im Wesentlichen kontinuierlich verlaufen und in Strömungskommunikation mit der oberen ringförmigen Seitenwand (24) und der oberen Innenkammer (34) stehen;
einer Einrichtung (20) zum Befördern von zu zerkleinerndem Material in die obere Innenkammer (34) des oberen Gehäuses (12) durch dessen oberes Ende (12D);
einer Einrichtung (16) zum Zuführen eines Luftstroms durch das Loch (56) in der oberen ringförmigen Seitenwand (24) in die obere Innenkammer (34) längs eines Strömungspfads, der an der Innenseite des oberen Gehäuses (12) verläuft; und
einer Einrichtung (18) zum Ausstoßen von Luft aus der oberen Innenkammer (34) des oberen Gehäuses (12) durch dessen oberes Ende (12D), so dass die Einrichtung (16) zum Zuführen von Luft und die Einrichtung (18) zum Ausstoßen von Luft mit dem Loch (56) in der oberen ringförmigen Seitenwand (24) und der oberen und der unteren Innenkammer (34, 36) zusammenwirken, um einen zirkulären Wirbelluftstrom innerhalb der oberen und der unteren Innenkammer (34, 36) zu erzeugen, der ein Zerkleinern und Trocknen von Material im Wesentlichen in der oberen Innenkammer (34), einen Auslass von Luft von der oberen Innenkammer (34) nach oben durch deren oberes Ende, eine Bewegung von zerkleinertem Material durch die untere Innenkammer (36) nach unten und einen Auslass des zerkleinerten Materials aus der unteren Innenkammer (36) durch das offene untere Ende (30B) des unteren Gehäuses (14) bewirkt, wobei die untere Innenkammer (36) eine umgekehrte konische Form aufweist, die den zirkulären Wirbelstrom von Luft und Material in der oberen und der unteren Innenkammer (34, 36) verstärkt,

gekennzeichnet durch wenigstens eine Ablenkplatte (90), die an der oberen ringförmigen Seitenwand (24) an der Innenseite des oberen Gehäuses (12) neben dem Loch (56) befestigt ist und eine ringförmige Konfiguration relativ zu der oberen ringförmigen Seitenwand (24) zum Ablenken von Luft weg von dem Loch (56) definiert, so dass die Luft von der Einrichtung (16) zum Zuführen eines Luftstroms **durch** das Loch (56) in die obere Innenkammer (34) nicht gestört wird.

2. Gerät nach Anspruch 1, wobei das Loch (56) durch die obere ringförmige Seitenwand (24) ein Schlitz ist, der
eine Höhe aufweist, die so orientiert ist, dass sie zwischen dem oberen und dem unteren Ende des oberen Gehäuses (12) und generell quer dazu verläuft, und/oder
eine Länge aufweist, die so orientiert ist, dass sie zwischen der äußeren und der inneren Seite (12A, 12B) des oberen Gehäuses (12) und in einem spitzen Winkel dazu verläuft.

3. Gerät nach einem der vorstehenden Ansprüche, ferner mit einer Stützstruktur zum Halten des oberen und des unteren Gehäuses (12, 14) in einer aufrechten Orientierung mit dem oberen Gehäuse (12) über dem unteren Gehäuse (14), so dass das obere und das untere Gehäuse (12, 14) und deren obere und untere Innenkammern (34, 36) eine Tandemorientierung zueinander aufweisen.

4. Gerät nach einem der vorstehenden Ansprüche, wobei das obere Gehäuse (12) ferner eine Einrichtung (58) zum Anpassen der Größe des Lochs (56) durch die obere ringförmige Seitenwand (24) aufweist.

5. Gerät nach Anspruch 4, wobei die Einrichtung (58) zum Anpassen der Größe des Lochs (56) eine Platte (60) und eine entriegelbare Befestigungsanordnung (64) aufweist, die die Platte (60) an der oberen ringförmigen Seitenwand (24) an der Außenseite des oberen Gehäuses (12) neben dem Loch (56) durch die obere ringförmige Seitenwand (24) befestigt, um eine Schiebebewegung bezüglich der oberen ringförmigen Seitenwand (24) und des Lochs (56) dadurch zu ermöglichen, so dass die effektive Größe des Lochs (56), durch das der Luftstrom hindurchtreten kann, variiert.

6. Gerät nach einem der vorstehenden Ansprüche, wobei die Einrichtung (16) zum Zuführen von Luft die Luft in komprimierter Form bereitstellt.

7. Gerät nach einem der vorstehenden Ansprüche, wobei die Einrichtung (16) zum Zuführen von Luft aufweist:

wenigstens eine Rohrverzweigung (68), die an der oberen ringförmigen Seitenwand (24) des oberen Gehäuses (12) an dessen Außenseite befestigt ist und einen Luftsammelhohlraum (86) eingrenzt, der das Loch (56) durch die obere ringförmige Seitenwand (24) aufweist und in Strömungskommunikation damit angeordnet ist, wobei die Rohrverzweigung (68) einen Luftzuführeinlass (88) aufweist; und
wenigstens ein Rohr (70), das von einer externen Quelle mit vorzugsweise komprimierter Luft ausgeht und mit dem Luftzuführeinlass (88) der Rohrverzweigung (68) in Strömungskommunikation verbunden ist, so dass die Luftströmung durch das Rohr (70), durch den Luftzuführeinlass (88) der Rohrverzweigung (68), in und durch den Luftsammelhohlraum der Rohrverzweigung (68), durch das Loch (56) des oberen Gehäuses (12) und in die obere Innenkammer (34) strömt.

8. Gerät nach Anspruch 7, wobei die Einrichtung (18) zum Ausstoßen von Luft aus der oberen Innenkammer (34) ein Ausstoßrohr (92) aufweist, das ein offenes oberes Ende (92A) und ein offenes unteres Ende (92B) hat und an dem oberen Ende (12D) des oberen Gehäuses (12) befestigt ist und durch dieses hindurchreicht, so dass das offene obere Ende (92A) des Ausstoßrohrs (92) außerhalb und oberhalb des oberen Gehäuses (12) angeordnet ist, und das offene untere Ende (92B) des Ausstoßrohrs (92) innerhalb und in Strömungskommunikation mit der oberen Innenkammer (34) angeordnet ist, wobei das offene untere Ende (92B) des Ausstoßrohrs (92) näher an dem offenen unteren Ende (12C) des oberen Gehäuses (12) als an dessen oberen Ende (12D) angeordnet ist.

9. Gerät nach Anspruch 8, wobei das obere Ende (12D) des oberen Gehäuses (12) eine Oberseitenabdekkung (26) mit einer im Wesentlichen zentrischen Öffnung (28) aufweist.

10. Gerät nach Anspruch 8 oder 9, wobei
das Ausstoßrohr (92) auch eine Oberseitenöffnung (94) aufweist, die außerhalb und oberhalb des oberen Gehäuses (12) angeordnet ist, sowie eine Unterseitenöffnung (96), die innerhalb und in Strömungskommunikation mit der oberen Innenkammer (34) des oberen Gehäuses (12) angeordnet ist, und die Einrichtung (20) zum Befördern von zu zerkleinerndem Material in die obere Innenkammer (34) ein Versorgungsrohr (110) mit einem offenen oberen Ende (110A) und einem offenen unteren Ende (110B) aufweist und an der oberen und der unteren Seitenöffnung (94, 96) des Ausstoßrohrs (92) befestigt und durch dieses hindurch angeordnet ist, so dass das offene obere Ende (110A) des Versorgungsrohrs (110) außerhalb des oberen Gehäuses (12) und neben einer Seite des Ausstoßrohrs (92) angeordnet ist, und das offene untere Ende (110B) des Versorgungsrohrs (110) innerhalb des oberen Gehäuses (12) und neben einer entgegengesetzten Seite des Ausstoßrohrs (92) und innerhalb und in Strömungskommunikation mit der oberen Innenkammer (34) angeordnet ist, so dass zu zerkleinerndes Material über das Versorgungsrohr (110) durch das Ausstoßrohr (92) von außerhalb des oberen Gehäuses (12) in den zirkulären Wirbelluftstrom in der oberen Innenkammer (34) des oberen Gehäuses (12) zugeführt werden kann.

11. Gerät nach Anspruch 9 oder 10, ferner mit einer Klappe (104), die bewegbar an dem Ausstoßrohr (92) befestigt ist und zum Regeln des Luftstroms von der oberen Innenkammer (34) durch das Ausstoßrohr (92) anpassbar ist, um dadurch die Größe, zu der das Material in der oberen Innenkammer (34) zerkleinert werden soll, zu regulieren.

12. Verfahren zum Zerkleinern von Material, wobei:

ein oberes Gehäuse (12) vorgesehen wird, das eine innere und eine äußere Seite aufweist, wobei die innere Seite eine Innenkammer eingrenzt, die wenigstens ein Loch (56) vorbestimmter Größe aufweist, das zwischen deren äußerer und innerer Seite (12A, 12B) gebildet und so orientiert ist, dass sie zwischen der äußeren und der inneren Seite (12A, 12B) und in einem spitzen Winkel dazu verläuft, um eine Strömungskommunikation zwischen der äußeren Seite und deren oberer Innenkammer (34) zu ermöglichen;
ein unteres Gehäuse (14) vorgesehen wird, das unterhalb und in einer Tandemanordnung mit

dem oberen Gehäuse (12) angeordnet ist, und eine umgekehrte konische Konfiguration aufweist, so dass eine untere Innenkammer (36) des unteren Gehäuses (14) im Wesentlichen kontinuierlich und in Strömungskommunikation mit der oberen Innenkammer (34) des oberen Gehäuses (12) verläuft;
zu zerkleinerndes Material durch ein oberes Ende (12D) des oberen Gehäuses (12) in die obere Innenkammer (34) befördert wird;
ein Luftstrom durch das Loch (56) in dem oberen Gehäuse (12) in deren obere Innenkammer (34) längs eines Strömungspfads zugeführt wird, der an der Innenseite des oberen Gehäuses (12) verläuft;
der innerhalb des oberen Gehäuses (12) zirkulierende Luftstrom weg von dem Loch (56) abgelenkt wird, so dass die innerhalb des oberen Gehäuses (12) zirkulierende Luft nicht die Luft stört, die durch das Loch (56) in die obere Innenkammer (34) strömt, wobei wenigstens eine Ablenkplatte (90) verwendet wird, die an der oberen ringförmigen Seitenwand (24) an der inneren Seite des oberen Gehäuses (12) neben dem Loch (56) befestigt ist und eine ringförmige Konfiguration relativ zu der inneren Seite des oberen Gehäuses (12) aufweist; und
Luft aus der oberen Innenkammer (34) des oberen Gehäuses (12) durch dessen oberes Ende (12D) ausgestoßen wird, so dass das Zuführen und das Ausstoßen von Luft mit dem Loch (56) in dem oberen Gehäuses (12) und der oberen und der unteren Innenkammer (34, 36) zusammenwirken, um einen zirkulären Wirbelluftstrom innerhalb der oberen und der unteren Innenkammer (34, 36) zu erzeugen, der ein Zerkleinern und Trocknen von Material im Wesentlichen in der oberen Innenkammer (34), eine Bewegung von zerkleinertem Material durch die untere Innenkammer (36) nach unten und einen Auslass des zerkleinerten Materials aus der unteren Innenkammer (36) des unteren Gehäuses (14) durch dessen offenes unteres Ende (30B) bewirkt, wobei die untere Innenkammer (36) eine umgekehrte konische Form aufweist, die den zirkulären Wirbelstrom von Luft und Material in der oberen und der unteren Innenkammer (34, 36) verstärkt.

13. Verfahren nach Anspruch 12, wobei die zugeführte Luft
in komprimierter Form vorliegt, und/oder
in einer Temperatur innerhalb des Bereichs von etwa 4°C (40°F) bis etwa 500°C (900°F) vorliegt, und/oder
in einem Druck innerhalb des Bereichs von etwa 1,5 mPa (10 psi) bis etwa 90 mPa (600 psi) vorliegt, und/oder
in einer Geschwindigkeit innerhalb des Bereichs von etwa 0,1 m^3/Min. (5 Kubikfuß/Min.) bis etwa 320 m^3/Min. (12000 Kubikfuß/Min.) vorliegt, und/oder
Dampf mit einer Temperatur innerhalb des Bereichs von etwa 100°C (212°F) bis etwa 1100°C (2000°F) aufweist.

14. Verfahren nach Anspruch 12, wobei ferner die Größe des Lochs (56) des oberen Gehäuses (12) angepasst wird.

Revendications

1. Appareil de broyage de matériau, comprenant :

une enceinte supérieure (12) comportant une paroi latérale annulaire supérieure (24) et présentant une extrémité supérieure (12D), une extrémité inférieure ouverte (12C) et des côtés extérieur et intérieur opposés (12A, 12B), ladite paroi latérale annulaire supérieure (24) définissant une chambre intérieure supérieure (34) sur ledit côté intérieur de ladite enceinte supérieure (12) et présentant au moins un trou (56) d'une taille prédéterminée formé à travers ladite paroi latérale annulaire supérieure (24) entre lesdits côtés extérieur et intérieur (12A, 12B) de ladite enceinte supérieure (12) de manière à fournir une communication fluidique entre ledit côté extérieur de ladite enceinte supérieure (12) et ladite chambre intérieure supérieure (34) de celle-ci ;
une enceinte inférieure (14) disposée au-dessous et dans une disposition en tandem avec ladite enceinte supérieure (12), ladite enceinte inférieure (14) comportant une paroi latérale annulaire inférieure (30) présentant une configuration conique sensiblement inversée et des extrémités supérieure et inférieure ouvertes (30A, 30B) et définissant une chambre intérieure inférieure (36), ladite paroi latérale annulaire inférieure (30) de ladite enceinte inférieure (14) étant montée au niveau de ladite extrémité supérieure ouverte (30A) de celle-ci sur ladite paroi latérale annulaire supérieure (24) sur ladite extrémité inférieure ouverte (30B) de ladite enceinte supérieure (12) de telle sorte que ladite paroi latérale annulaire inférieure (30) et ladite chambre intérieure inférieure (36) sont sensiblement continues et en communication fluidique avec ladite paroi latérale annulaire supérieure (24) et la chambre intérieure supérieure (34) ;
des moyens (20) pour délivrer le matériau à broyer à l'intérieur de ladite chambre intérieure supérieure (34) de ladite enceinte supérieure (12) à travers ladite extrémité supérieure (12D) de celle-ci ;
des moyens (16) pour faire passer un courant

d'air à travers ledit trou (56) dans ladite paroi latérale annulaire supérieure (24) à l'intérieur de ladite chambre intérieure supérieure (34) le long d'un trajet d'écoulement s'étendant autour dudit côté intérieur de ladite enceinte supérieure (12) ; et

des moyens (18) pour aspirer l'air de ladite chambre intérieure supérieure (34) de ladite enceinte supérieure (12) à travers ladite enceinte supérieure (12D) de celle-ci de telle sorte que lesdits moyens (16) pour faire passer l'air et lesdits moyens (18) pour aspirer l'air co-agissent avec ledit trou (56) dans ladite paroi latérale annulaire supérieure (24) et avec lesdites chambres intérieures supérieure et inférieure (34, 36) pour créer un écoulement d'air tourbillonnaire à l'intérieur desdites chambres intérieures supérieure et inférieure (34, 36) qui provoque le broyage et le séchage du matériau sensiblement dans ladite chambre intérieure supérieure (34), l'évacuation vers le haut de l'air depuis ladite chambre intérieure supérieure (34) à travers ladite extrémité supérieure de celle-ci, le déplacement vers le bas du matériau broyé à travers ladite chambre intérieure inférieure (36) et l'évacuation vers le bas du matériau broyé provenant de ladite chambre intérieure inférieure (36) à travers ladite extrémité inférieure ouverte (30B) de ladite enceinte inférieure (14), ladite chambre intérieure inférieure (36) présentant une forme conique inversée qui augmente ledit écoulement d'air tourbillonnaire et de matériau dans lesdites chambres intérieures supérieure et inférieure (34, 36),

caractérisé par au moins une plaque de déviation (90) montée sur ladite paroi latérale annulaire supérieure (24) sur ledit côté intérieur de ladite enceinte supérieure (12) de manière adjacente audit trou (56) et définissant une configuration annulaire par rapport à ladite paroi latérale annulaire supérieure (24) pour dévier l'air dudit trou (56) de manière à ne pas briser l'air s'écoulant desdits moyens (16) pour faire passer un courant d'air à travers ledit trou (56) à l'intérieur de ladite chambre intérieure supérieure (34).

2. Appareil selon la revendication 1, dans lequel ledit trou (56) à travers ladite paroi latérale annulaire supérieure (24) est une fente présentant :

une hauteur orientée de manière à s'étendre entre et dans une relation généralement transversale auxdites extrémités supérieure et inférieure de ladite enceinte supérieure (12), et/ou

une longueur orientée de manière à s'étendre entre et suivant un angle aigu par rapport auxdits côtés extérieur et intérieur (12A, 12B) de ladite enceinte supérieure (12).

3. Appareil selon l'une quelconque des revendications précédentes, comprenant en outre une structure de support supportant lesdites enceintes supérieure et inférieure (12, 14) dans une orientation verticale avec ladite enceinte supérieure (12) au-dessus de ladite enceinte inférieure (14) de telle sorte que lesdites enceintes supérieure et inférieure (12, 14) et lesdites chambres intérieures supérieure et inférieure (34, 36) de celle-ci se trouvent dans une orientation en tandem les unes par rapport aux autres.

4. Appareil selon l'une quelconque des revendications précédentes, dans lequel ladite enceinte supérieure (12) comporte en outre des moyens (58) pour régler ladite taille dudit trou (56) à travers ladite paroi latérale annulaire supérieure (24).

5. Appareil selon la revendication 4, dans lequel lesdits moyens (58) pour régler ladite taille dudit trou (56) comportent une plaque (60) et un agencement de fixation libérable (64) montant ladite plaque (60) sur ladite paroi latérale annulaire supérieure (24) sur ledit côté extérieur de ladite enceinte supérieure (12) de manière adjacente audit trou (56) à travers ladite paroi latérale annulaire supérieure (24) pour subir un déplacement coulissant par rapport à ladite paroi latérale annulaire supérieure (24) et audit trou (56) à travers celui-ci pour modifier la taille effective dudit trou (56) à travers lequel ledit courant d'air peut passer.

6. Appareil selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens (16) pour faire passer l'air fournissent l'air à l'état comprimé.

7. Appareil selon l'une quelconque des revendications précédentes, dans lequel lesdits moyens (16) pour faire passer l'air comportent :

au moins un collecteur (68) monté sur ladite paroi latérale annulaire supérieure (24) de ladite enceinte supérieure (12) sur ledit côté extérieur de celle-ci et définissant une cavité de collecte d'air (86) enfermant et disposée en communication fluidique avec ledit trou (56) à travers ladite paroi latérale annulaire supérieure (24), ledit collecteur (68) présentant une entrée d'amenée d'air (88) ; et

au moins un tube (70) s'étendant depuis une source externe d'air de préférence comprimé et raccordé à, et en communication fluidique avec, ladite entrée d'amenée d'air (88) dudit collecteur (68) de telle sorte que le courant d'air passe à travers ledit tube (70), à travers ladite entrée d'amenée d'air (88) dudit collecteur (68), à l'intérieur de, et à travers, ladite cavité de collecte

d'air dudit collecteur (68), à travers ledit trou (56) de ladite enceinte supérieure (12), et à l'intérieur de ladite chambre intérieure supérieure (34).

8. Appareil selon la revendication 7, dans lequel lesdits moyens (18) pour aspirer l'air de ladite chambre intérieure supérieure (34) comportent un tuyau d'échappement (92) présentant une extrémité supérieure ouverte (92A) et une extrémité inférieure ouverte (92B) et monté sur et disposé à travers ladite extrémité supérieure (12D) de ladite enceinte supérieure (12) de telle sorte que ladite extrémité supérieure ouverte (92A) dudit tuyau d'échappement (92) est disposée à l'extérieur et au-dessus de ladite enceinte supérieure (12) et ladite extrémité inférieure ouverte (92B) dudit tuyau d'échappement (92) est disposée à l'intérieur de, et en communication fluidique avec, ladite chambre intérieure supérieure (34), ladite extrémité inférieure ouverte (92B) dudit tuyau d'échappement (92) étant positionnée en étant plus proche de ladite extrémité inférieure ouverte (12C) de ladite enceinte supérieure (12) que de ladite extrémité supérieure (12D) de celle-ci.

9. Appareil selon la revendication 8, dans lequel ladite extrémité supérieure (12D) de ladite enceinte supérieure (12) comporte un couvercle supérieur (26) présentant une ouverture sensiblement centrale (28).

10. Appareil selon la revendication 8 ou 9, dans lequel :

ledit tuyau d'échappement (92) présente également une ouverture latérale supérieure (94) disposée à l'extérieur de et au-dessus de ladite enceinte supérieure (12) et une ouverture latérale inférieure (96) disposée à l'intérieur de et en communication fluidique avec ladite chambre intérieure supérieure (34) de ladite enceinte supérieure (12) ; et
lesdits moyens (20) pour amener le matériau à broyer à l'intérieur de ladite chambre intérieure supérieure (34) comportent un tube d'alimentation (110) présentant une extrémité supérieure ouverte (110A) et une extrémité inférieure ouverte (110B) et monté sur et disposé à travers lesdites ouvertures latérales supérieure et inférieure (94, 96) dudit tuyau d'échappement (92), de telle sorte que ladite extrémité supérieure ouverte (110A) dudit tube d'alimentation (110) est disposée à l'extérieur de ladite enceinte supérieure (12) et de manière adjacente à un côté dudit tuyau d'échappement (92) et ladite extrémité inférieure ouverte (110B) dudit tube d'alimentation (110) est disposée à l'intérieur de ladite enceinte supérieure (12) et de manière adjacente à un côté opposé dudit tuyau d'échappement (92) et à l'intérieur et en communication fluidique avec ladite chambre intérieure supérieure (34) de telle sorte que le matériau à broyer peut être amené par le biais dudit tube d'alimentation (110) à travers ledit tuyau d'échappement (92) depuis l'extérieur de ladite enceinte supérieure (12) à l'intérieur dudit écoulement d'air tourbillonnaire dans ladite chambre intérieure supérieure (34) de ladite enceinte supérieure (12).

11. Appareil selon la revendication 9 ou 10, comprenant en outre un amortisseur (104) monté de manière mobile sur ledit tuyau d'échappement (92) et pouvant être réglé pour réguler le courant d'air provenant de ladite chambre intérieure supérieure (34) à travers ledit tuyau d'échappement (92) et réguler de ce fait la taille à laquelle le matériau est broyé dans ladite chambre intérieure supérieure (34).

12. Procédé de broyage de matériau, comprenant les étapes consistant à :

pourvoir une enceinte supérieure (12) d'un côté intérieur et d'un côté extérieur, ledit côté intérieur définissant une chambre intérieure, d'au moins un trou (56) d'une taille prédéterminée formé entre les côtés extérieur et intérieur (12A, 12B) de celle-ci et orienté de manière à s'étendre entre et suivant un angle aigu par rapport aux côtés extérieur et intérieur (12A, 12B) de manière à fournir une communication fluidique entre ledit côté extérieur et une chambre intérieure supérieure (34) de celle-ci ;
fournir une enceinte inférieure (14) au-dessous et en configuration en tandem avec l'enceinte supérieure (12) et présentant une configuration conique inversée de telle sorte qu'une chambre intérieure inférieure (36) de l'enceinte inférieure (14) est sensiblement continue et en communication fluidique avec la chambre intérieure supérieure (34) de l'enceinte supérieure (12) ;
délivrer le matériau à broyer à l'intérieur de la chambre intérieure supérieure (34) à travers une extrémité supérieure (12D) de l'enceinte supérieure (12) ;
pour faire passer un courant d'air à travers le trou (56) dans l'enceinte supérieure (12) à l'intérieur de la chambre intérieure supérieure (34) de celle-ci le long d'un trajet d'écoulement s'étendant autour du côté intérieur de l'enceinte supérieure (12) ;
dévier le courant d'air circulant à l'intérieur de l'enceinte supérieure (12) dudit trou (56) de sorte que l'air circulant à l'intérieur de l'enceinte supérieure (12) ne brise pas l'air s'écoulant dudit trou (56) à l'intérieur de ladite chambre intérieure supérieure (34), en utilisant au moins une plaque de déviation (90) montée sur ledit côté in-

térieur de ladite enceinte supérieure (12) de manière adjacente audit trou (56) et définissant une configuration angulaire par rapport audit côté intérieur de ladite enceinte supérieure (12) ; et

aspirer l'air de la chambre intérieure supérieure (34) de l'enceinte supérieure (12) à travers l'extrémité supérieure (12D) de celle-ci de telle sorte que l'amenée et l'aspiration d'air co-agissent avec le trou (56) dans l'enceinte supérieure (12) et les chambres intérieures supérieure et inférieure pour créer un courant d'air tourbillonnaire à l'intérieur des chambres intérieures supérieure et inférieure (34, 36) qui provoque le broyage et le séchage du matériau sensiblement dans la chambre intérieure supérieure (34), le déplacement vers le bas du matériau broyé à travers la chambre intérieure inférieure (36) et l'évacuation vers le bas du matériau broyé depuis la chambre intérieure inférieure (36) de l'enceinte inférieure (14) à travers une extrémité inférieure ouverte (30B) de celle-ci, la chambre intérieure inférieure (36) présentant une forme conique inversée qui augmente l'écoulement tourbillonnaire d'air et de matériau dans les chambres intérieures supérieure et inférieure (34, 36).

13. Procédé selon la revendication 12, dans lequel l'air amené

se trouve dans un état comprimé, et/ou

se trouve à une température dans la plage d'environ 4°C (40°F) à environ 500°C (900°F), et/ou

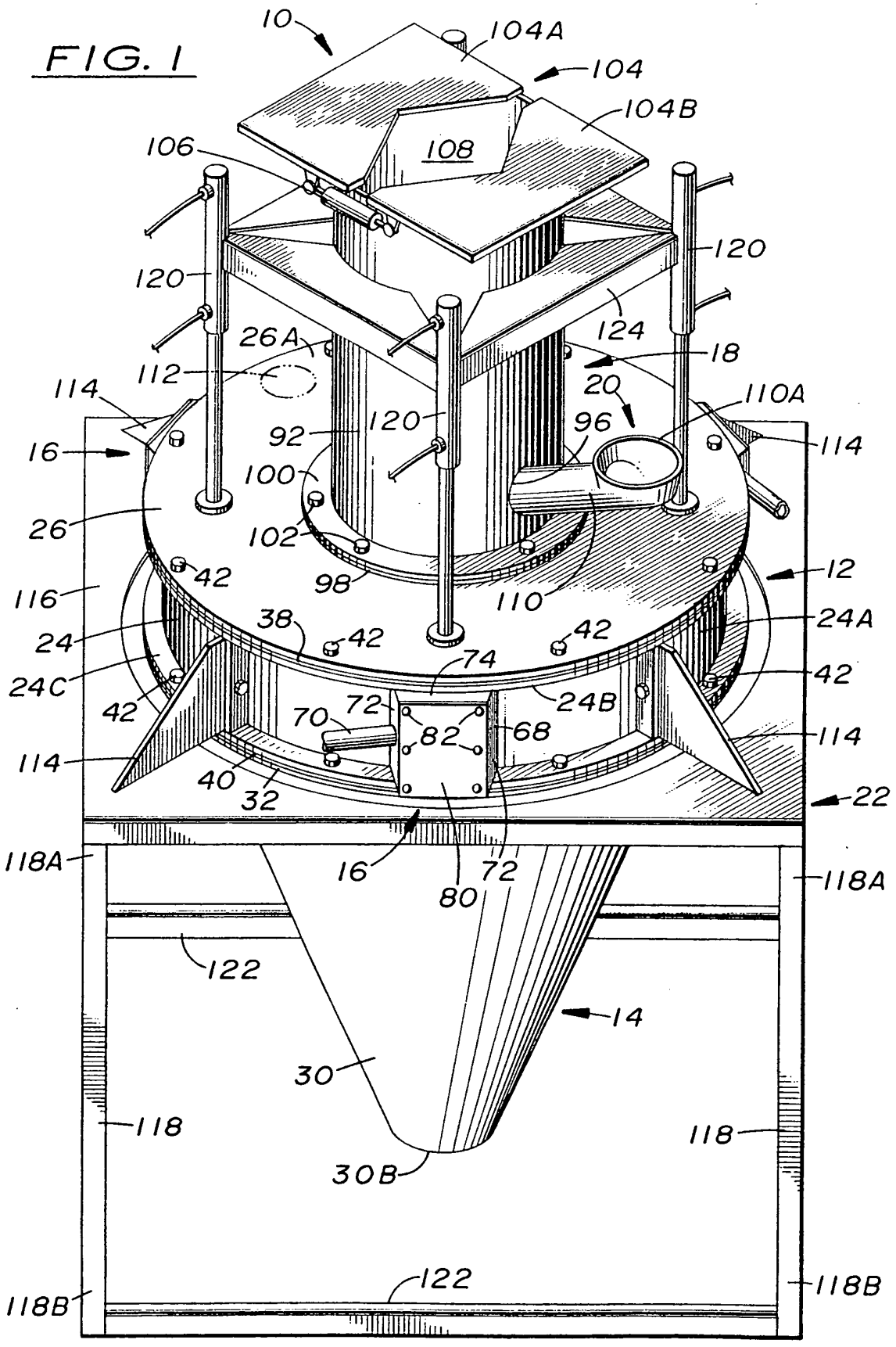
se trouve à une pression dans la plage d'environ 1,5 mPa (10 psi) à environ 90 mPa (600 psi), et/ou

se trouve à une vitesse dans la plage d'environ 0,1 m^3/min (5 pieds cube par minute) à environ 320 m^3/min (12000 pieds cube par minute), et/ou

contient de la vapeur présentant une température dans la plage d'environ 100°C (212°F) à environ 1100°C (2000°F).

14. Procédé selon la revendication 12, comportant en outre l'étape consistant à régler ladite taille dudit trou (56) de ladite enceinte supérieure (12).

FIG. 1


10
104A
104
104B
108
106
120
120
124
18
26A
112
20
110A
114
92
120
96
114
16
100
26
102
42
12
116
98
110
38
42
42
24A
24
74
42
24C
24B
42
72
70
82
68
114
114
40
32
22
118A
16
72
80
118A
122
14
30
118
118
30B
122
118B
118B

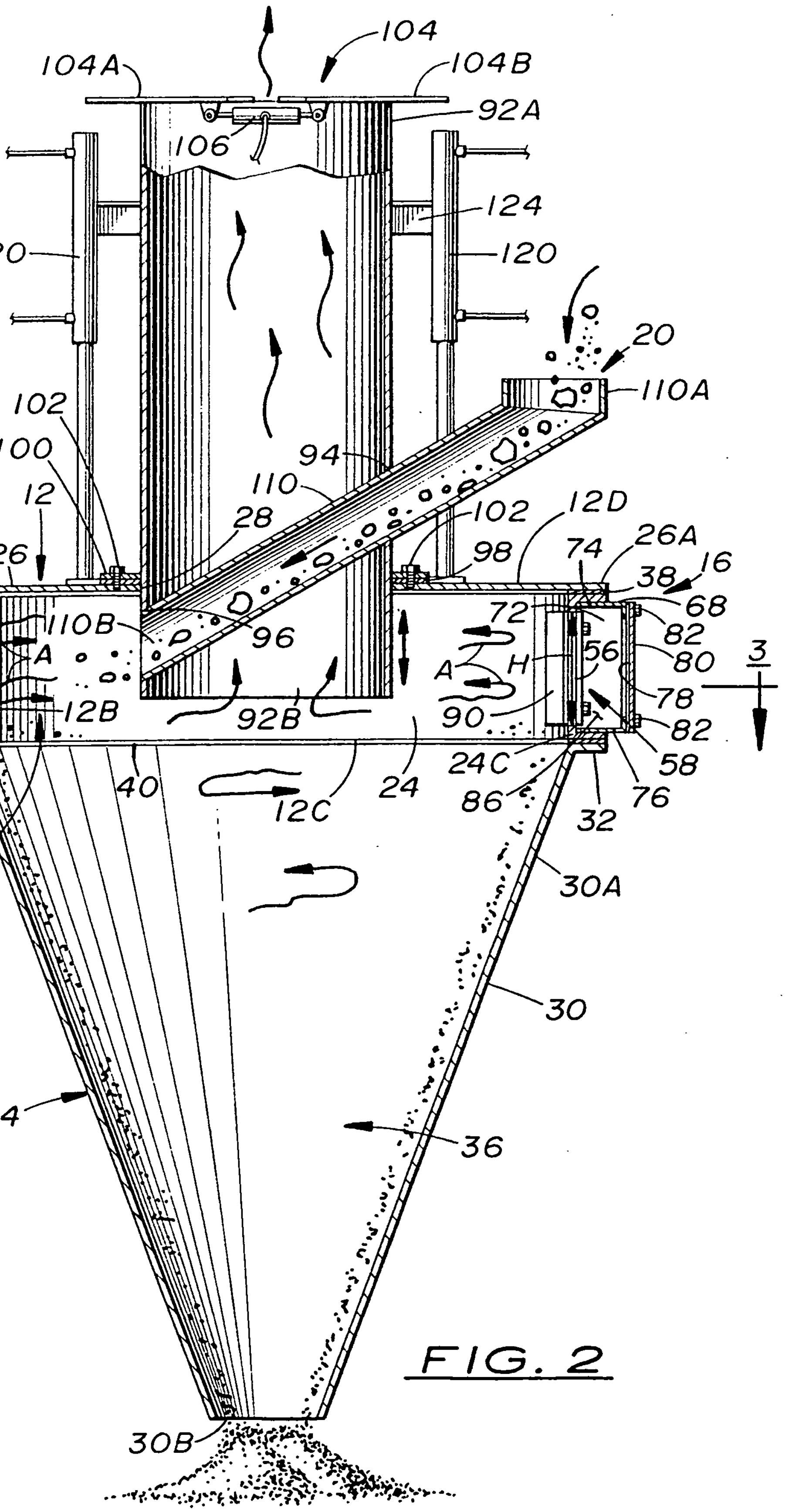

104
104A
104B
92A
106
124
120
120
20
110A
102
100
94
110
46
44
12
28
102
12D
48A
48
26
98
74
26A
24B
38
16
50
68
72
82
110B
96
52
54
A
A
H
56
80
3
3
12A
78
24A
54
12B
92B
90
82
52
58
50
24C
48A
40
12C
24
76
86
46A
48
32
44
34
30A
46
46B
30
14
36
30B

FIG. 2

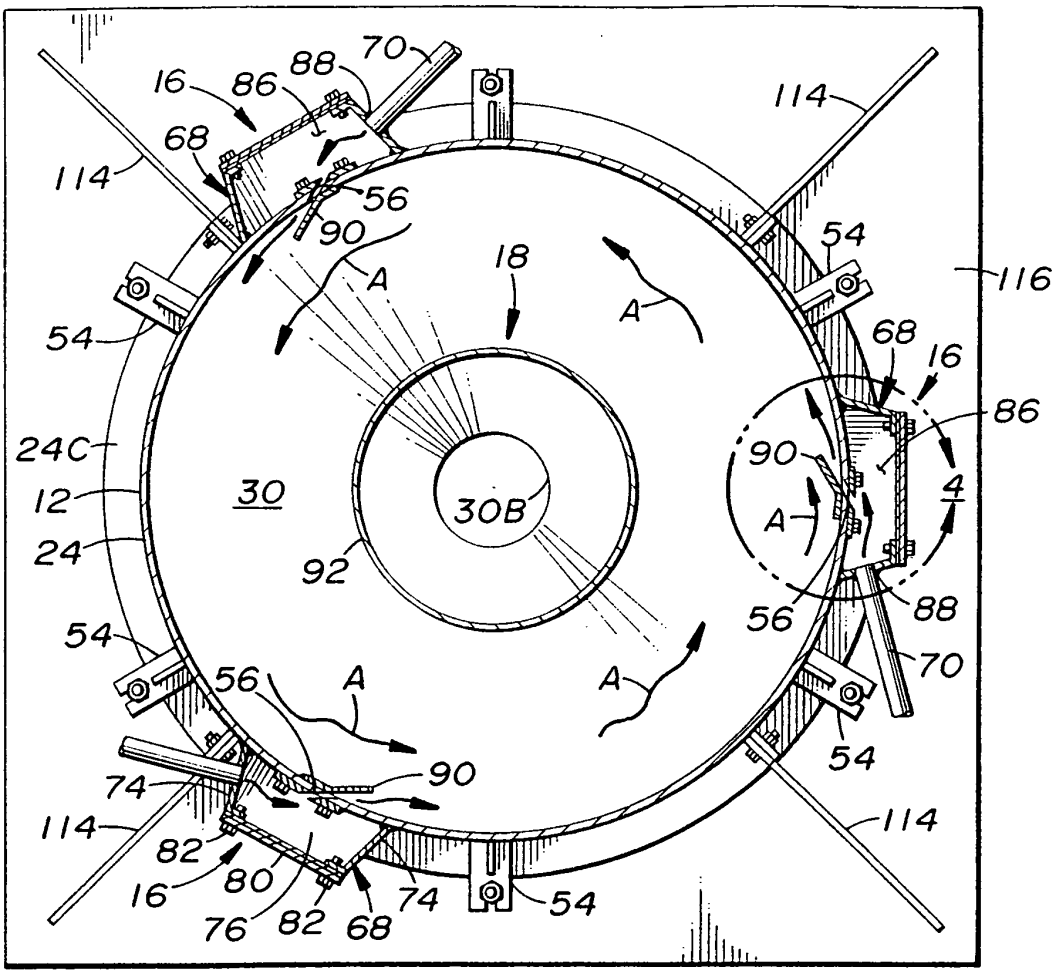


FIG. 3

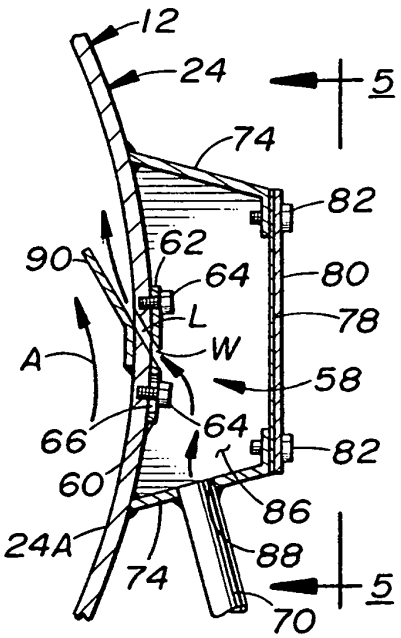


FIG. 4

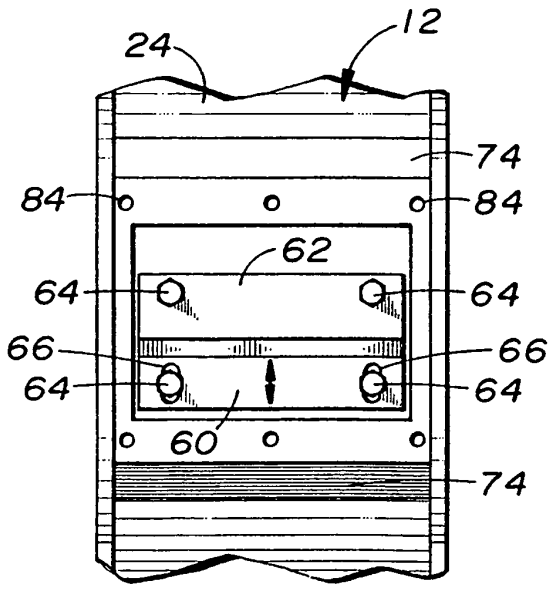


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 1123033 A, Stobie **[0002]**
- US 2362351 A, Burmeister **[0002]**
- US 2562753 A, Trost **[0002]**
- US 2690880 A, Chatelain **[0002]**
- US 3058674 A, Kocher **[0002]**
- US 4248387 A, Andrews **[0002]**
- US 4280664 A, Jackson **[0002]**
- US 5012619 A, Knepprath **[0002]**
- FR 778415 **[0002]**
- WO 9319848 A **[0004]**
- US 2958472 A **[0005]**