US006971594B1

(12) **United States Patent**
Polifka

(10) **Patent No.: US 6,971,594 B1**
(45) **Date of Patent: Dec. 6, 2005**

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/719,846**

(22) PCT Filed: **Mar. 16, 2000**

(86) PCT No.: **PCT/US00/06853**

§ 371 (c)(1),
(2), (4) Date: **Dec. 15, 2000**

(87) PCT Pub. No.: **WO00/56460**

PCT Pub. Date: **Sep. 28, 2000**

Related U.S. Application Data

(60) Provisional application No. 60/125,570, filed on Mar. 23, 1999.

(51) **Int. Cl.**[7] **B02C 19/06**
(52) **U.S. Cl.** **241/5**; 241/39
(58) **Field of Search** 241/5, 39, 12, 241/60, 48

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(57) **ABSTRACT**

A material grinding apparatus (**10**) includes an annular upper enclosure (**12**) defining an upper chamber (**34**) into which material to be ground is introduced from above, a conical lower enclosure (**14**) defining a lower chamber (**36**) and supported in tandem with the upper enclosure (**12**), and one or more angled slots (**56**) defined in the sidewall of the upper enclosure (**12**) through which compressed air is introduced relatively circumferentially into the upper chamber (**34**) so as to generate a circular vortex flow of air and material in the upper enclosure (**12**) for grinding and drying to take place. The air flow is exhausted by a pipe (**92**) through an upper end of the upper enclosure (**12**) and the dried ground material is discharged through an open lower end of the lower enclosure (**14**). The lower enclosure (**14**) is a downward continuation and extension of the upper enclosure (**12**) so as not to extend upwardly into nor past the upper chamber (**34**) thereof.

44 Claims, 3 Drawing Sheets

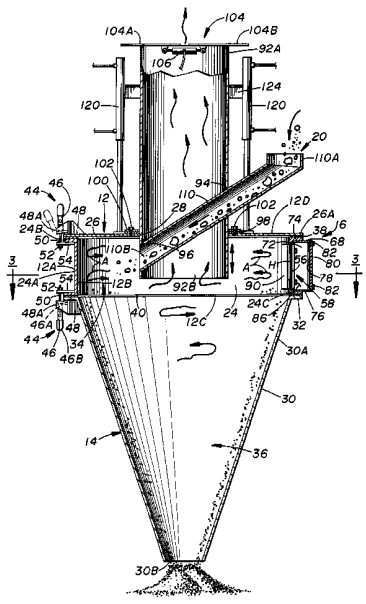
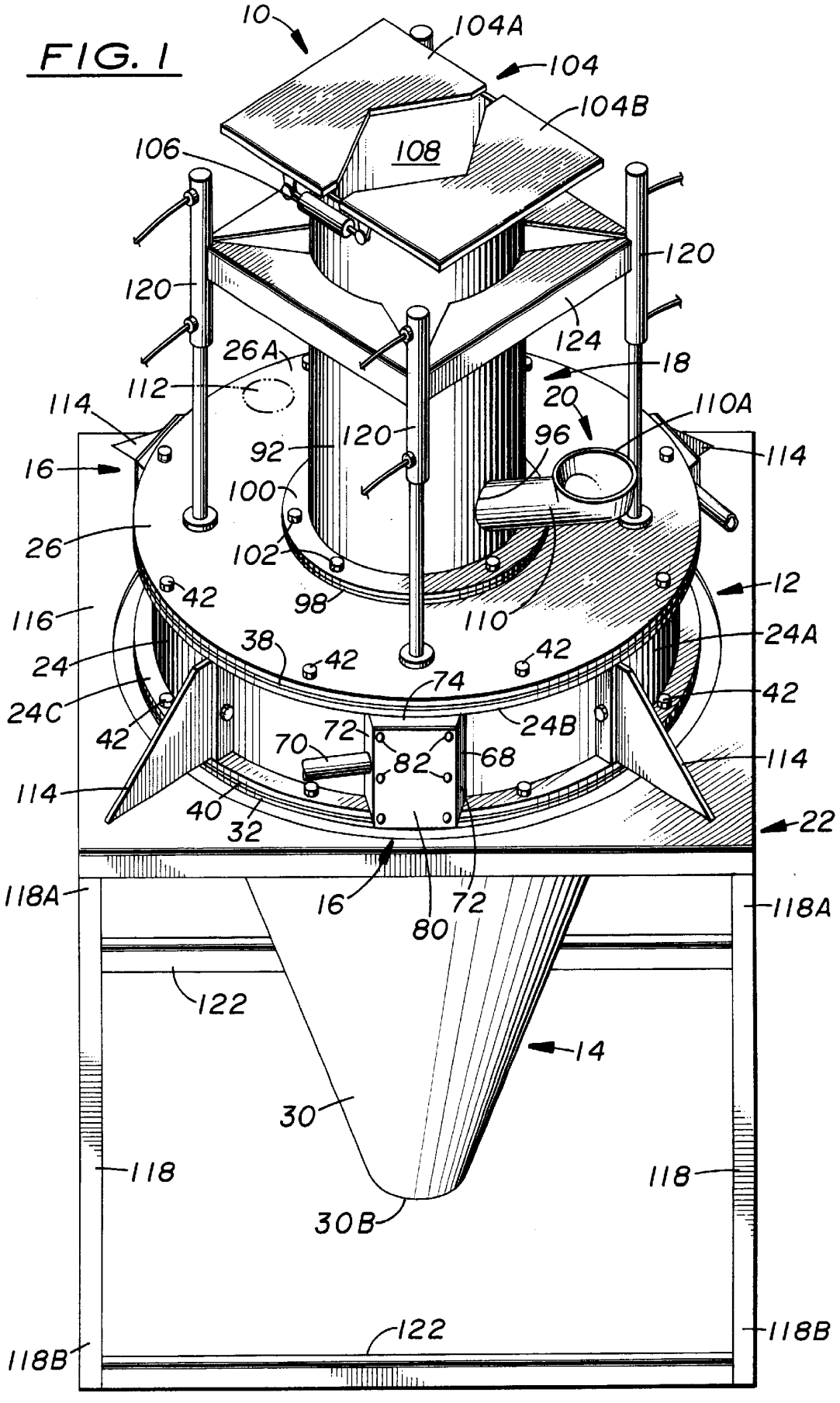


FIG. 1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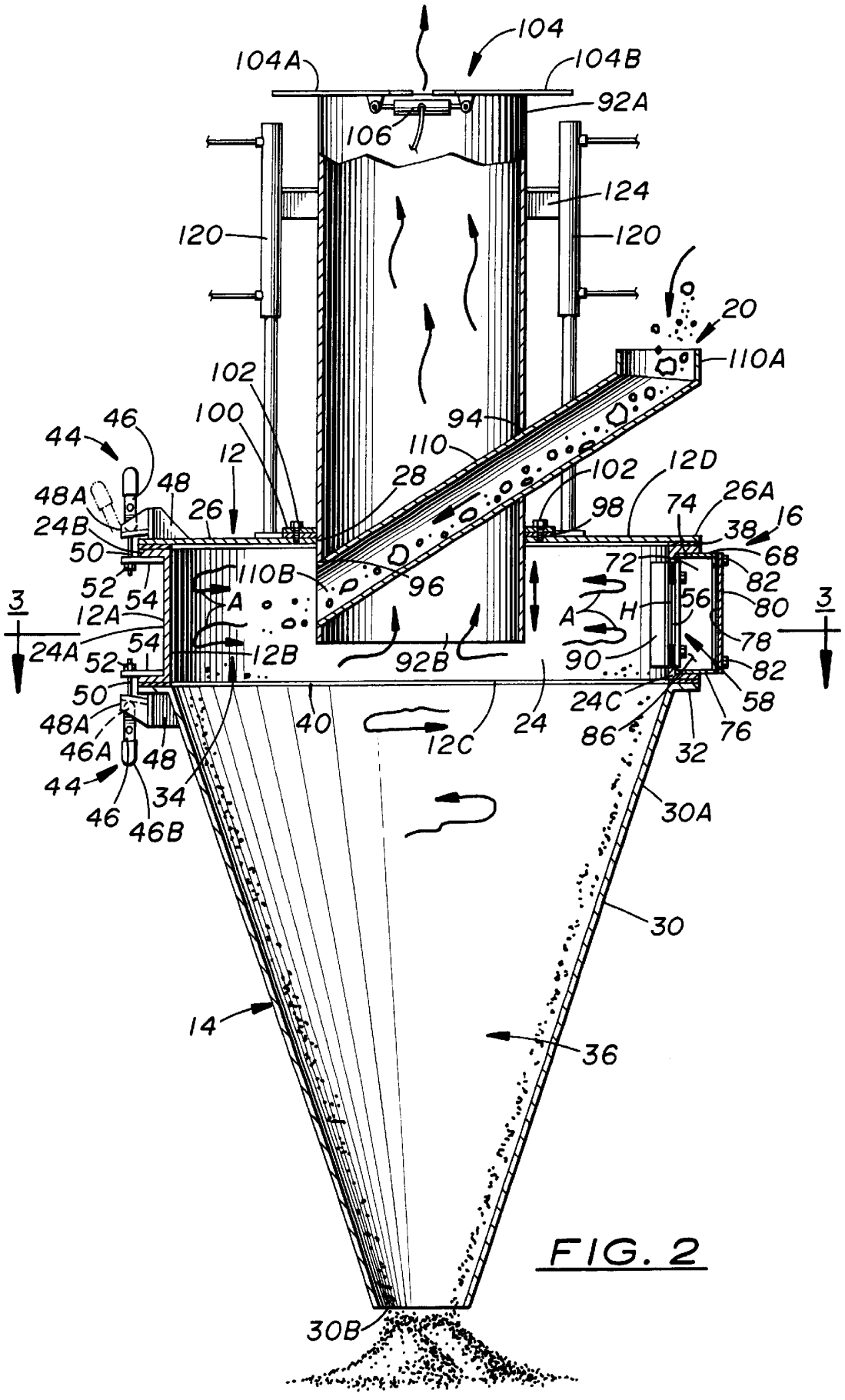
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24B
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68
72
110B
96
82
52
54
A
56
80
3
12A
A
H
3
24A
54
12B
92B
90
78
52
82
50
24C
58
48A
40
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32
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30
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36
30B

FIG. 2

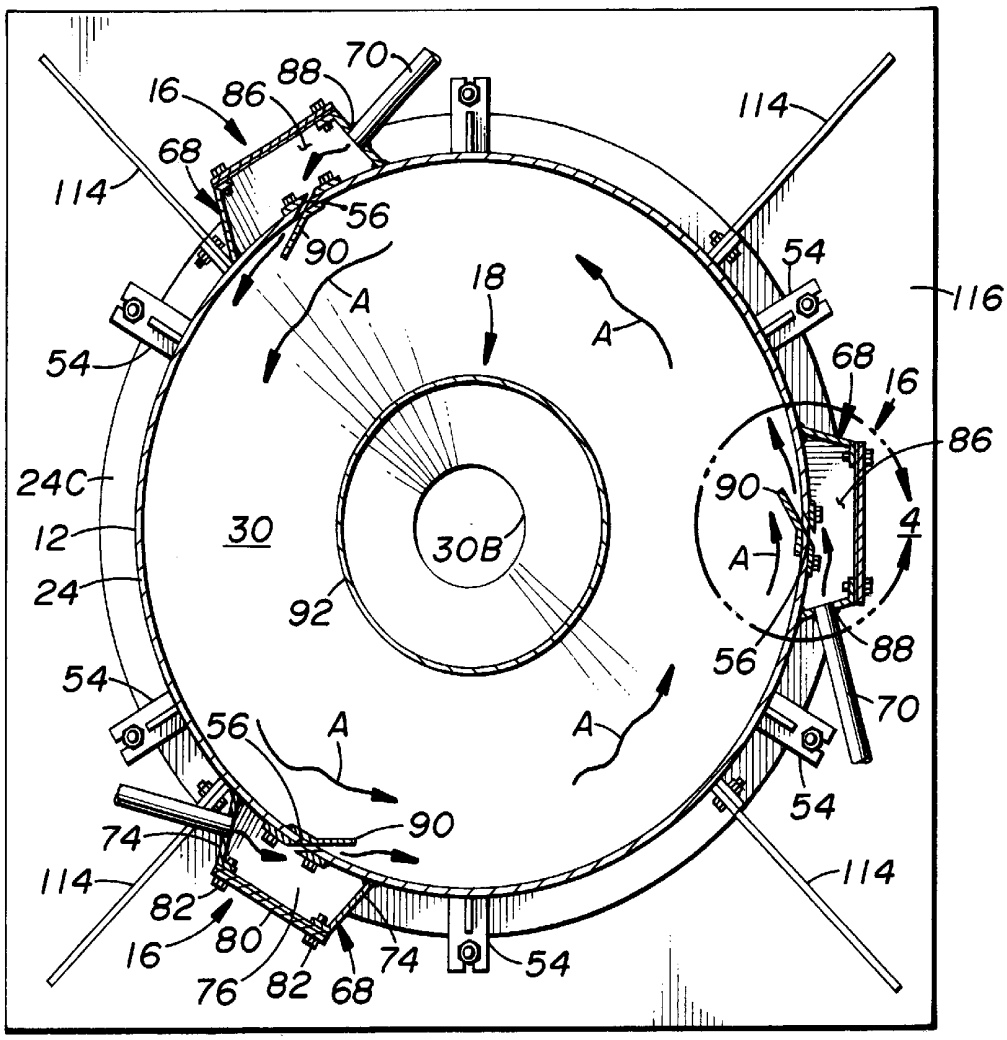

FIG. 3

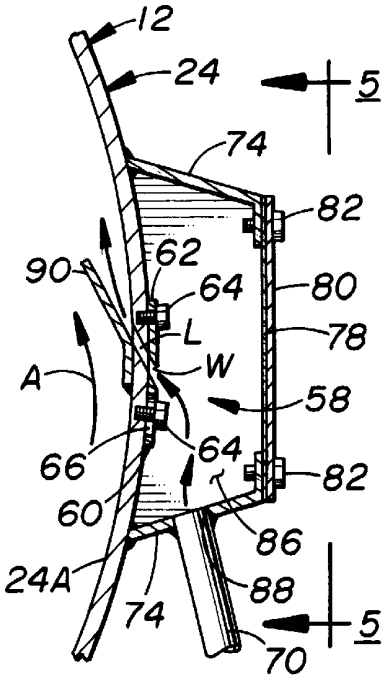

FIG. 4

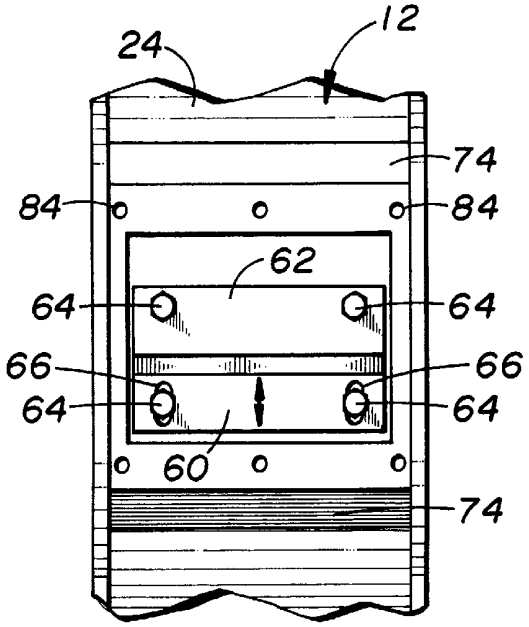

FIG. 5

APPARATUS AND METHOD FOR CIRCULAR VORTEX AIR FLOW MATERIAL GRINDING

This application claims the benefit of provisional application No. 60/125,570 filed Mar. 23, 1999.

TECHNICAL FIELD

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

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 and German Pat. No. 328,386 to Aktiengesellschaft. 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.

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.

DISCLOSURE OF INVENTION

The present invention provides an apparatus and method for compressed air vortex flow material grinding designed to satisfy the aforementioned need. The grinding apparatus of the present invention 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.

Accordingly, the present invention is directed to a material grinding apparatus which comprises: (a) an upper enclosure including an upper annular sidewall, an upper 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.

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.

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.

The present invention also is directed to a material grinding method which 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 sides 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.

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

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

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.

Referring to FIGS. **1** to **5**, the upper enclosure **12** includes a continuous upper annular sidewall **24** and has opposite

exterior and interior sides **12**A, **12**B, an open lower end **12**C and a closed upper end **12**D. Its closed upper end **12**D 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 **24**A of substantially cylindrical configuration and upper and lower annular lip portions **24**B, **24**C being substantially identical to one another. The upper and lower annular lip portions **24**B, **24**C are rigidly fixed to upper and lower opposite open ends of the main annular wall portion **24**A 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 **26**A upon the upper annular lip portion **24**B of the upper annular sidewall **24** so as to overlie and close the open upper end of the main annular wall portion **24**A of the upper annular sidewall **24** and thus the upper end **12**D of the upper enclosure **12**. The top cover **26** has defined therethrough a central opening **28** of a substantially circular configuration.

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 **30**A, **30**B. The open upper end **30**A of the lower annular sidewall **30** has a diameter which is substantially greater than the diameter of the open lower end **30**B thereof and substantially the same as the diameter of the upper annular sidewall **24** at the lower end **12**C 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 **30**A 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 **24**C 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.

The upper enclosure **12** at the interior side **12**B thereof defines an upper interior chamber **34** within the upper annular sidewall **24**, below the top cover **24** and above the open lower end **12**C 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 **30**A, **30**B 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**.

The upper annular sidewall **24** and top cover **26** of the upper enclosure **12** at their respective upper annular lip portion **24**B and peripheral edge portion **26**A 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 **24**B and the peripheral edge portion **26**A at locations circumferentially spaced apart about the upper enclosure **12**. The upper annular sidewall **24** and lower annular sidewall **30** at their respective lower annular lip portion **24**C 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 **24**C 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 **46**A to an outer end **48**A of a bracket **48** fixedly attached on respective ones of the peripheral edge portion **26**A 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 **46**A, **46**B 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 **24**B, **24**C 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**.

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 **24**A of the upper annular side wall **24** of the upper enclosure **12** and open at each of the exterior and interior sides **12**A, **12**B 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 **12**D, **12**C 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 **12**A, **12**B 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**.

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 **12**A thereof on one side of

the adjacent air hole **56**. The adjustable plate **60** is slidably mounted 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 **60**A, **62**A 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 fastener **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**.

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 **12**A 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**.

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**.

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 **12**B 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**.

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 **92**A, **92**B. 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 **92**A and the upper side opening **94** of the exhaust pipe **92** are disposed externally above the upper enclosure **12** and the open lower end **92**B 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 **92**B of the exhaust pipe **92** is disposed closer to the open lower end **12**B than to the closed upper end **12**A of the upper enclosure **12**. The open upper end **92**A 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 **92**B of the exhaust pipe **92** is disposed from the top cover **26**.

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**.

The apparatus **10** also includes a damper **104** mounted on the open upper end **92**A of the exhaust pipe **92** and an actuator **106**. The damper **104** has two half portions **104**A, **104**B substantially identical to and mirror images of one another. The actuator **106** interconnects the half portions **104**A, **104**B 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 **104**A, **104**B. 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 **92**A 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.

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 **110**A, **110**B. The upper end **110**A 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 **110**A of the feed tube **110** is disposed externally to the upper enclosure **12** and the exhaust pipe **92** whereas the open lower end **110**B 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 **26**A thereof, such as at the location **112** shown in dashed outline in FIG. **1**.

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 **12**A 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 **116**A. The attached upper and lower enclosures **12, 14** are received through the central opening **116**A of the support platform **116** and the mounting braces **114** by resting upon the support platform **116** about its central opening **116**A 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 **118**A, **118**B and are rigidly connected at their upper ends **118**A to the support platform **116** at the respective corners **116**B 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 **118**B 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**.

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 **30**B thereof, as shown in FIG. **2**. The circular vortex flow creates a vacuum in the center of each of the upper and lower interior chambers **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 **30**B 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.

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 **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 5 to about 12,000 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 40° F. to about 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 212° F. to 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 feet per minute.

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**.

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 **92**B of the exhaust pipe **92** to the exit or lower end **30**B 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

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.

Pasteurization. The temperature of the air at 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%.

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.

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.

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.

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.

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.

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.

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.

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.

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

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.

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.

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 spirit and scope of the invention or sacrificing all of its material advantages, the form hereinbefore described being merely preferred or exemplary embodiment thereof.

What is claimed is:

1. A material grinding apparatus, comprising:

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

(b) a lower enclosure disposed below and in a tandem arrangement with said upper enclosure, said 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, said lower annular sidewall of said lower enclosure being mounted at said open upper end thereof to said upper annular sidewall at said open lower end of said upper enclosure such that said lower annular sidewall and lower interior chamber of said lower enclosure are substantially continuous and in flow communication with said upper annular sidewall and upper interior chamber of said upper enclosure;

(c) means for delivering material to be ground into said upper interior chamber of said upper enclosure through said upper end of said thereof;

(d) means for supplying a flow of air through said hole in said upper annular sidewall of said upper enclosure into said upper interior chamber thereof to along a flow path extending about said interior side of said upper enclosure;

(e) one or more deflection plates, mounted to said interior side of said upper enclosure adjacent to said one or more holes through said upper annular sidewall defining an angular configuration relative to said upper annular sidewall, for deflecting air circulating within the upper interior chamber away from said one or more holes so that air circulating withing the upper interior chamber does not disrupt air flowing from said one or more holes into said upper interior chamber; and

(f) means for exhausting air from said upper interior chamber of said upper enclosure through said upper end thereof such that said means for supplying air and said means for exhausting air coact with said hole in said upper annular sidewall and with said upper and interior chambers of said upper and lower enclosures to create a circular vortex flow of air within said upper and lower interior chambers of said upper and lower enclosures that causes grinding and drying of material substantially in said upper interior chamber of said upper enclosure, upward discharge of air from said upper interior chamber through said upper end thereof, downward travel of ground material through said lower interior chamber of said lower enclosure and downward discharge of the ground material from said lower interior chamber through said open lower end of said lower enclosure, said lower interior chamber of said lower enclosure having an inverted conical shape which augments said circular vortex flow of air and material in said upper and lower interior chambers of said upper and lower enclosures.

2. The apparatus of claim **1** further comprising:

a support structure supporting said upper and lower enclosures in an upright orientation with said upper enclosure above said lower enclosure such that said upper and lower enclosures and said upper and lower interior chambers thereof are in a tandem orientation with one another.

3. The apparatus of claim **1** wherein said hole through said upper annular sidewall of said upper enclosure 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.

4. The apparatus of claim **1** wherein said hole through said upper annular sidewall of said upper enclosure is a slot having a length oriented so as to extend between and at an acute angle relative to said exterior and interior sides of said upper enclosure.

5. The apparatus of claim **1** wherein said upper enclosure further includes means for adjusting said size of said hole through said upper annular sidewall of said upper enclosure.

6. The apparatus of claim **5** wherein said means for adjusting said size of said hole includes a plate and a releasable fastening arrangement mounting said plate to said upper annular sidewall at said exterior side of said upper enclosure adjacent to said hole through said upper annular sidewall for undergoing slidable movement in relation to said upper annular sidewall and said hole therethrough for varying the effective size of said hole through which said flow of air can pass.

7. The apparatus of claim 1 wherein said means for supplying air provides the air in a compressed state.

8. The apparatus of claim 1 wherein said means for supplying air includes:

a manifold mounted to said upper annular sidewall of said upper enclosure on said exterior side thereof and defining an air collection cavity enclosing and disposed in flow communication with said hole through said upper annular sidewall, said manifold having an air supply inlet; and

at least one tube extending from an external source of air and being connected to and in flow communication with said air supply inlet of said manifold such that the flow of air passes through said tube, through said air supply inlet of said manifold, into and through said air collection cavity of said manifold, through said hole of said upper enclosure and into said upper interior chamber of said upper enclosure.

9. A material grinding apparatus, comprising:

(a) an upper enclosure including an upper annular sidewall and having an upper end, open lower end and opposite exterior and interior sides, said upper annular sidewall defining an upper interior chamber at said interior side of said upper enclosure and having a plurality of slots each of a predetermined size formed through said upper annular sidewall between said exterior and interior sides of said upper enclosure and being circumferentially spaced apart from one another about said upper annular sidewall and being oriented so as to extend between and at an acute angle relative to said exterior and interior sides of said upper enclosure such that said slots provide flow communication between said exterior side of said upper enclosure and said upper interior chamber thereof at spaced apart locations on said upper enclosure;

(b) a lower enclosure disposed below and in a tandem arrangement with said upper enclosure, said 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, said lower annular sidewall of said lower enclosure being mounted at said open upper end thereof to said upper annular sidewall at said open lower end of said upper enclosure such that said lower annular sidewall and said lower interior chamber of said lower enclosure are substantially continuous and in flow communication with said upper annular sidewall and said upper interior chamber of said upper enclosure;

(c) means for delivering material to be ground into said upper interior chamber of said upper enclosure through said upper end thereof;

(d) means for supplying a flow of air through said slots in said upper annular sidewall of said upper enclosure into said upper interior chamber thereof to along a flow path extending about said upper annular sidewall at said interior side of said upper enclosure;

(e) one or more deflection plates, mounted to said interior side of said upper enclosure adjacent to said one or more slots in said upper annular sidewall defining an angular configuration relative to said upper annular sidewall, for deflecting air circulating within the upper interior chamber away from said one or more slots so air circulating within the upper interior chamber does not disrupt air flowing from said one or more slots into said upper interior chamber; and

(e) means for exhausting air from said upper interior chamber of said upper enclosure through said upper end thereof such that said means for supplying air and said means for exhausting air coact with said slots in said upper annular sidewall and with said upper and interior chambers to create a circular vortex flow of air within said upper and lower interior chambers of said upper and lower enclosures that causes grinding and drying of material substantially in said upper interior chamber of said upper enclosure, upward discharge of air from said upper interior chamber of said upper enclosure through said upper end thereof, downward travel of ground material through said lower interior chamber of said lower enclosure and discharge of the ground material from said lower interior chamber through said open lower end of said lower enclosure, said lower interior chamber of said lower enclosure having an inverted conical shape which augments said circular vortex flow of air and material in said upper and lower interior chambers of said upper and lower enclosures.

10. The apparatus of claim 9 further comprising:

a support structure supporting said upper and lower enclosures in an upright orientation with said upper enclosure above said lower enclosure such that said upper and lower enclosures and said upper and lower interior chambers thereof are in a tandem orientation with one another.

11. The apparatus of claim 9 wherein each of said slots through said upper annular sidewall of said upper enclosure has 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. The apparatus of claim 9 wherein said upper enclosure further includes means for adjusting said size of each of said slots through said upper annular sidewall of said upper enclosure.

13. The apparatus of claim 12 wherein said slot size adjusting means includes a plate and a releasable fastening arrangement mounting said plate to said upper annular sidewall at said exterior side of said upper enclosure adjacent to each of said slots through said upper annular sidewall for undergoing slidable movement in relation to said upper annular sidewall and said slot therethrough for varying the effective width of said slot through which said flow of air can pass.

14. The apparatus of claim 9 wherein said means for supplying air provides the air in a compressed state.

15. The apparatus of claim 9 wherein said means for supplying air includes:

a plurality of manifolds each mounted to said upper annular sidewall of said upper enclosure on said exterior side thereof and defining an air collection cavity enclosing and disposed in flow communication with one of said slots through said upper annular sidewall, each of said manifolds having an air supply inlet; and

a plurality of tubes extending from an external source of compressed air and being connected to and in flow communication with said air supply inlets of said manifolds such that air in the compressed state passes through said tubes, through said air supply inlets of said manifolds, into and through said air collection cavities of said manifolds, through said slots of said upper enclosure and into said upper interior chamber of said upper enclosure.

16. The apparatus of claim 15 wherein said means for exhausting air from said upper interior chamber of said upper enclosure includes an exhaust pipe having an open upper end and an open lower end and being mounted to and

disposed through said upper end of said upper enclosure such that said open upper end of said exhaust pipe is disposed externally of and above said upper enclosure and said open lower end of said exhaust pipe is disposed within and in flow communication with said upper interior chamber of said upper enclosure, said open lower end of said exhaust pipe being located closer to said open lower end of said upper enclosure than to said upper end thereof.

17. The apparatus of claim **16** wherein said upper end of said upper enclosure includes a top cover having a substantially central opening.

18. The apparatus of claim **16** wherein:

said exhaust pipe also has an upper side opening disposed externally of and above said upper enclosure and a lower side opening disposed within and in flow communication with said upper interior chamber of said upper enclosure; and

said means for delivering material to be ground into said upper interior chamber of said upper enclosure includes a feed tube having an open upper end and an open lower end and being mounted to and disposed through said upper and lower sides openings of said exhaust pipe such that said open upper end of said feed tube is disposed externally of said upper enclosure and adjacent to a side of said exhaust pipe and said open lower end of said feed tube is disposed internally of said upper enclosure and adjacent to an opposite side of said exhaust pipe and within and in flow communication with said upper interior chamber of said upper enclosure such that material to be ground can be fed via said feed tube across said exhaust pipe from exteriorly of said upper enclosure into said circular vortex flow of air in said upper interior chamber of said upper enclosure.

19. The apparatus of claim **16** wherein each of said slots through said upper annular sidewall of said upper enclosure has a height oriented so as to extend between and in a generally transverse relationship to said upper and lower ends of said upper enclosure.

20. The apparatus of claim **16** further comprising:

a damper movably mounted to said exhaust pipe and being adjustable to regulate the flow of air from said upper interior chamber of said upper enclosure through said exhaust pipe and thereby regulate the size to which the material is ground in said upper interior chamber of said upper enclosure.

21. A material grinding apparatus, comprising:

(a) an upper enclosure comprising an upper annular sidewall, an upper end, an open lower end an exterior and interior sides, said interior side of said upper enclosure defining an upper interior chamber, where one or more holes are formed through said upper annular sidewall;

(b) a lower enclosure disposed below said upper enclosure, said lower enclosure comprising a lower annular sidewall having a substantially inverted conical configuration, exterior and interior sides and open upper and open lower ends, said interior side of said lower enclosure defining a lower interior chamber, said lower enclosure being mounted at its open upper end to said upper enclosure at its open lower end such that said lower interior chamber is substantially continuous with said upper interior chamber;

(c) a feed tube for delivering material into said upper enclosure;

(d) an air supply tube for supplying a flow of air through said one or more holes in said upper annular sidewall of said upper enclosure into said upper interior chamber;

(e) one or more deflection plates, mounted to said interior side of said upper enclosure adjacent to said one or more holes in said upper annular sidewall and defining an angular configuration relative to said upper sidewall, for deflecting air circulating within the upper interior chamber away from said one or more holes so that air circulating within the upper interior chamber does not disrupt air flowing from said one or more holes into said upper interior chamber; and

(f) an exhaust pipe for exhausting air from said upper interior chamber of said upper enclosure through said upper end of said upper enclosure,

wherein said air supply tube and said exhaust pipe coact with said one or more holes and with said upper and lower interior chambers to create a vortex flow of air within said upper and lower interior chambers sufficient to grind, dry and dehydrate materials, upwar discharge of air and downward travel and discharge of the ground material.

22. The apparatus of claim **21** further comprising:

a support structure supporting said upper and lower enclosures in an upright orientation with said upper enclosure above said lower enclosure such that said upper and lower enclosures and said upper and lower interior chambers thereof are in a tandem orientation with one another.

23. The apparatus of claim **21** wherein each hole through said upper annular sidewall of said upper enclosure 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.

24. The apparatus of claim **21** wherein each hole through said upper annualr sidewall of said upper enclosure is a slot having length oriented so as to extend between and at an acute angle relative to said exterior and interior sides of said upper enclosure.

25. The apparatus of claim **21** wherein said upper enclosure further comprises one or more adjustable plates, mounted on said exterior side of said upper enclosure adjacent to each hole in said upper annular sidewall, for varying the effective size of each hole.

26. The apparatus of claim **21** wherein said air supply tube provides air in a compressed state.

27. The apparatus of claim **21** wherein said air supply tube comprises the following components:

a manifold mounted to said upper annular sidewall of said upper enclosure on said exterior side thereof and defining an air collection cavity enclosing said one or more holes through said upper annular sidewall, said manifold having an air supply inlet; and

at least one tube extending from an external source of air and being connected to said air supply inlet of said manifold such that the flow of air passes through said tube, through said air supply inlet of said manifold, into and through said air collection cavity of said manifold, through at least one of said holes of said upper enclosure and into said upper interior chamber of said upper enclosure.

28. A material grinding apparatus, comprising:

(a) an upper enclosure comprising an upper annular sidewall, an upper end, an open lower end and exterior and interior sides, said interior side of said upper enclosure defining an upper interior chamber, where a plurality of slots are formed through said upper annular sidewall which are circumferentially spaced apart from one another about said upper annular sidewall and

oriented to extend between and at an acute angle relative to said exterior and interior sides;

(b) a lower enclosure disposed below said upper enclosure, said lower enclosure comprising a lower annular sidewall having a substantially inverted conical configuration, exterior and interior sides and open upper and open lower ends, said interior side of said lower enclosure defining a lower interior chamber, said lower enclosure being mounted at its open upper end to said upper enclosure at its open lower end such that said lower interior chamber is substantially continuous with said upper interior chamber;

(c) a feed tube for delivering material into said upper interior chamber of said upper enclosure;

(d) an air supply tube for supplying a flow of air through said slots in said upper annular sidewall into said upper interior chamber;

(e) one or more deflection plates, mounted to said interior side of said upper enclosure adjacent to said one or more slots in said upper annular sidewall and defining an angular configuration relative to said upper annular sidewall, for deflecting air circulating within the upper interior chamber away from said one or more slots so that air circulating within the upper chamber does not disrupt air flowing from said one or more slots into said upper interior chamber; and

(f) an exhaust pipe for exhausting air from said upper interior chamber of said upper enclosure through said upper end of said upper enclosure,

wherein said air supply tube and said exhaust pipe coact with said slots and said upper and lower interior chambers to create a vortex flow of air within said upper and lower interior chambers that causes grinding, drying and dehydration of material, upward discharge of air and downward travel and discharge of the ground material.

29. The apparatus of claim **28** further comprising:

a support structure supporting said uper and lower enclosures in an upright orientation with said upper enclosure above said lower enclosure such that said upper and lower enclosures and said upper and lower interior chambers thereof are in a tandem orientation with one another.

30. The apparatus of claim **28** wherein each of said slots throug said upper annular sidewall of said upper enclosure has a height oriented so as to extend between and in a generally transverse relationship to said upper and lower ends of said upper enclosure.

31. The apparatus of claim **28** wherein said upper enclosure further comprises one or more adjustable plates, mounted on said exterior side of said upper enclosure adjacent to each slot in said upper annular sidewall, for varying the size of each slot.

32. The apparatus of claim **28** wherein said air supply tube provides the air in a compressed state.

33. The apparatus of claim **28** wherein said air supply tube comprises the following components:

a plurality of manifolds each mounted to said upper annular sidewall of said upper enclosure on said exterior side thereof and defining an air colleciton cavity enclosing one of said slots through said upper annular sidewall, each of said manifolds having an air supply inlet; and

a plurality of tubes extending from an external source of compressed air and being connected to said air supply inlets of said manifolds such that air in the compressed state passes through said tubes, through said air supply inlets of said manifolds, into and through said air collection cavities of said manifolds, through said slots of said upper enclosure and into said upper interior chamber of said upper enclosure.

34. The apparatus of claim **28** wherein said exhaust pipe has an open upper and an open lower end and is mounted to and disposed through said upper end of said upper enclosure such that said open upper end of said exhaust pipe is disposed externally of and above said upper enclosure and said open lower end of said exhaust pipe is disposed within said upper interior chamber of said upper enclosure, said open lower end of said exhaust pipe being located closer to said open lower end of said upper enclosure than to said upper end thereof.

35. The apparatus of claim **34** wherein said upper end of said upper enclosure includes a top cover having substantially central opening.

36. The apparatus of claim **34** wherein:

said exhaust pipe also has an upper side opening disposed externally of and above said upper enclosure and a lower side opening disposed within isaid upper interior chamber of said upper enclosure; and

said feed tube has an open upper end and an open lower end and is mounted to and disposed through said upper and lower sides openings of said exhaust pipe such that said open upper end of said feed tube is disposed externally of said upper enclosure and adjacent to a side of said exhaust pipe and said open lower end of said feed tube is disposed internally of said upper enclosure and adjacent to an opposite side of said exhaust pipe and within said upper interior chamber of said upper enclosure such that material to be ground can be fed via said feed tube across said exhaust pipe from exteriorly of said upper enclosure into said circular vortex flow of air in said upper interior chamber of said upper enclosure.

37. The apparatus of claim **28** wherein each of said slots through said upper annular sidewall of said upper enclosure has a height oriented so as to extend between and in a generally transverse relationship to said upper and lower ends of said upper enclosure.

38. The apparatus of claim **28** further comprising;

a damper movably mounted to said exhaust pipe and being adjustable to regulate the flow of air from said upper interior chamber of said upper enclosure through said exhaust pipe and thereby regulate the size to which the material is ground in said upper interior chamber of said upper enclosure.

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

(a) providing an upper enclosure with an interior side and an exterior side, said interior side defining an interior chamber, with one or more holes formed between the exterior and interior sides and oriented so as to extend between and at an acute angle relative to the exterior and interior sides;

(b) providing a lower enclosure below and in tandem with the upper enclosure and having an inverted conical configuration such that lower interior chamber of the lower enclosure is substantially continuous 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 of the upper enclosure;

(d) supplying a flow of air through the hole or holes in the upper enclosure into the upper interior chamber thereof;

(e) deflecting the flow of air circulating within the upper enclosure away from said one or more holes so that air circulating within the upper enclosure does not disrupt air flowing from said one or more holes into said upper enclosure, using one or more deflection plates mounted to said interior side of said upper enclosure adjacent to said one or more holes and defining an angular configuration relative to said interior side of said upper enclosure; and

(f) exhausting air from the upper interior chamber of the upper enclosure through the upper end thereof

such that the supplying and the exhausting of air coact with said one or more holes and the upper and interior chambers to create a vortex flow of air within the upper and lower interior chambers that causes grinding, drying and dehydration of material and downward travel and discharge of ground material.

40. The method of claim **39** wherein the air being supplied is in a compressed state.

41. The method of claim **39** wherein the air being supplied is at a temperature within the range of about 40° F. to about 900° F.

42. The method of claim **39** wherein the air being supplied is at a pressure within the range of from about 10 psi to about 600 psi.

43. The method of claim **39** wherein the air being supplied is at a velocity within the range of from about five cubic feet per minute to about 12,000 cubic feet per minute.

44. The method of claim **39** wherein the air being supplied contains steam having a temperature within the range of from about 212° F. to about 2000° F..

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