June 28, 1949. F. J. KOEHNE 2,474,314

METHOD AND APPARATUS FOR SIZE REDUCTION AND FIBERIZING OF CRUDE FIBROUS MATERIALS

Filed Nov. 28, 1944 2 Sheets-Sheet 1

Fig. 1.

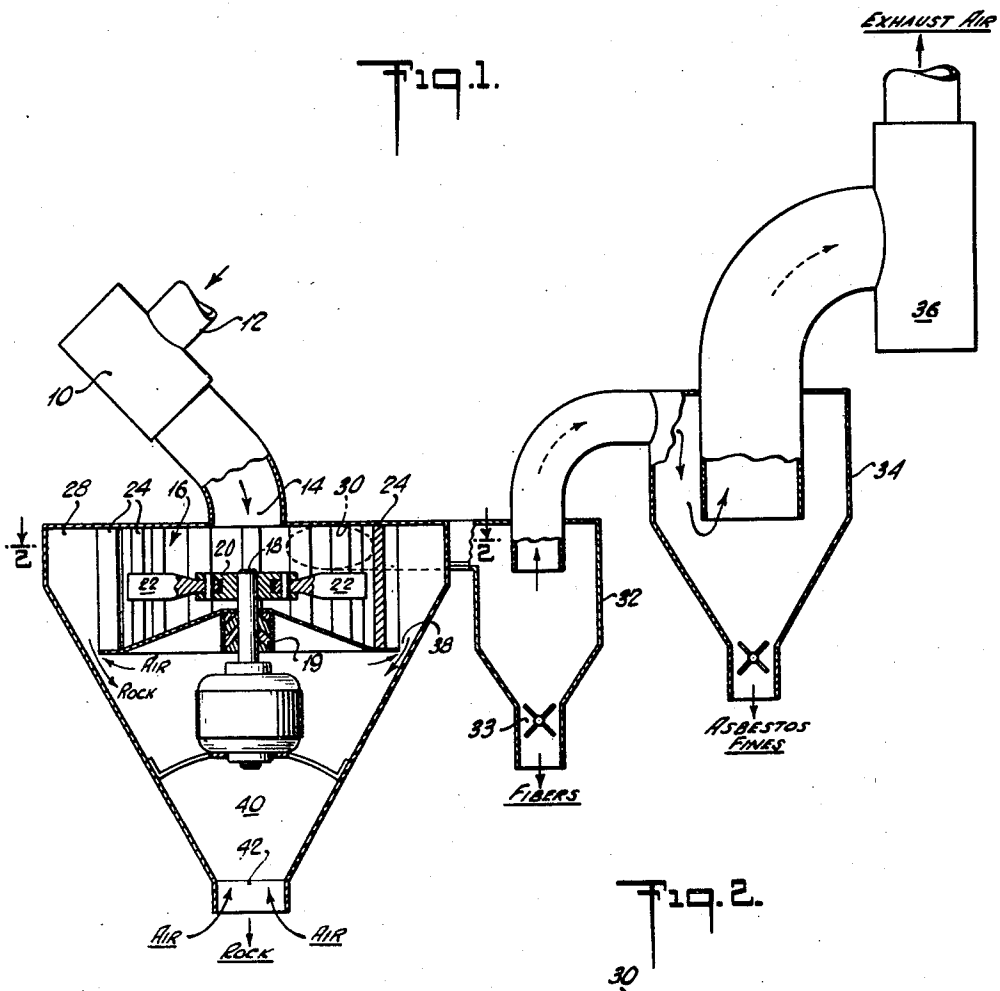
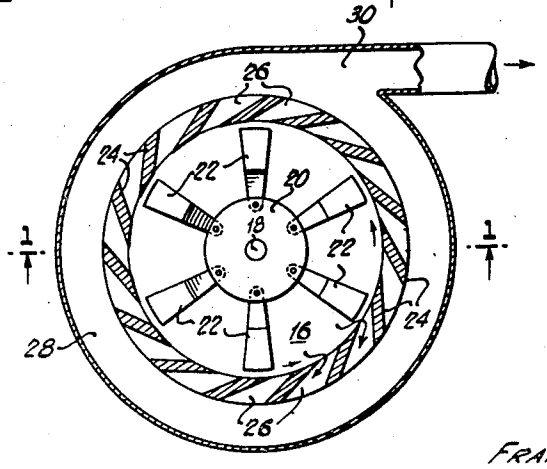


Fig. 2.



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Fig. 3.

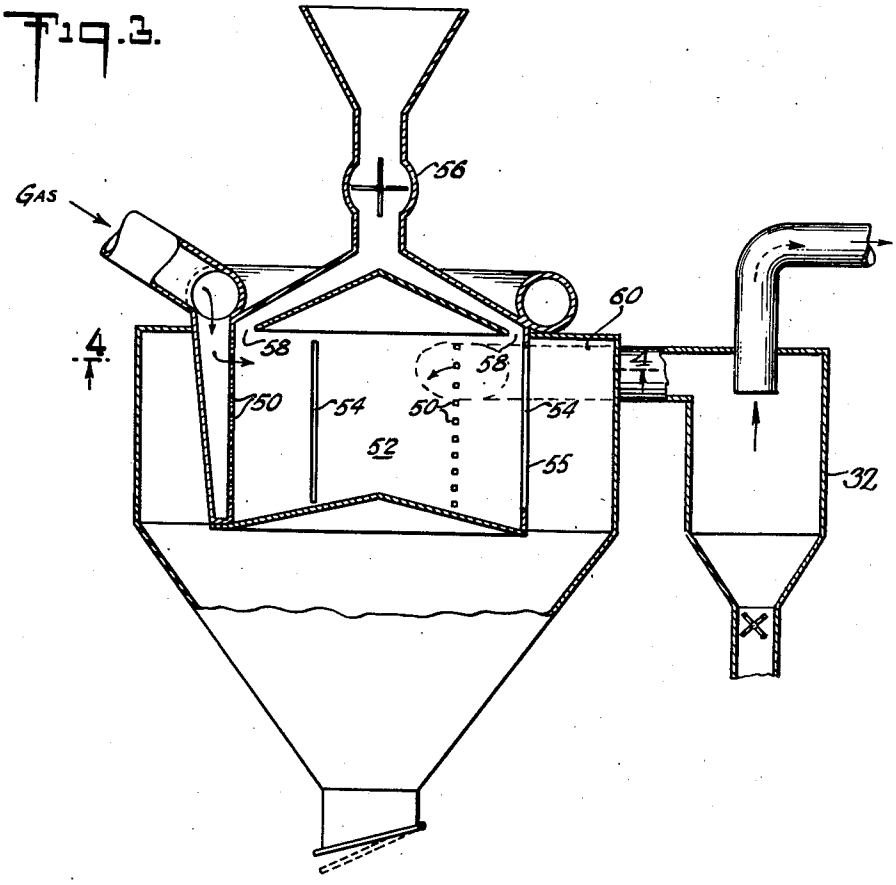
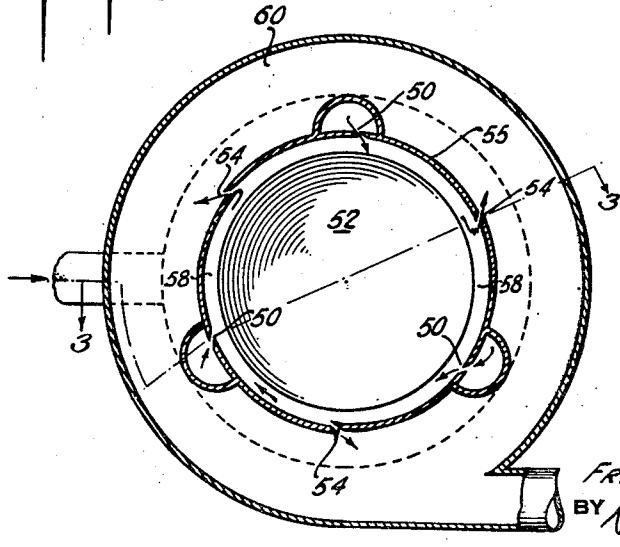


Fig. 4.



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METHOD AND APPARATUS FOR SIZE REDUCTION AND FIBERIZING OF CRUDE FIBROUS MATERIALS

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Application November 28, 1944, Serial No. 565,546

10 Claims. (Cl. 241—4)

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This invention relates to improvements in method and equipment for dry crushing and fiberizing coarse, fibrous materials, and is particularly concerned with improvements in method and apparatus whereby crude fibrous materials such as asbestos may be efficiently crushed, opened and cleaned.

In the dry crushing and size reduction of coarse granular and fibrous materials, efficient practice requires removal of the finished product from the crushing zone as soon as a specified size and physical condition has been attained. The present practice of subjecting the entire charge to attrition forces until all portions of the charge can meet requisite size classifications is extremely wasteful of power and equipment capacity, and is also wasteful of charge material that is reduced beyond useful size classifications. Granular particles or fibers which are reduced to specification size early in the crushing process, when further subjected to attrition forces, are not only reduced below optimum specification size, but also by their presence tend to prevent efficient reduction of coarser materials, because the fine materials shield and mask the coarser material from the full force of the attrition influence. Excessive amounts of undesirable fines are thus produced. Furthermore, heat generated by excessive over-crushing may injure the quality of the final product. Improved practice partially corrects these serious defects in conventional attrition methods and equipment by treating the crude material for only a portion of the time essential for its complete reduction, followed by removal and size classification of the charge material, and recharging of the incompletely reduced material to the crushing or attrition zone.

A primary object of the present invention is to provide improvements in method and apparatus whereby the dry crushing and fiberizing of crude fibrous materials can be carried out efficiently, with removal of the finished product from the fiberizing zone as soon as it has reached suitable size and shape specifications.

Another object is to provide improvements in method and apparatus for crushing and opening crude fibrous materials while avoiding serious deterioration of the fibers and while minimizing wear upon the crushing and fiberizing equipment.

Crude fibrous asbestos is composed essentially of rodlike bundles of fine asbestos fibers or filaments with which are associated substantial amounts of undesirable impurities such as asbestos fines, rock gangue and dust. Reduction

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of crudy asbestos is advantageously carried out in crushers or hammer mills in slow stages, so as to preserve as much as possible the original fiber length. Conventional methods of fiberizing crude asbestos tend to develop serious attrition and breakage of the fibers, thus producing a fibrous product which has a market value substantially lower than the potential market value of the unbroken fibers.

Methods and equipment designed for impact pulverizing and cyclone classification of granular products are predicated on Stokes Law, which applies specifically to granular particles but not to fibrous material such as asbestos. The separation of granular particles according to Stokes Law is effected in accordance with the average diameters and masses of the particles. Any attempt to adapt pneumatic impact pulverizing and cyclone separating and classifying equipment designed for handling granular materials to the treatment of crudy fibrous materials such as asbestos would necessitate maintenance of suitable turbulence in the pneumatic system in order to cause the fibers to behave as spherical particles such as the equipment is designed to handle. In the absence of turbulence the fibers tend to orient themselves into alignment with the longitudinal axes of the pulverizing and separating zones and to discharge rapidly under gravity pull from such zones. The more thoroughly the crudy asbestos fibers are fiberized or opened by the initial impact pulverizing treatment, and the greater the resulting ratio of length to thickness of the fibers, the less easily can the opened fibers be cleansed of non-fibrous impurity particles or dust by conventional cyclone cleaning and classifying equipment.

A further object of the invention is to provide improved method and equipment suitable for efficiently and economically fiberizing and cleaning crude asbestos fibers.

According to the present invention, coarse fibrous material undergoing treatment is thinly suspended in an air or gas vortex within an attrition chamber which may be of the hammer mill or jet pulverizer type. However, the conventional hammer mill or jet pulverizer unit is modified to the extent of incorporating tangential exit ports in front of and between a plurality of overlapping striker bars or striker plates which substantially surround a cylindrical attrition chamber. The attrition chamber is in turn enclosed by a collector jacket. The striker plates all lap each other in the direction of vortex flow, and the direction of rotation of the air vortex and

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suspended charge within the attrition chamber is such that particles suspended in the air vortex are thrown by centrifugal force against exposed surfaces of the striker plates, from whence they rebound toward the center of the chamber, so that the inertia momentum of the heavier and denser particles tends to carry them past or away from the exit ports. By maintaining a high rotational velocity at the periphery of the vortex, the suspended fibers are caused to travel in a path of such length as to comb them into longitudinal alignment with the rotational direction of their movement. The exit ports open out of the attrition chamber in a direction opposite to the direction of rotation of the vortex. By maintaining a controlled pressure drop between the attrition chamber and the collector jacket, air flow is induced from the attrition chamber through the outlet ports into the collector jacket, and this air flow can be made to entrain and remove fibers which have been reduced to a predetermined size or condition within the attrition chamber. The thus reduced fibers are finally cleansed of non-fibrous impurity particles and dust by conventional cyclone cleaning and classifying equipment. The improvement which is thus effected in the attrition operation is substantial, and increases the efficiency of the operation by reducing the time and energy consumption, and increasing the useful capacity of the apparatus.

With the aforementioned objects and features in view, the invention consists in the improvements in method and apparatus for crushing, fiberizing and cleaning asbestos and similar fibrous materials which are hereinafter described and more particularly defined by the accompanying claims.

In the following more complete description of the invention, reference will be made to the attached drawings, in which:

Fig. 1 is a diagrammatic assembly view, with parts shown in vertical section, of one preferred arrangement of apparatus adapted for the practice of the invention;

Fig. 2 is a horizontal section of the attrition chamber and fiber collector jacket, taken on the line 2—2 of Fig. 1;

Fig. 3 is a diagrammatic vertical section of a jet pulverizer type of attrition apparatus modified in accordance with the present invention; and

Fig. 4 is a horizontal section taken on the line 4—4 of Fig. 3, looking upward.

The improvements in method and apparatus of the present invention are designed to effect the crushing, fiberizing and cleaning of crude fibrous materials while thinly suspended in air, and to develop efficient separation and segregation of opened and cleaned fibers as a part of the same operation in which the fibers are crushed and fiberized and liberated from non-fibrous impurities.

One form of apparatus adapted for the practice of the invention, is portrayed in Figs. 1 and 2. This apparatus may include a blower 10 to which crude fibers to be crushed and fiberized are delivered in air suspension through a suction intake 12. From blower 10 the air suspended crude fibers are discharged under pressure through an intake port 14 into an upright cylindrical attrition and fiberizing chamber 16. A motor driven shaft 18 is mounted axially in attrition chamber 16, such shaft being journaled in a bearing 19. A cylindrical hub or drum 20 is supported centrally within the attrition chamber

on shaft 18, and a plurality of hammers 22 extend radially from hub 20 with their ends in closely spaced clearance relation to the inner circumferential lining of chamber 16. Rotation of hammers 22 at high speed develops circulation of the air and fibers in the attrition chamber in a rapidly moving vortex.

In the improved design of hammer mill which is shown in Figs. 1 and 2, the exit bars and striker plates of the conventional mill are combined in the form of spaced striker plates 24 substantially entirely surrounding the attrition chamber and arranged in overlapping relation, each plate forming an oblique angle with the direction of movement of the hammers. Air and fiber exit ports 26 lie in front of each striker plate, or between adjacent striker plates. Ports 26 lead off tangentially from the attrition chamber in a direction generally opposite to the direction of rotation of the hammers, so that the reduced and fiberized charge material must substantially reverse its direction of movement in leaving the attrition zone. This arrangement of striker plates and exit ports specifically favors the selective removal of opened and cleaned fibrous material from the attrition zone in preference to incompletely reduced fibers and granular material, the greater momentum of which within the attrition zone tends to restrain exit from the mill.

Air and fibers finally escape from chamber 16 through the exit ports 26 into an annular collector jacket 28. From jacket 28 air carrying fibers and dust in suspension exits through a tangential offtake 30 which leads to the intake port of a cyclone fiber separator 32. The discharge port of separator 32 is connected to an asbestos fines and dust separator 34. The offtake port of dust separator 32 is connected to a suction blower 36. The bottom of cyclone separator 32 is provided with an air lock gate 33 for the removal of opened and cleaned fibers. Any asbestos fines and dust which are carried over into separator 34 are classified therein and most of the dust is entrained with outgoing air under control of the suction blower 36.

The bottom of collector jacket 28 is ported out through a narrow circumferential opening 38 into an underlying chamber 40. A rock and gangue discharge chute 42 leads off from the base of chamber 40, and chute 42 also serves as an inlet for induced flow of additional cleaning and entraining air through chamber 40 and opening 38 into jacket 28 and thence into cyclone separators 32 and 34. The collector jacket is thus constructed for operation as a primary cyclone separator for separation of coarse non-fibrous material. Any coarse, fibrous material which may be discharged with the rock and gangue through chamber 40 can be introduced into another crushing and fiberizing unit similar to that portrayed in Figs. 1 and 2.

The striker plates 24 are all lapped in the same direction, and the direction of rotation of the air vortex and suspended charge within the attrition chamber is such that the suspended fibers are thrown by centrifugal force at high velocity against exposed surfaces of the striker plates. The coarse and partly opened fibers rebound from the plates toward the center of the chamber 16 and their weight inertia tends to carry them past or away from outlet ports 26. By maintaining a controlled pressure drop between the attrition chamber 16 and the collector jacket 28, and by adjusting the amount of overlap of the plates 24 and the cross-sectional areas of the ports 26, as by mechanical position adjusting mechanism

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for the plates of conventional design, the velocity at which air exits from the chamber **16** through ports **26** can be regulated to a point at which such outgoing air streams entrain and remove opened and cleaned fibers from the attrition chamber as soon as such fibers are reduced to suitable size classification by the attrition operation.

By forcing the fibers to travel at high velocity in a circular path around the inner lining of the attrition chamber, their path of travel is so extended as to afford ample time for the orientation of the opened and cleaned fibers with their major axes aligned with the direction of rotational travel. Since the entraining air is compressible, centrifugal force, intermittently opposed by the deflecting action of the plates **24**, develops a fluctuating pumping action forcing the air transversely in and out across the path of the moving crude fibers, whereas the greater momentum of the fibers tends to keep them traveling in a circular path and to resist such deflection. The resulting pulsations of the compressible air carrier cause bending and flexing of the crude fibers as successive portions of their lengths enter and leave the areas wherein this lateral pulsation is induced. The flexing and bending of the individual fibers or fiber bundles tends to open and split the fibers and to chip loose from their surfaces any adhering dust and granular impurities. Each impact of a fiber against a hammer or striker plate tends to crush the crude fiber and to effect a fiberizing and opening operation thereon. Because of the great amount of turbulence which is developed within the attrition zone, a substantial proportion of the total attrition and fiberizing which takes place within the chamber results directly from mutual impingement of crudy fibers and granular particles. Variations in rate of movement or acceleration between the fibers and the entraining air develop a scouring action upon the flexing fibers, which still further aids separation of non-fibrous impurities from the fibers.

As the fibers and suspending air travel at high velocity around and adjacent the peripheral walls of the attrition zone, a pressure differential is maintained between the attrition chamber and collector jacket, as by controlling the degree of pressure in the jacket, and this pressure differential promotes outrush of air through slots **26** accompanied by open and clean fibers entrained in the air. After the vortex charge of air and suspended incompletely opened fibers has passed the inward face of a striker plate in its advance within the attrition chamber, unopposed centrifugal force operates to again drift the air suspended fibers towards the circumference of the attrition chamber preparatory to impact against the succeeding striker plate in the direction of vortex movement.

A conventional jet pulverizer is provided with tangential compressed air or steam injection ports, some of which operate as feed injectors. Turbulence is developed by the high velocities created by expansion of air or steam jets within the attrition zones. Removal of reduced material is effected through a central or axial outlet. The design of the conventional jet pulverizer limits the volume of the attrition chamber to a shallow cylinder of approximately 1 inch depth and 12–24 inches diameter, in order to restrain the introduction of feed material to the sphere of influence of the jets and to hold down the centrifugal force of the particles to speeds within which reduction by mutual impingement of particles predominates.

The improved design of jet pulverizer which is shown in Figs. 3 and 4 operates on the principle of developing a gas vortex of high centrifugal force by converting the fluid pressure of tangential gas inlet jets into velocity head by their expansion to substantially atmospheric pressure as they enter the attrition chamber. Dissipation of most of the pressure energy into velocity energy at points near the jet outlets develops intense local velocity gradients and turbulence at such points, whereby a substantial proportion of the total reduction and fiberizing of the material takes place by mutual impingement of particles.

A plurality of small air or steam jet inlet ports **50** open tangentially at spaced intervals into cylindrical attrition chamber **52** of the improved jet pulverizer, and gas outlet slots **54** are ported out of chamber **52** tangentially at spaced points about its periphery, each outlet being circumferentially spaced with respect to adjacent tangential inlet ports. Each peripheral wall section **55** of the chamber **52** overlaps an adjacent wall section in the direction of vortex flow. Crude fibrous material may be introduced into the attrition chamber from an air-lock feeder **56** through a top annular feed inlet **58**. The amount of turbulence within the chamber is increased by alternate location of gas injection jets and gas outlet or relief ports about the chamber periphery. A high velocity gas vortex is maintained within the attrition chamber, and a substantial pressure differential is maintained between the attrition chamber and a fiber collector jacket **60** surrounding the chamber. The gas exist ports **54** lead out of the attrition chamber tangentially in a direction which is opposite to the direction of rotation of the gas at the periphery of the vortex within the chamber. Opened and cleaned fibers are removed from the circumference of the attrition chamber only after being forced to reverse their normal direction of flow within the chamber. Such removal of clean fibers takes place by entrainment in the air streams which leave the attrition chamber through the ports **54**. This circumferential removal of clean fibers from the attrition chamber insures greater efficiency of operation within the chamber, by maintaining the working space and impact surfaces of the attrition chamber unclogged with completely opened and fiberized fibers. Thus a greater amount of room and impact surface is insured within the attrition chamber for attrition of incompletely fiberized fibers by impact and by mutual impingement. Control of the characteristics of the product is provided through regulation of the rate of introduction of feed and of entraining air, and through adjustment of the pressure differential between the attrition chamber and the surrounding collector jacket. By providing alternately located and spaced tangential jet inlet ports and gas outlet ports in the walls of the attrition zone, this modified jet pulverizer unit retains efficient fiberizing and pulverizing functions when constructed in much greater sizes and depth than practical for conventional jet pulverizers. In other words, the equipment is freed of any size and capacity limitations, and is converted to a general purpose machine having utility for other purposes than those of a micro-pulverizer.

While the methods and apparatus herein described normally employ air as the entraining and transporting gas, use of high pressure steam has advantages in the treatment of coarse vegetable fibers, because of certain advantages of steam over air for softening such fibers and liberating

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resins associated therewith. There is also an advantage in employing hot gases such as furnace combustion gases or burner gases as the carrying and entraining gas in jet pulverizers used for the reduction of scrap asbestos-cement material to effect liberation and recovery of asbestos fibers therefrom. Greater turbulence can be developed with a given amount of gas by the use of high temperature burner gases, and the use of such gases has the additional advantage of promoting a certain amount of disassociation of the material under treatment by explosive evaporation of water of crystallization or constitution. Serious damage to the liberated fibers by contact with high temperature gas is largely avoided by the introduction of cooling air to the vortex, and by the evaporation of liberated and uncombined moisture present in the feed materials.

The attrition chambers are designed to operate on crude unopened fiber bundles to reduce and fiberize such bundles and to separate non-fibrous impurities from the open fibers while preventing serious attrition of individual fiber length. The partially cleaned and crudy fibers which are not fully opened and cleaned during their sojourn in one attrition zone may be passed in series through one or more additional attrition chambers, or may be recycled through the same individual attrition chamber, until their classification and physical characteristics meet acceptable specifications.

The rate of supply of air to the attrition chamber, and the rate of rotation of the air within the attrition chamber, are controlled to develop and maintain peripheral air velocities high enough so that the entraining effect of outgoing air through ports **26** and **54** will not allow the crude or incompletely reduced fibers to escape from the attrition chamber at a rate too fast to permit suitably efficient fiberizing and impingement reduction treatment. Air velocity rates are limited to a maximum which does not tend to develop excessive reduction and break down of open fibers, causing undesirable shortening of opened fiber length.

What I claim is:

1. The method of dry crushing and opening coarse fibrous material which comprises, forming and maintaining a thin suspension of the coarse material in a rapidly rotating gaseous fluid vortex, reducing and fiberizing the charge material by centrifugal impact against striking surfaces and by mutual impingement of particles, deflecting the rotational gas flow inwardly at said striking surfaces and developing inertia momentum of incompletely fiberized material tending to retain it within the vortex, and selectively removing suitably reduced and opened fibers tangentially outward from the attrition zone before excessive attrition thereof by reversing the direction of flow of said reduced and opened fibers at the periphery of the vortex.

2. The method of dry crushing and fiberizing crude fibrous material which comprises, introducing the crude fibers into a rapidly rotating vortex of a gaseous fluid, maintaining a high volume ratio of gas to fiber to provide a thin suspension of fibers, reducing and fiberizing the material by tangential impact against striking surfaces and by mutual impingement of particles, combing the fibers into longitudinal alignment with the rotational direction of their movement, periodically deflecting the rotational gas flow inwardly at impact surfaces adjacent the periphery of the vortex, thereby developing components of gas movement which are transverse to the direction of fiber rotation and causing flexing and bending of the fibers whereby to loosen and scour impurities from the fiber surfaces, removing clean open fibers outwardly from the periphery of said gas vortex by entraining them in gas which is withdrawn from the vortex in a tangential direction generally reverse to the direction of vortex flow, and developing inertia momentum of incompletely fiberized material tending to retain it within the vortex.

3. The method of dry crushing, fiberizing and cleaning coarse, fibrous material which comprises, establishing and maintaining a thin suspension of the material in a rapidly rotating gas vortex about a vertical axis, reducing and fiberizing the material by centrifugal impact against peripheral striking surfaces and by mutual impingement of coarse particles, deflecting the rotational gas flow inwardly at said striking surfaces and developing inertia momentum of incompletely fiberized material tending to retain it within the vortex, continuously withdrawing air from the periphery of the vortex in a direction which is tangential to the vortex and generally opposite in direction to the direction of vortex flow, controlling the rate of air removal from the vortex by maintaining a regulated pressure drop between the zone of the vortex and the path of air removal, selectively removing the suitably reduced and fiberized fibers from the vortex by entrainment in the outgoing air, and separating granular and dust impurities from the air suspended fibers by selective cyclone classification.

4. The method of treating crude and coarse fibers to open the fibers and to separate impurities adhering thereto comprising, introducing the crude material into a rapidly rotating hot gas vortex, maintaining a high volume ratio of gas to material to provide a thin suspension of material, combing the fibers into longitudinal alignment with the rotational direction of their movement, reducing and fiberizing the material by impact against striking surfaces and by mutual impingement of particles, periodically deflecting the rotational gas flow inwardly at impact surfaces adjacent the periphery of the vortex, removing clean open fibers outwardly from the periphery of said gas vortex by causing a reversal in the direction of flow of the opened fibers, and adjusting the rate of removal of the opened fibers from the vortex to avoid contamination by gas carrying coarse non-fibrous impurities and incompletely opened fibers in suspension.

5. Apparatus for fiberizing crude fibrous material comprising, an upright cylindrical chamber of substantial depth in relation to its diameter, gas discharge ports opening out of said chamber tangentially at spaced points around the circumference thereof, a crude fiber charging port opening into the chamber, overlapping striker plates disposed to form encircling walls of said chamber between gas discharge ports, and means for setting up and maintaining a high velocity gas vortex within the chamber carrying crude fiber in suspension in a direction opposite to the direction in which gas carrying clean fibers in suspension exits through the gas discharge ports, the impact surfaces of said plates being disposed in inwardly deflecting relation in the path of the gas vortex.

6. Apparatus adapted for the size reduction and fiberizing of coarse fibrous material comprising, an upright cylindrical attrition chamber of substantial depth in relation to its diameter,

peripherally spaced striker plates disposed in overlapping relation about the periphery of said chamber, narrow vertical gas outlet slots each mounted between adjacent striker plates, means for establishing and maintaining a rapidly rotating gas vortex suspension of fibrous material within said chamber, said plates being disposed in inwardly deflecting relation in the path of the gas vortex, an inlet port arranged for introducing coarse and crude fibers into said vortex, gas exit ports leading off from said slots in a direction substantially opposite to the direction of vortex flow, a fiber collector jacket surrounding said chamber into which said exit ports discharge, and a cyclone separator having its inlet port connected with said collector jacket.

7. Apparatus for reducing and fiberizing coarse, fibrous materials as defined in claim 6, in which the collector jacket is connected with the cyclone separator by a port leading off tangentially from the top of the collector jacket, and in which the bottom of the collector jacket comprises an annular outlet port for granular non-fibrous impurities and an inlet port for additional entraining air, thereby converting such collector jacket into a primary cyclone separator.

8. Apparatus adapted for reducing coarse fibrous material comprising, an upright substantially cylindrical attrition chamber, striker plates forming the peripheral walls of said chamber, a plurality of gas injection ports opening at spaced intervals tangentially into said chamber and operable to establish and maintain a rapidly moving gas vortex therein, a vertical slot in the peripheral wall of said chamber spaced from adjacent gas inlet ports, a gas exit port leading off from said slot tangentially in a direction substantially opposite to the direction of vortex flow, a fiber collecting jacket surrounding said chamber into which said exit port discharges, means for introducing coarse fiber into the chamber at points adjacent the gas inlet ports, and means for maintaining a pressure in the jacket which is lower than that in the attrition chamber.

9. The method of treating crude and coarse fibers to open the fibers and to separate impurities adhering thereto which comprises, forming and maintaining a thin suspension of the crude fibers in a rapidly rotating gas vortex, combing the fibers into longitudinal alignment with the rotational direction of their movement by transporting the fibers in suspension within the vortex periphery at high velocity and in a path of substantial length, periodically deflecting the rotational gas flow inwardly at impact surfaces around the periphery of the vortex thereby flexing and bending the fibers and opening the same, inducing gas flow outwardly from the vortex at spaced points around the periphery thereof in a direction reverse to the direction of vortex flow, and removing well opened fibers from the vortex by entraining them in the reversely outwardly flowing gas.

10. Apparatus adapted for reducing and fiberizing coarse fibrous material comprising, a cylindrical attrition chamber having a depth which is substantial in relation to its diameter and having a major volumetric proportion of free space, means for developing and maintaining a thin suspension of said material in a rapidly rotating gas vortex within said chamber, closely spaced striker plates forming an encircling peripheral wall lining for said chamber, said plates overlapping each other in the direction of vortex flow and having their impact surfaces disposed in inwardly deflecting relation in the path of the vortex, and a narrow gas exit port for removing fiberized fibers, said port being located between adjacent overlapping striker plates and opening out tangentially from said chamber in a direction opposite to that of vortex flow.

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