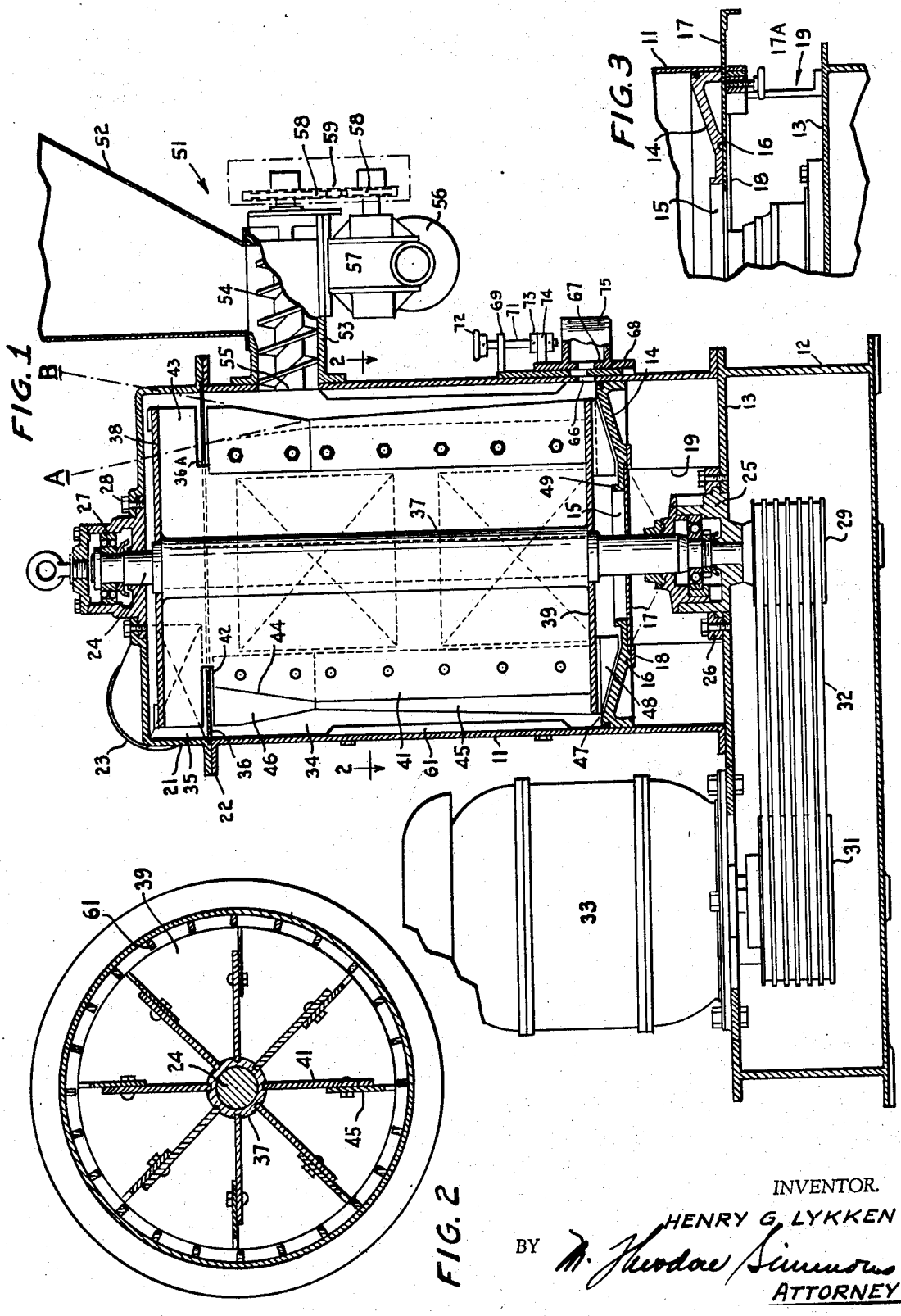
Sept. 14, 1943. H. G. LYKKEN 2,329,208

PULVERIZING AND CLASSIFYING MACHINE

Filed May 29, 1940 3 Sheets-Sheet 1

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PULVERIZING AND CLASSIFYING MACHINE

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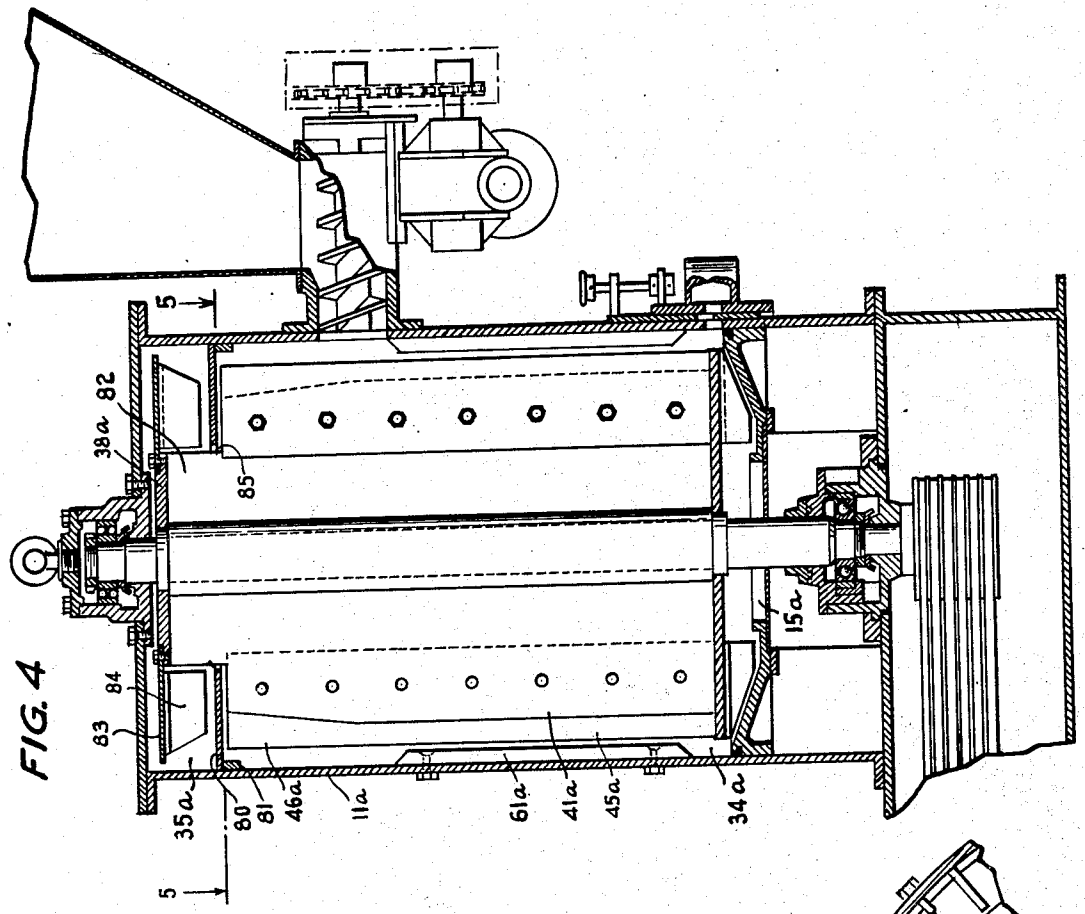


FIG. 4

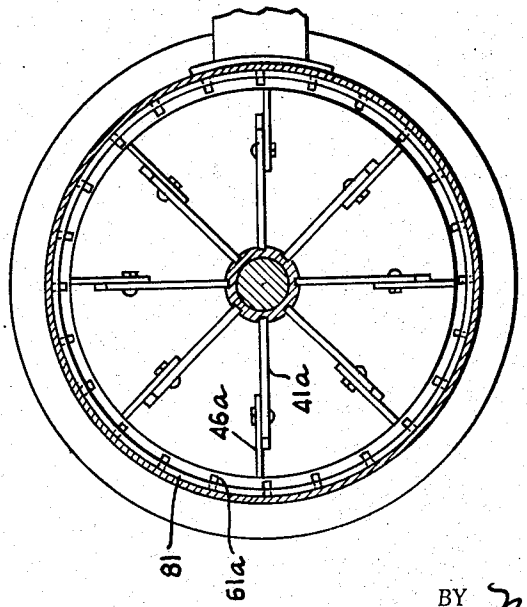


FIG. 5

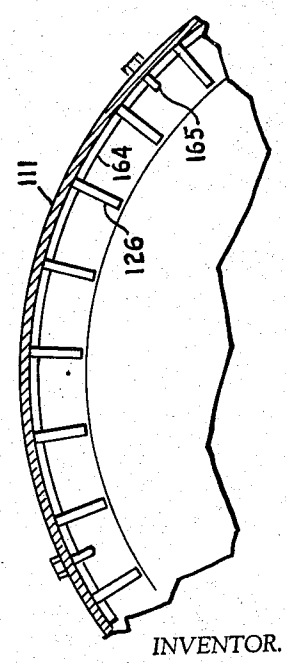


FIG. 10

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PULVERIZING AND CLASSIFYING MACHINE

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FIG. 9

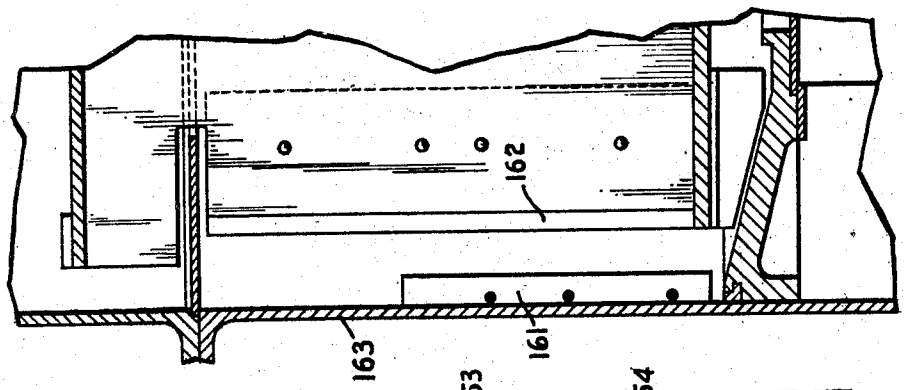



FIG. 8

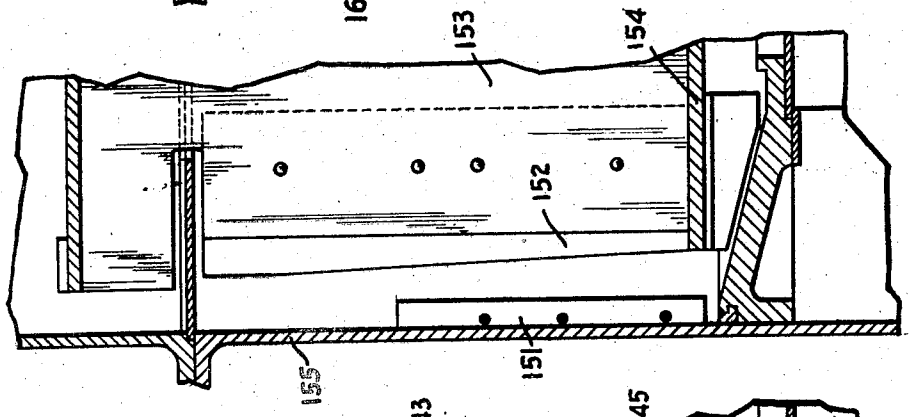



FIG. 7

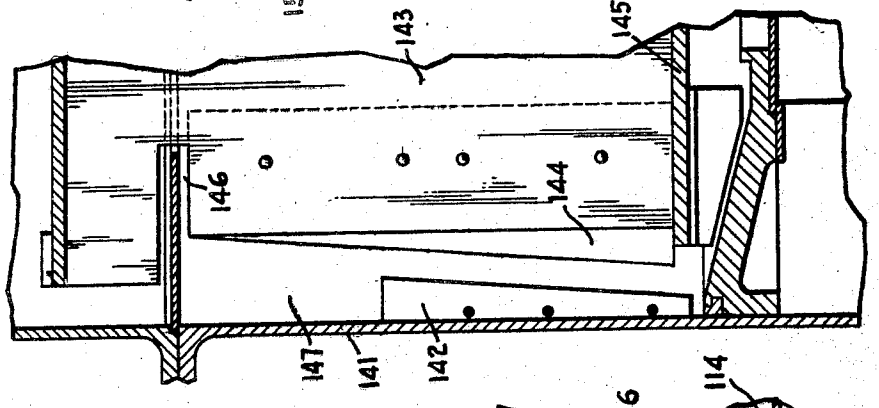
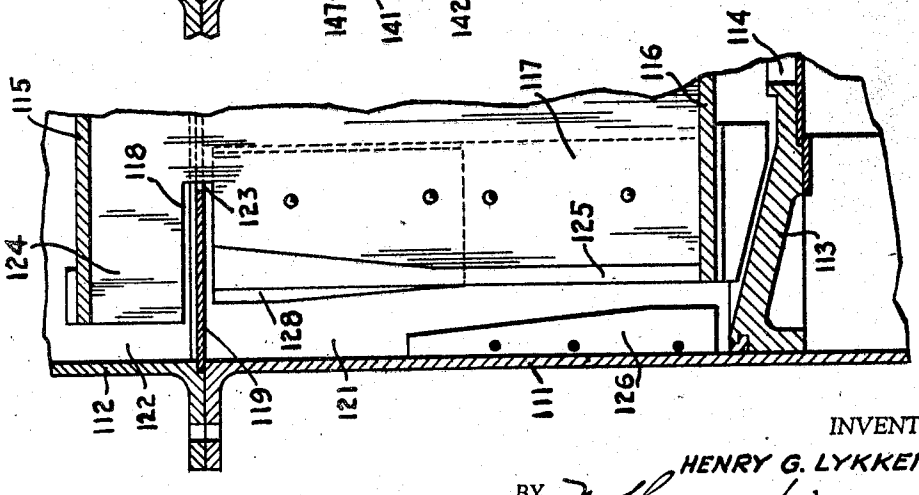



FIG. 6

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Patented Sept. 14, 1943

2,329,208

# UNITED STATES PATENT OFFICE

2,329,208

## PULVERIZING AND CLASSIFYING MACHINE

Henry G. Lykken, Minneapolis, Minn.

Application May 29, 1940, Serial No. 337,742

14 Claims. (Cl. 83—11)

My invention relates to apparatus for reducing materials in particle size and for selecting the particle sizes delivered by the apparatus.

My prior Patent No. 1,838,560, issued December 29, 1931, for example, shows a machine for pulverizing materials by whirling the materials, while suspended in air or other gaseous medium, in a high speed vortex. This has proven to be a very effective and practical method of pulverization, especially of friable materials. From time to time various improvements have been made in machines embodying this same vortex principle of pulverization, including improvements in means and methods of classification to determine the particle size or the maximum particle size delivered from the machine. In the co-pending application of applicant and William H. Lykken, Serial No. 285,484, filed July 20, 1939, there is shown a machine in which pulverization and classification are effected in the same chamber in which a bladed rotor occupies the full height of the chamber and is rotated to set up and maintain the vortex action. Thus, there is no space for vortex action free from the direct action of the rotor. The rotor is of the closed end type but a current of air is induced along its axis which air is drawn inwardly from the vortex that is around the rotor and passes out of the chamber through an axially disposed opening in the rotor. This induced air current and the rotor blades are proportioned to set up a differential action by which material of the desired particle size is withdrawn from the vortex and carried out of the machine, to be collected by any suitable collection system, while oversize material remains in the chamber for further pulverization.

A limiting factor of pulverizing machines of the above indicated character, particularly when using a vortex having a vertical axis, has been the tendency of materials of high specific gravity to accumulate at the bottom of the rotor chamber during pulverization and the tendency of mixed materials, having ingredients of different specific gravities, to segregate. Again, continued feeding material above the rated capacity would almost certainly produce the result of an excessive circulating load at the bottom of the rotor and might even result in mass grinding of material at this point, either of which conditions would lower the efficiency of the machine, as well as its effectiveness.

Another limiting factor has been that a particular machine would be suitable for only a few materials, while other materials would require another machine re-proportioned in substantially its entirety, and this has been true to some extent when different particle sizes of the same material have been desired.

Another limiting factor has been a low efficiency with certain fibrous materials.

The present invention relates to a machine of the type shown in the aforesaid co-pending application and overcomes all of the foregoing limitations.

It is one object of my invention to provide a pulverizing machine of the above indicated character in which the distribution of the circulating load in the pulverizing vortex is controlled so as to maintain the material in suspension evenly distributed without any excessive load in any part of the vortex, and notwithstanding the different specific gravities of materials.

It is another object of my invention to provide a machine of the above indicated character in which the same mechanism can be used for a wide variety of materials to be reduced, with only a simple replacement or adjustment of removable elements.

It is another object of my invention to provide a machine of the above indicated character in which by simple adjustment the same mechanism can be used to deliver particle sizes of the same or of different materials within wide limits.

It is another object of my invention to provide a machine of the above indicated character in which differential or selective pulverization is effected, i. e. where useful materials such as talc, graphite, clay, and materials suitable for fillers and coatings may be contaminated with impurities such as silica sand. In this case the useful material is pulverized to the desired degree while the impurity falls to the bottom of the machine and is removed with a negligible amount of, or no, pulverization. Likewise, different degrees of pulverization might be effected simultaneously for materials of different specific gravity.

It is another object of my invention to provide a mechanism of the above indicated character which may be readily and easily adapted for a wide variety of fibrous as well as non-friable materials.

Further objects of my invention are to provide a machine of the above indicated character in which the efficiency of the machine is increased substantially; in which the capacity of the machine for a given size of material delivered is increased substantially, and in which the amount of the circulating load carried by the vortex may be

increased while any excess above the capacity of the vortex will be discharged continuously from the machine and may be returned to the feed without disrupting the pulverizing effect of the vortex at any level.

Other and further objects of my invention will be appreciated from this specification taken in conjunction with the accompanying drawings, in which—

Figure 1 is a vertical sectional view of a pulverizing machine according to my invention;

Fig. 2 is a cross section on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary detail of the air control;

Fig. 4 is a vertical section of a modified form of mechanism, parts being broken away;

Fig. 5 is a cross section on the line 5—5 of Fig. 4;

Figs. 6, 7, 8 and 9 are respectively fragmentary views showing different arrangements of rotor and casing.

Fig. 10 is a detail showing one construction of ribbed lining.

According to the present invention, a cylindrical casing is provided with a bladed rotor extending the full height thereof and rotatable therein. The rotor is divided near the upper end thereof with a portion in an exhaust fan chamber and the remainder in the chamber in which both pulverization and classification take place. The exhaust fan need not be part of the same rotor and need not be in the same casing. In one form of machine, the rotor blades are spaced from the casing wall so as to leave an annular space therebetween in which the rotor sets up a high speed vortex. In some instances the blades are desirably so spaced from each other that vortices are also set up between the blades. These intra-blade vortices will be of even higher speed than the main or annular vortex, but they overlap or inter-engage with and are fed from the main vortex. In either case, air is admitted into the annular vortex zone from beneath the closed bottom disc of the rotor, and the sufficiently pulverized material is withdrawn from the pulverizing chamber along the axis of the rotor, being discharged into the exhaust fan chamber, and thence radially from that fan.

The material is fed into the vortex adjacent the top thereof. As the material enters it is picked up in the vortex, and under the action of gravity spirals slowly downwardly in this annular zone. At the same time, pulverization of the suspended particles by impingement, etc., upon each other proceeds. The proportioning of the apparatus is such that the material is maintained in suspension in the vortex and may be such that complete pulverization occurs before the bottom of the vortex chamber is reached. Again the arrangement may be such, as in differential grinding with impurities of higher specific gravity than the desired material, that certain materials will be permitted to gravitate to the bottom of the chamber and be blown out at that level. Again with some materials it is desirable to apparently overfeed the machine, so as to bring about a full and even distribution thereof over the entire vortex zone, while the excess will be blown out, to be returned to the feed. The rotor of the casing (or its lining) or both may be tapered so as to assist in the matter of maintaining the material evenly distributed in the vortex without any excess load at any level. These several adjustments are made easily by detachable rotor blades of the proper shape, and a detachable lining or ribs.

The exhaust fan draws air inwardly into the rotor and along the hub thereof out of the main chamber and into the exhaust fan or discharge chamber. The force of the withdrawn air current versus principally the centrifugal forces within the pulverizing and classifying chamber determines the size of the delivered particles, or the maximum size thereof. The rotor blades may be straight, or tapered inwardly or outwardly from the bottom to the top, or plates may be super-imposed upon the rotor adjacent the outlet from the pulverizing and classifying chamber, which plates will have a particular taper in accordance with the delivered particle size desired. Accordingly, the same rotor can be used for a given material, and the same exhaust fan, together with the same casing, yet particle sizes varying between 10 microns and 147 microns (approximately 100 screen mesh) can be obtained at will.

In another arrangement of apparatus, especially adapted for fibrous materials, wood flour, grains, etc., the rotor blades operate in close clearance with the lining or ribs on the casing wall so that something akin to a shearing action takes place between the blades and ribs. The centrifugal actions of the continuous blades force the material to the outside of the rotor, while the air, circulating in and out of the chamber as described above, carries away the material that is sufficiently reduced in size, etc., all as described above.

Referring to the form of the invention shown in Figs. 1, 2 and 3, the cylindrical casing 11 is suitably mounted upon a hollow base 12, the top plate 13 of which closes the casing at the bottom. Suitably mounted within the casing 11 and spaced above the plate 13 is a saucer-shaped member 14 which constitutes the base of the pulverizing and classifying chamber. The base 14 has a central opening 15 therein and on its under surface a depending boss 16 (Figs. 1 and 3) about the opening 15. The opening is closed by one or more slidable plates 17, which are slidably supported in the guides 18, the plates being locked in adjusted position by the screw 17A. The plates 17 control the amount of air admitted into the pulverizing and classifying chamber through the opening 15, which air enters the casing 11 through an opening 19 therein.

The top of the casing 11 is closed by a head 21, the head and casing having complementary flanges, indicated at 22, which are suitably bolted together. The head has a discharge outlet 23 at one side thereof, the arrangement for mounting the head being such that the discharge outlet can be variously located around the circumference of the pulverizing machine to meet the particular installation conditions.

A shaft 24 extends centrally through the casing and head, projecting above the head 21 and into the hollow base 12 at the respective ends thereof. The lower end of the shaft 24 is mounted in a self-aligning thrust bearing 25 which is fastened upon the plate 13 of the base structure 12 by means of the split ring 26 that is suitably bolted to the base 12. The upper end of the shaft is also mounted in a self-aligning bearing 27 which is suitably bolted to the head 21 as indicated at 28. On the lower end of the shaft 24 that projects into the hollow base 12 is a grooved pulley 29 which is connected to a pulley 31 by means of a plurality of belts 32, the pulley 31

being on the shaft of a motor 33 which is mounted on top of the base plate 13 with its shaft projecting therethrough into the hollow base.

The space in the casing 11 and the head 21 is divided into two chambers 34 and 35 respectively, which are separated by a split ring 36 that is held in place on top of the casing 11 by the head 21 as shown. Chamber 34 is the pulverizing and classifying chamber and chamber 35 is the outlet chamber, the opening 36A in ring 36 constituting the outlet opening from chamber 34 to chamber 35.

A hub 37 of a rotor is mounted on that portion of the shaft 24 within the chambers 34 and 35. Also mounted on the shaft at the top and bottom of the hub 37 are flat round discs 38 and 39, which extend outwardly toward the side walls of the head and casing respectively but are spaced therefrom. Between the discs 38 and 39 are a plurality of imperforate radial blades 41, these blades being mounted in slots in the hub 37 and being welded to the hub, and to the discs 38 and 39. These blades are radially slotted, as shown at 42, to provide clearance for the split ring 36 so that the rotor will rotate free thereof. As will be seen from Fig. 1, the portion 43 of the blades above the ring 36 extend the full distance outwardly to the edge of the top plate 38, while the lower portion of the blades 41 do not extend outwardly to the edge of the bottom disc 39. Also, the upper portion 44 of the blades 41 are tapered, being narrowest at the slot 42 and tapering outwardly and downwardly therefrom.

Within the chamber 34 the rotor is completed by the addition of removable plates 45 and 46, which are bolted to the blades 41. Plates 45 extend a major part of the height of chamber 34 and are shown as having an outer edge which tapers inwardly and upwardly from the outer edge of the bottom disc 39, thus producing a rotor of similar tapered construction, for reasons to be hereinafter referred to. The angle or degree of the taper of plates 45 may be altered, and these plates in some instances will have no taper whatever, thus presenting a rotor of uniform diameter. Plates 46 extend from the top of plate 45 to the level of the bottom of the slot 42, and complete that slot. The outer edges of plates 46 are tapered upwardly and outwardly from the juncture with the plates 45. For purposes to be hereinafter outlined, the angle or degree of the taper of plates 46 may be selected, according to conditions, to be anywhere between the angles indicated by the dot and dash lines A and B of Fig. 1, located approximately 12° either side of the vertical.

As has been stated, air is admitted into the chamber 34 through the opening 15 of the bottom 14, which is beneath the bottom disc 39 of the rotor. It will be noted from Fig. 1 that the outer edge of the bottom disc operates in fairly close clearance with the perimeter of the bottom 14, leaving an annular opening 47 through which air passes into the pulverizing and classifying chamber 34 in the space between the rotor and the casing. Fastened to the underside of the rotor disc 39 are a plurality of short radial fan blades 48, the lower edges of which are shaped to operate in close clearance with the bottom 14, as shown. These blades act as a centrifugal fan to force air into the annular space between the rotor and casing, and the collar 49 around the opening 15 serves to insure that the air is carried into the eye of the fan.

Material to be pulverized is fed into the chamber 34 by the feed mechanism 51 comprising feed hopper 52 which opens into a tube 53 in which operates a screw conveyer 54. The casing 11 has a feed opening 55 near the top thereof, and the tube 53 is mounted over that opening. The screw 54 is driven by the motor 56 through a speed reduction gearing 57, a pair of sprockets 58 and cooperating chain 59. The sprockets 58 are removable, and in order to obtain different rates of feed it is merely necessary to change one or both of the sprockets.

The interior of the casing 11 may be provided with a plurality of vertically extending corrugations or ribs 61. The depth of these ribs is exaggerated in the drawings, and the showing in Fig. 2 of the spacing thereof is largely diagrammatic, as the depth and particular spacing will vary with different materials. In one machine, pulverizing the ribs were $\frac{3}{8}$ inch wide by $\frac{3}{4}$ inch deep, and spaced on $2\frac{1}{2}$ inch centers.

In operation, material to be pulverized is fed from the hopper 52 into the chamber 34 by the feed screw 54. The rotor has previously been set into operation and air admitted into the machine through the openings 19 and 15, so that the rotor has set the air whirling in a high speed vortex. The entering material is picked up in that vortex and carried by the same in suspension, the material spiralling downwardly slowly under the action of gravity working in opposition to the tendency of the vortex to maintain the material in suspension, and in opposition to the current of air entering the annular vortex zone at the bottom and ascending therethrough. The particles of material strike each other violently as they move about in the vortex, and thus are broken up. Reduction also occurs by frictional interengagement of the particles. The particles are non-uniform in size so that under the action of the centrifugal force in the vortex they move about with the smaller and lighter particles moving inwardly toward the geographical center of the vortex, and the heavier and larger particles moving to the wall of the casing, as they whirl in the vortex. When a particle is broken into smaller pieces, these move in the vortex according to the same law, producing other impingements, and thus a very violent pulverizing action takes place. Furthermore, the ribs 61, in the structure of Fig. 1, act as means for retarding the movement of the outer layers of the circulating load of material in the vortex zone, thereby producing a greater differential of movement between the material in the outer part of the annular vortex and that carried nearer the rotor, and causing a more violent reducing interaction between the particles in the vortex.

With lighter weight materials, the rotor blades may be straight, i. e., neither tapered inwardly or outwardly; while with heavier materials the plates 45 may be tapered inwardly and upwardly as shown in Fig. 1. This latter arrangement produces a component force at an upward angle with respect to the horizontal, thus further retarding the downward movement of the material under the action of gravity. In both cases, the arrangement is desirably such that no material will reach or accumulate on the floor 14 of the rotor chamber, all the material being pulverized sufficiently before reaching the bottom 14.

Again, as will be explained later, the blades or plates may be tapered entirely from considerations of particle size of material delivered from the machine.

In addition to the pulverizing action that has been referred to, further pulverization will occur in the individual high speed vortices set up between each pair of rotor blades, when the blades are so spaced apart that a vortex is created between each set of blades due to the relationship of the leading face of one blade and the trailing face of the preceding (in the direction of rotation) blade. A formula for obtaining such action is set forth in my co-pending application Serial No. 110,732, filed November 13, 1936. Such vortices occur within the rotor and hence within the annular vortex, except that the inner surface of the annular vortex and the outer surfaces of the small vortices overlap or inter-engage so that the finer material passes from the annular vortex into the smaller vortices, where further reducing actions occur on the same principles as in the annular vortex.

Just as soon as material is reduced to the desired size it is important that the same be removed promptly from the chamber **34** because no further work need be done with respect thereto and because its presence interferes with pulverization of the material not yet sufficiently reduced. At the same time, it is important that only the material that is sufficiently reduced in particle size should be removed immediately from the chamber **34**. For this removal purpose the fan **43** in the chamber **35** induces an air current along the hub of the rotor and through the outlet opening **36A**. The proportioning is such that the finished material is removed while that which is oversize remains for further reduction.

Thus air and material sufficiently reduced in size to be carried by this air is drawn substantially radially into the rotor and upwardly along the hub **37**, through the opening **36A** into the fan chamber **35**, and thence out of the machine through the outlet **23**. The prompt removal of this material is aided by the vertical rise of the air admitted through the annular opening **47** into the vortex zone at the bottom.

With regard to classification or selection of particle size, it has been noted above that the plates **46** may be tapered outwardly or inwardly at any angle between the lines B and A, respectively, thus producing a correspondingly shaped rotor. The degree and nature of the taper will be altered in accordance with whether very fine particle sizes are desired, or coarser particle sizes. With the blades inclined as shown in Fig. 1, only very fine particle sizes will be delivered while very much coarser particle sizes will be obtained if the plates are tapered to coincide with the line A. Angles intermediate between these two points, will cause intermediate sizes of material to be withdrawn from the chamber **34** and delivered from the machine, and even slight changes in the angle produce substantial changes in size of particles.

With the blades tapered as shown in Fig. 1, it will be apparent that there is a maximum centrifugal force adjacent the outlet **36A**, which force acts upon the particles passing upwardly through the rotor to eject any remaining oversize particles from the rotor as the same approach the outlet. An alternate consideration is that the fan section **43** draws a column of air through the outlet opening **36A** unless some counteracting force interferes therewith. The greater the centrifugal force of the blades and plates **46**, up to the limit determined by the angle B, the smaller will be the area of the air column which passes undisturbed and directly into the fan chamber **35** through the outlet **36A**. The normal vortex action will bring the finer particles to the hub **37** and the particles will be progressively larger in size toward the outside of the vortex. Hence with the wide plates **46** at the upper end of the chamber **34** diverting the outer portion of the column of air, with the correspondingly heavier material, permits only the finer material to pass directly into the fan chamber **35**. Conversely the less the taper at the upper part of the pulverizing and classifying rotor section, the less centrifugal force will act upon the column adjacent the outlet, and hence the coarser will be the material delivered to the fan chamber **35** and through the machine outlet **23**.

As indicated above, in some cases it is desirable to do differential grinding, that is to say, if talc is contaminated with silica sand, it is feasible and practical with the machine shown in Fig. 1 to pulverize the talc to whatever size desired, and to eject the silica sand substantially without being pulverized, at least to a size which would be carried off with the talc. This latter material being of lower specific gravity and more friable than the silica sand will be sufficiently pulverized in less time than could any appreciable reduction be made on the silica sand, which will then readily find its way to the bottom of the chamber **34**. I have found it practical to continuously remove the silicia sand or other impurity from the chamber **34** while the pulverizing and classifying actions are taking place. For this purpose I provide one or more openings **66** at the bottom level of the chamber **34** and close the same by means of a gate valve **67** operating in a guide **68**. The guide **68** is mounted upon the arm **69** which is screw threaded to receive the threaded shaft **71** of an adjusting screw **72** which is rotatably mounted in the bushing **73** carried by the fixed arm **74**. The guide **68** has an outlet nozzle **75** with which can be connected to a hose or any other suitable conveyer or container for receiving the material discharged through the opening **66**. The centrifugal pressure in the chamber **34** will be sufficient to act upon the material reaching the bottom **14** of the chamber **34** to force the same out of the chamber as it is carried around in the vortex at this point, and there will not be enough such holes to interfere, as a practical matter, with the actions occurring in the chamber.

This blow-off and gate valve arrangement is also useful in other cases than with differential grinding. For example, with some materials it is desirable to feed into the vortex a greater amount of material than can be normally sufficiently pulverized therein before the material reaches the bottom **14**. In such cases, the presence of the blow-off opening **66** will enable the excess material to be removed from the bottom without accumulating there or causing an excessive circulating load at this point. At the same time being able to remove this excess material insures use of the entire vortex zone. The material removed through the opening **66** can be fed back into the hopper to be re-fed into the machine.

It will be understood that the arrangement of the fan blades **48** for directing the air into the pulverizing and classifying chamber **34** not only serves to overcome any centrifual pressure in this chamber, but also provides a running seal against any material getting through the opening **47** and

beneath the rotor bottom disc 39. If on the shutdown any small amount of material left in the machine settles to the bottom of the chamber, it is immediately blown out into the chamber when the rotor is started up again. Also, it will be understood that the feeding mechanism 51 is merely symbolical of other arrangements that may be used for effecting a feed of a controlled amount of material directly into the vortex zone.

Referring now to Figs. 4 and 5, there is shown a machine similar in construction to the machine of Fig. 1, except that in this case the rotor plates 45a, attached to the rotor blades 41a are arranged to operate in close clearance with the ribs or bars 61a. In this case the plates 46a are likewise shown as having a straight outer edge in line with the outer edges of the plates 45a, but these plates 46a may be tapered inwardly or outwardly similarly to the plates 46 as described in connection with Fig. 1.

This disclosure also shows the optional arrangement of having the cylinder wall 11a extend sufficiently far to enclose the fan chamber 35a, with the ring 80 (not necessarily split) resting upon supports 81 that are fastened to the interior of the casing 11a. The top disc 38a of the rotor is foreshortened, and the portions 82 of the rotor blades 41a entering the fan chamber 35a do not extend outwardly to form the fan. Instead a second ring shaped disc 83 is bolted to the disc 38a and has depending therefrom a plurality of fan blades 84. Air is admitted to the pulverizing and classifying chamber 34A through opening 15A as described for the machine of Fig. 1. Likewise material is fed in the same manner, and is withdrawn through the opening 85 in ring 80, and from the machine through an outlet opening that is not shown.

The construction just described is especially suitable for grinding fibrous materials such as wood flour. In order to effect the reduction in size of these materials it has been found desirable to provide a cutting or shearing action thereon, and such action is obtained between the plates 45a and the ribs 61a in the machine of Fig. 4. Inasmuch as the annular space shown in Fig. 1 between the rotor and chamber has been done away with in Fig. 4, there will be no pulverizing vortex of air suspended material set up around the rotor in the latter case. However, the rotor blades 41A and their plates will function to keep the larger material moving to the casing wall, and the classification of the particle sizes of the finished material will follow the same principles as outlined above in connection with Figure 1.

Fig. 6 indicates a form of mechanism which has been successfully used commercially in pulverizing a mixture of sugar and cocoa, among other things, to a particle size of all less than 45 microns.

The basic construction of casing 111, head 112 and base 113 with a central air opening 114 is the same as that in Fig. 1. Likewise, the rotor comprises a top disc 115, a bottom disc 116, and a plurality of radial blades 117 which are slotted at 118 to provide running clearance for a split ring 119 mounted between the casing 111 and the head 112 to form a lower pulverizing and classifying chamber 121 and an upper outlet chamber 122 jointed by the opening 123, all in accordance generally with the construction of Fig. 1. An outlet opening is provided from the chamber 122 and the portion 124 of the rotor blades constitutes a fan for the radial discharge of the finished material.

Within the chamber 121 the rotor blades 117 have bolted thereto a plate 125 which in this case, extends from the lower disc 116 to the lower edge of the slot 118, and the outer edge of the plate extends perpendicularly to the lower disc 116. The interior of the casing 111 in the chamber 121 is provided with a plurality of retarder ribs 126 which are widest at the bottom, and the inner edges of which extend parallel with the rotor blades for a short distance, then taper upwardly and outwardly to the top. This construction likewise aids in keeping the material distributed above the floor 113 of the chamber 121.

In this case plates 128 are added to the plates 125, at the top of the rotor in chamber 121 to give the particular particle size classification desired. It will be noted that the outer edges of these plates taper upwardly and outwardly a substantial part of the height, and each has an upper edge portion which is parallel with the rotor blade plate 125.

It will be understood that these plates 125 and 128 and the ribs 126, as in all cases, may be made of any suitable material. The machine of Fig. 6 operates in accordance with the principles outlined in connection with Fig. 1 both as to pulverization and classification.

Figs. 7, 8 and 9 illustrate alternate arrangements and relationships of rotor blading and retarder ribs which may be used for different materials and different particle sizes. In Fig. 7 the casing 141 has retarder bars 142 thereon which taper inwardly and upwardly from the bottom, and the rotor blades 143 have fastened thereto plate 144 the outer edges of which taper inwardly and upwardly from the bottom disc 145 to the slot 146. It will be noted that the inner and outer edges of the ribs 142 and plates 144 respectively are parallel, but that the ribs do not extend the full height of the pulverizing and classifying chamber 147.

In the machine of Fig. 8 the retarder ribs 151 have straight inner edges but the plates 152 bolted to the blades 153 of the rotor taper upwardly and outwardly from the bottom disc 154 to a point beyond the upper ends of the ribs 151 and then the outer edge is parallel with the casing wall 155.

In the machine of Fig. 9 the retarder ribs 161 are similar to the ribs 151 and the outer edges of plates 162 are vertical and parallel with the inner edges of the ribs 161 and the casing wall 163.

In each of Figs. 7, 8 and 9 the mechanism operates on the same principles as the machines of Figs. 1 and 6. The arrangement of Fig. 7 will be used for coarser grinding of between 100 and 200 screen mesh. That of Fig. 8 will be used for a very fine particle sizes of about 10 microns, while that of Fig. 9 will deliver material of particle sizes between 200 and 250 screen mesh. These examples will apply to a mill having a pulverizing and classifying chamber 15 inches in height; and it will be noted that there is but a single removable plate on the rotor blades in each case. The alternate method of fineness control is that described in connection with Fig. 6, for example, where additional plates are superimposed on the rotor blades adjacent the outlet and having whatever shape at the outer edges may be desired for the particular particle size to be delivered.

The detail showing one arrangement for mounting the ribs in all the constructions illustrated herein is detailed in Fig. 10. The ribs 126 may be strung on two or more cables 164 of a length approximately that of the inner circumference of the casing 111, and the ribs are held

against the casing wall by a plurality of spaced apart clamping bolt 165 which are mounted in the casing and engage the cables, as indicated.

The foregoing examples illustrate the new principles of this invention, and the obtaining of the desired results for a wide variety of materials using the same mechanism but with interchangeable plates to meet the specific conditions of material and particle size wanted. Various combinations of the several plate arrangements can be used, and the rotor blade or a single blade may have the several angles indicated for the outer edges of the plates.

Other modifications may be made in the arrangement and location of parts within the spirit and scope of my invention, and such modifications are intended to be covered by the appended claims.

I claim:

1. In a pulverizing and classifying machine, a cylindrical casing provided with a base having an air opening therein, a head, and a ring dividing the casing and head into separate chambers with a central communicating opening therebetween, a rotor mounted vertically in the casing and spaced from the casing to provide a pulverizing vortex zone around the rotor, said rotor comprising a shaft extending centrally through said casing, top and bottom imperforate discs mounted on the shaft adjacent said head and base, a plurality of radial blades mounted on the shaft and extending between the discs, the blades being slotted to provide a running clearance for said ring, a removable plate secured to each blade within the casing chamber and extending radially to the outer edge of the bottom disc, the outer edges of the plates being tapered from said bottom disc toward the slot for said ring, other plates secured to said rotor blades and extending downwardly from the slot for said ring and having the outer edges thereof tapered, retarder bars on the interior of the casing at least partly co-extensive with the rotor and spaced from the rotor, means adjacent the upper end of the casing chamber for feeding thereto material to be pulverized, a motor for driving the rotor, and an outlet in said head for pulverized material.

2. In a pulverizing and classifying machine, a cylindrical casing provided with a base having an air opening therein, a head, and a ring dividing the casing and head into separate chambers with a central communicating opening therebetween, a rotor mounted vertically in the casing and spaced from the casing to provide a pulverizing vortex zone around the rotor, said rotor comprising a shaft extending centrally through said casing, top and bottom imperforate discs mounted on the shaft adjacent said head and base, a plurality of radial blades mounted on the shaft and extending between the discs, the blades being slotted to provide a running clearance for said ring, a removable plate secured to each blade within the casing chamber and extending radially to the outer edge of the bottom disc, the outer edges of the plates being tapered inwardly and upwardly from said bottom disc toward the slot for said ring, other plates secured to said rotor blades and extending downwardly from the slot for said ring and having the outer edges thereof tapered inwardly and downwardly therefrom, retarder bars on the interior of the casing at least partly co-extensive with the rotor and spaced from the rotor, means adjacent the upper end of the casing chamber for feeding thereto material to be pulverized, a motor for driving the rotor, and an outlet in said head for pulverized material.

3. In a pulverizing and classifying machine, a cylindrical casing provided with a base having an air opening therein, a head, and a ring dividing the casing and head into separate chambers with a central communicating opening therebetween, a rotor mounted vertically in the casing and spaced from the casing to provide a pulverizing vortex zone around the rotor, said rotor comprising a shaft extending centrally through said casing, top and bottom imperforate discs mounted on the shaft adjacent said head and base, a plurality of radial blades mounted on the shaft and extending between the discs, the blades being slotted to provide a running clearance for said ring, a removable plate secured to each blade within the casing chamber and extending radially to the outer edge of the bottom disc, the outer edges of the plates being tapered outwardly and upwardly from said bottom disc toward the slot for said ring, other plates secured to said rotor blades and extending downwardly from the slot for said ring and having the outer edges thereof tapered outwardly and downwardly therefrom, retarder bars on the interior of the casing at least partly co-extensive with the rotor and spaced from the rotor, means adjacent the upper end of the casing chamber for feeding thereto material to be pulverized, a motor for driving the rotor, and an outlet in said head for pulverized material.

4. In a pulverizing and classifying machine, a cylindrical casing provided with a base having an air opening therein, a head, and a ring dividing the casing and head into separate chambers with a central communicating opening therebetween, a rotor mounted vertically in the casing and spaced from the casing to provide a pulverizing vortex zone around the rotor, said rotor comprising a shaft extending centrally through said casing, top and bottom imperforate discs mounted on the shaft adjacent said head and base, a plurality of radial blades mounted on the shaft and extending between the discs, the blades being slotted to provide a running clearance for said ring, a removable plate secured to each blade within the casing chamber and extending radially to the outer edge of the bottom disc, other plates secured to said rotor blades and extending downwardly from the slot for said ring and having a portion of different diameter than the first mentioned plates with the outer edges thereof parallel with the casing and thence tapered toward the first mentioned plates, retarder bars on the interior of the casing at least partly co-extensive with the rotor and spaced from the rotor, means adjacent the upper end of the casing chamber for feeding thereto material to be pulverized, a motor for driving the rotor, and an outlet in said head for pulverized material.

5. In a pulverizing and classifying machine, a cylindrical casing provided with a base having an air opening therein, a head, and a ring dividing the casing and head into separate chambers with a central communicating opening therebetween, a rotor mounted vertically in the casing and spaced from the casing to provide a pulverizing vortex zone around the rotor, said rotor comprising a shaft extending centrally through said casing, top and bottom imperforate discs mounted on the shaft adjacent said head and base, a plurality of radial blades mounted on the shaft and extending between the discs, the blades

being slotted to provide a running clearance for said ring, removable plates secured to the blades within the casing chamber and extending radially therefrom to define the outer edge of the rotor, the outer edges of the plates for each of said blades being tapered upwardly from said bottom disc toward the slot for said ring and tapered downwardly from adjacent said slot but at a different angle from the upward taper, the tapers being toward a common level between the slot and bottom disc, retarder bars on the interior of the casing at least partly co-extensive with the rotor and spaced from the rotor, means adjacent the upper end of the casing chamber for feeding thereto material to be pulverized, a motor for driving the rotor, and an outlet in said head for pulverized material.

6. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with the central opening of the ring providing communication between the chambers, a rotor vertically mounted in and extending the full height of the pulverizing and classifying chamber and spaced from said casing, the rotor being operated to provide a pulverizing vortex of air and suspended material in the zone around the rotor, and comprising an imperforate bottom disc, a hub, and a plurality of radial blades mounted thereon and extending from the disc to adjacent the ring which partly overlies the blades, a removable plate on each of said blades and extending radially beyond the outer edges of the blades, the outer edges of said plates adjacent the ring being tapered downwardly to govern the fineness of the particle size of pulverized material delivered from the machine, an outlet in said outlet chamber, fan means for withdrawing sufficiently pulverized material from the pulverizing and classifying chamber through the opening in said ring and delivering the same through said outlet, means for feeding material to the pulverizing and classifying chamber near the top thereof, and a motor connected to operate said rotor.

7. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with the central opening of the ring providing communication between the chambers, means for feeding material to the pulverizing and classifying chamber near the top thereof, a rotor vertically mounted in and extending the full height of the pulverizing and classifying chamber and spaced from said casing, the rotor being operated to provide a pulverizing vortex of air and suspended material in the zone around the rotor, and comprising an imperforate bottom disc, a hub, and a plurality of radial blades mounted thereon and extending from the disc to adjacent the ring which partly overlies the blades, a removable plate along each of said blades and extending radially to the edge of said bottom disc, the outer edges of said plates being tapered upwardly in the lower part thereof to maintain the material being pulverized distributed in the pulverizing vortex, an outlet in said outlet chamber, fan means for withdrawing sufficiently pulverized material from the pulverizing and classifying chamber through the opening in said ring and delivering the same through said outlet, and a motor connected to operate said rotor.

8. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with the central opening of the ring providing communication between the chambers, means for feeding material to the pulverizing and classifying chamber near the top thereof, a rotor vertically mounted in and extending the full height of the pulverizing and classifying chamber and spaced from said casing, the rotor being operated to provide a pulverizing vortex of air and suspended material in the zone around the rotor, and comprising an imperforate bottom disc, a hub, and a plurality of radial blades mounted thereon and extending from the disc to adjacent the ring which partly overlies the blades, a removable plate along each of said blades adjacent the bottom disc and extending radially to the edge thereof, the outer edges of said plates being tapered upwardly to maintain the material being pulverized distributed in the pulverizing vortex, an additional removable plate along each of said blades adjacent said ring and extending radially, the outer edges of said additional plates being tapered downwardly at an angle within an area of 12° of either side of a vertical line intersecting the taper near the base thereof so as to govern the fineness of the particle size of pulverized material delivered from the machine, an outlet in said outlet chamber, fan means for withdrawing sufficiently pulverized material from the pulverizing and classifying chamber through the opening in said ring and delivering the same through said outlet, and a motor connected to operate said rotor.

9. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with the central opening of the ring providing communication between the chambers, a rotor vertically mounted in and extending the full height of the pulverizing and classifying chamber and spaced from said casing, the rotor being operated to provide a pulverizing vortex of air and suspended material in the zone around the rotor, and comprising an imperforate bottom disc, a hub, and a plurality of radial blades mounted thereon and extending from the disc to adjacent the ring which partly overlies the blades, a plurality of radially projecting ribs mounted on the interior of the casing and at least partly co-extensive with the lower portion of the rotor, the inner edges of the ribs being tapered outwardly from the top toward the bottom thereof, an outlet in said chamber, fan means for withdrawing sufficiently pulverized material from the pulverizing and classifying chamber inwardly between the blades of the rotor from the pulverizing vortex and through the opening in said ring and delivering the same through said outlet, means for feeding material to the pulverizing and classifying chamber near the top thereof, and a motor connected to operate said rotor.

10. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with the central opening of the

ring providing communication between the chambers, a rotor vertically mounted in and extending the full height of the pulverizing and classifying chamber and spaced from said casing, the rotor being operated to provide a pulverizing vortex of air and suspended material in the zone around the rotor, and comprising an imperforate bottom disc, a hub, and a plurality of radial blades mounted thereon and extending from the disc to adjacent the ring which partly overlies the blades, the outer edges of the rotor blades in the pulverizing and classifying chamber being tapered from the bottom to the top thereof, a plurality of radially projecting ribs mounted on the interior of the casing and at least partly co-extensive with the rotor in the lower part thereof, the inner edges of the ribs being tapered from the top to the bottom thereof parallel with but spaced from the rotor blades, an outlet in said chamber, fan means for withdrawing sufficiently pulverized material from the pulverizing and classifying chamber inwardly between the blades of the rotor from the pulverizing vortex and through the opening in said ring and delivering the same through said outlet, means for feeding material to the pulverizing and classifying chamber near the top thereof, and a motor connected to operate said rotor.

11. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with the central opening of the ring providing communication between the chambers, a rotor vertically mounted in and extending the full height of the pulverizing and classifying chamber and spaced from said casing, the rotor being operated to provide a pulverizing vortex of air and suspended material in the zone around the rotor, and comprising an imperforate bottom disc substantially the diameter of the rotor, a hub, and a plurality of radial blades mounted thereon and extending from the disc to adjacent the ring which partly overlies the blades, a removable plate on each of said blades near the top thereof and extending radially therefrom, the outer edges of said plates being tapered downwardly from adjacent said ring at an angle chosen in the area approximately 12° either side of the vertical to thereby increase or decrease the width of the rotor adjacent the opening in said ring to control the size of the particles of pulverized material delivered from the machine, an outlet in said fan chamber, fan means for withdrawing sufficiently pulverized material from the pulverizing and classifying chamber inwardly between the blades of the rotor from the pulverizing vortex and through the opening in said ring and delivering the same through said outlet, means for feeding material to the pulverizing and classifying chamber near the top thereof, and a motor connected to operate said rotor.

12. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with the central opening of the ring providing communication between the chambers, a rotor vertically mounted in and extending the full height of the pulverizing and classifying chamber and spaced from said casing, the rotor being operated to provide a pulverizing vortex of air and suspended material in the zone around the rotor, and comprising an imperforate bottom disc substantially the diameter of the rotor, a hub, and a plurality of radial blades mounted thereon and extending from the disc to adjacent the ring which partly overlies the blades, fan means for withdrawing sufficiently pulverized material from the pulverizing and classifying chamber inwardly between the blades of the rotor from the pulverizing vortex and through the opening in said ring and delivering the same through said outlet, means for feeding material to the pulverizing and classifying chamber near the top thereof, a motor connected to operate said rotor, a blow-off opening in the side of the casing near the level of the bore of the pulverizing and classifying chamber, and a gate valve for said blow-off opening.

13. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with a central communicating opening therebetween, a rotor vertically mounted in the casing and spaced therefrom, said rotor comprising a shaft extending centrally therethrough, an imperforate bottom disc mounted on the shaft, a plurality of radial blades extending the full height of the pulverizing and classifying chamber, bars on the interior of the casing co-extensive with the rotor for at least a part of is height and extending inwardly close to the path of the outer edges of the rotor blades, means adjacent the upper end of the casing chamber for feeding thereto fibrous material, which is reduced in particle size by shearing action between the rotor blades and said bars, fan means for withdrawing sufficiently reduced material from the pulverizing and classifying chamber through the opening in said ring, a motor for driving the rotor, and an outlet in said head for pulverized material.

14. In a pulverizing and classifying machine, a cylindrical casing having a base with an air opening therein and a head, a ring mounted near the top of the casing and dividing the same into a pulverizing and classifying chamber and an outlet chamber with the central opening of the ring providing communication between the chambers, a rotor vertically mounted in and extending the full height of the pulverizing and classifying chamber and spaced from said casing, the rotor being operated to provide a pulverizing vortex of air and suspended material in the zone around the rotor, and comprising an imperforate bottom disc substantially the diameter of the rotor, a hub, and a plurality of radial blades mounted thereon and extending from the disc to adjacent the ring which partly overlies the blades, a readily detachable plate mounted on each of said blades and extending along the upper part thereof and radially therefrom, the outer edges of said blades having a taper the angle of which is within approximately 12° either side of the vertical, an outlet in said fan chamber, fan means for withdrawing sufficiently pulverized material from the pulverizing and classifying chamber through the opening in said ring and delivering the same through said outlet, means for feeding material to the pulverizing and classifying chamber near the top thereof, and a motor connected to operate said rotor.

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