

Dec. 8, 1942.

H. G. LYKKEN

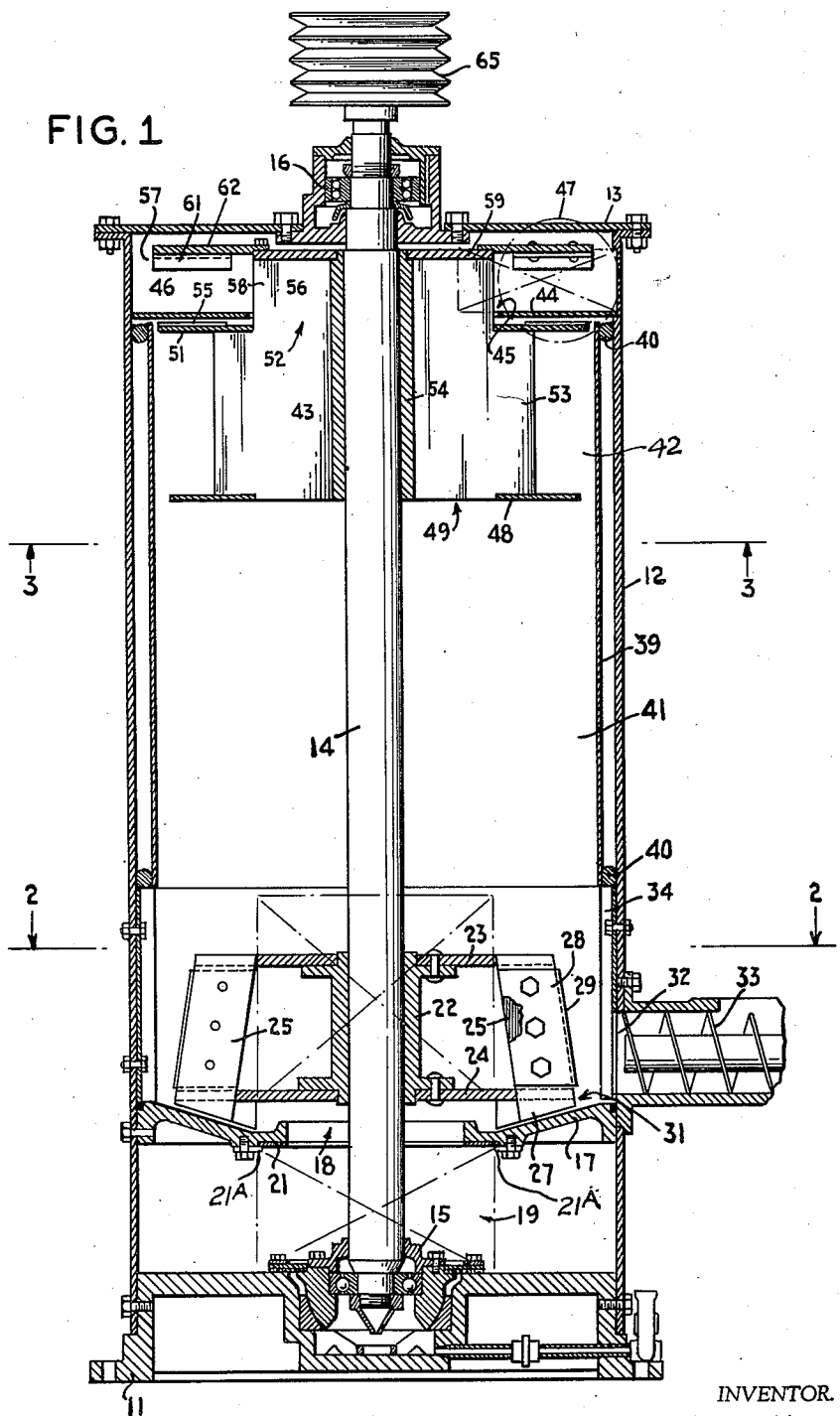
2,304,264

APPARATUS FOR PULVERIZING AND CLASSIFYING MATERIAL

Filed Jan. 16, 1939

4 Sheets-Sheet 1

FIG. 1



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APPARATUS FOR PULVERIZING AND CLASSIFYING MATERIAL

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4 Sheets-Sheet 2

FIG. 2

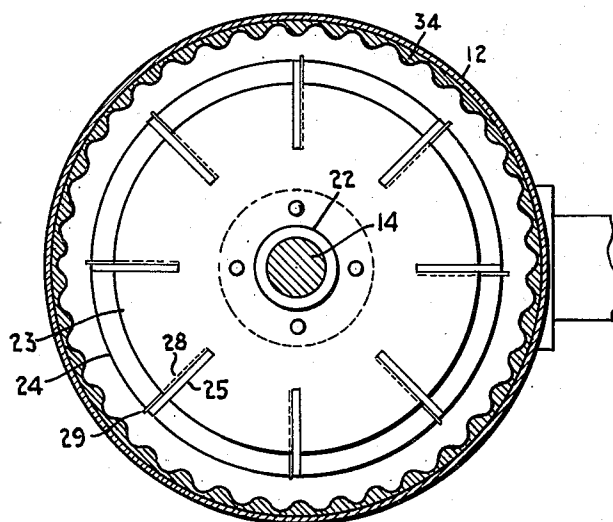
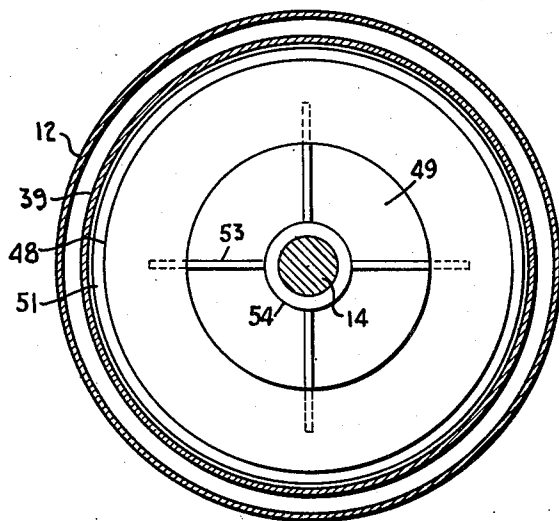


FIG. 3



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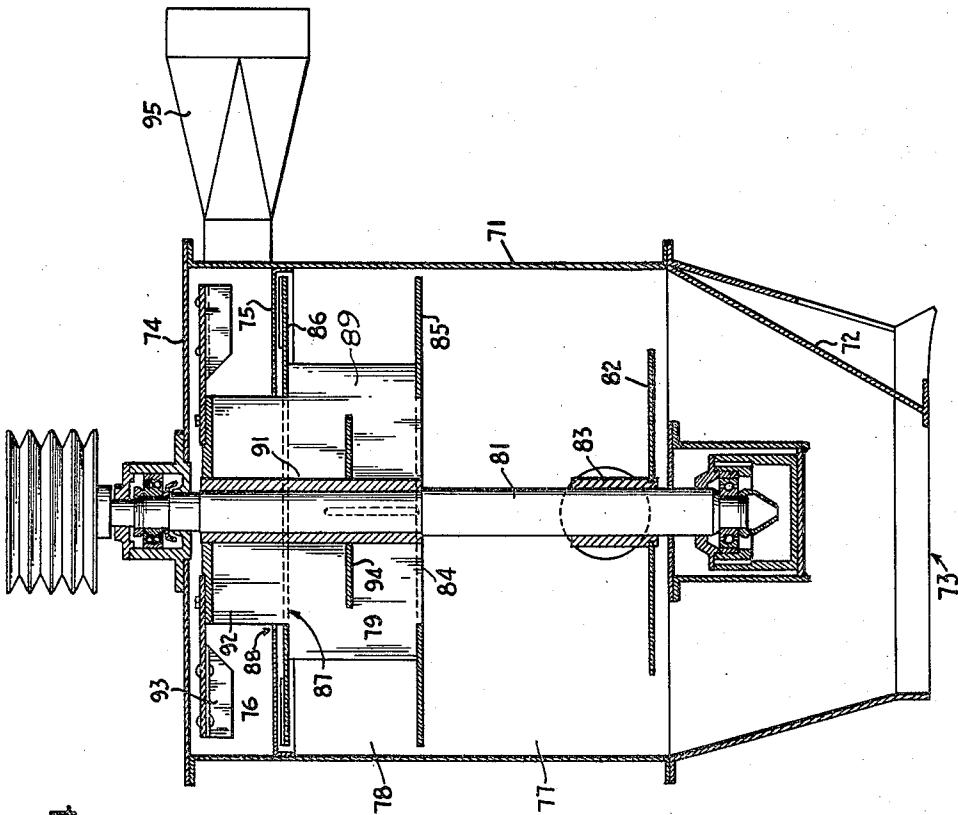
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APPARATUS FOR PULVERIZING AND CLASSIFYING MATERIAL

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4 Sheets-Sheet 3



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APPARATUS FOR PULVERIZING AND CLASSIFYING MATERIAL

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4 Sheets-Sheet 4

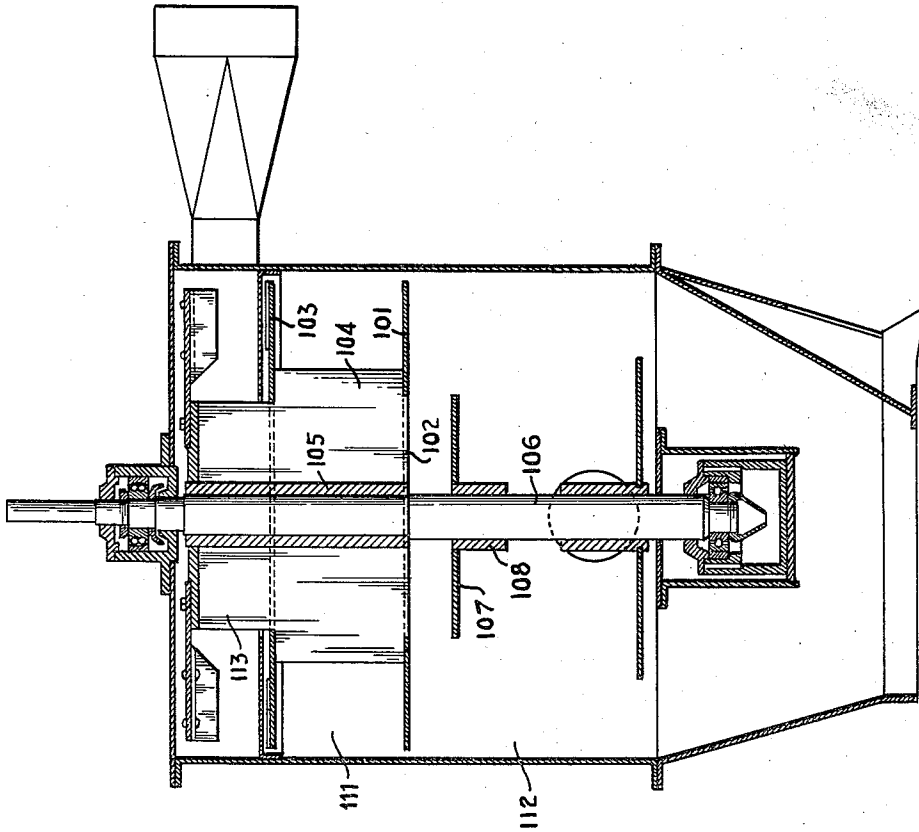


FIG. 5

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2,304,264

APPARATUS FOR PULVERIZING AND
CLASSIFYING MATERIALS

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Application January 16, 1939, Serial No. 251,062

14 Claims. (Cl. 83—11)

My invention relates to new and improved apparatus for pulverizing and for classifying friable material, i. e., so as to deliver from the apparatus all particles of pulverized material smaller than a determinable particle size.

More specifically, my invention relates to such apparatus wherein pulverization and classification each occurs in a vortex of air and suspended material. Throughout this specification and claims reference will be made to the use of air as the medium in which the material is suspended and conveyed, but it will be understood that air is merely an example of other gaseous media that may be and which has been used, especially where the nature of the material makes it desirable to have a different gaseous atmosphere in the apparatus.

The improvements in connection with pulverization can be used with any desired classifier, and the improvements with respect to classification also can be used with any desired pulverizing apparatus. Furthermore, the pulverization and classification apparatus can be part of the same housing or they may be separate, interconnected units.

In the pulverization of friable materials, there are many factors which adversely affect the efficiency of pulverization per unit of power input. Of course, the chemical nature and physical structure of the material, its specific gravity, the ratio of mass to weight of particles of material, the size of the material fed to the pulverizing chamber, and the degree and amount of pulverization desired all must be considered in the design of the apparatus. Additionally, some factors affecting efficiency are adequate and even distribution of material to be pulverized throughout the vortex, the prompt and complete removal therefrom of all material that is sufficiently pulverized, the return thereto of any oversize particles that escape from the pulverizing vortex so as not to interfere with the pulverizing action or the removal of the sufficiently pulverized material, etc.

In the classification of pulverized material, it has heretofore been proposed to use the vortex action for classification because, in a vortex, material is acted upon according to its mass and the velocity of the vortex, and the oversize material thus will be thrown to the outside of the vortex and the material of desired size will remain in or find its way to the center of the vortex, from which it can be removed while the oversize is returned to the pulverizing chamber for further pulverization.

Also, means heretofore have been provided for maintaining the velocity of the vortex with or without creating turbulence in the vortex. Again, many of the same factors, referred to above, adversely affect the efficiency of the classifier action. Usually the desideratum is to deliver as much pulverized material as possible of the selected particle size, i. e., with a very small amount of fines therein, and, for many purposes, it is essential that no particles larger than the selected size escape from the classification chamber with the finished material.

Broadly speaking, it is the object of my invention to provide pulverization and classification apparatus of the indicated character which will operate efficiently in handling large quantities of material with any desired selected size delivered from the machine, even with extremely fine particles.

It is another object of my invention to provide apparatus of the above indicated character in which changes and adjustments can be quickly and simply made so as to accommodate the machine to handling different types of material or to deliver different selected particle sizes.

It is still another object of my invention to provide pulverizing apparatus of the indicated character with an improved form of rotor for creating the pulverizing vortex.

It is still another object of my invention to provide a classification chamber in which there is an upwardly spiralling vortex feeding into an open end type of rotor.

It is a further object of my invention to provide a machine in which pulverization and classification occur wherein the material is pulverized in a vortex of air and suspended material, the vortex passes into a free vortex zone for preliminary classification and then into a zone having a centrifugal action at a right angle to the axis of the vortex to remove the remaining particles above a pre-determined size.

It is a still further object of my invention to provide an apparatus for classifying pulverized material to extremely fine particle sizes in which accurate classification is obtained efficiently with relatively low speed whirling action.

It is a still further object of my invention to provide a pulverizing and classifying machine wherein vortices of air-suspended material are used for both pulverization and classification and in which a large volume of air passes through both the pulverizing vortex and the classification chamber while maintaining efficient

and accurate classification of particles delivered from the machine.

It is an even further object of my invention to provide a pulverizing and classifying machine in which the material is carried in large volumes of air and in which recirculation of air in the classification chamber can be regulated.

An even further object of my invention is to provide a pulverizing and classifying machine which is economical to manufacture and assemble, in which it is easy to clean or replace parts, and which is simple and efficient in operation.

Other and further objects and advantages of my invention will appear from the following specification taken in conjunction with the accompanying drawings, in which—

Figure 1 is a vertical longitudinal section of a pulverizing and classifying machine, showing one embodiment of my invention;

Fig. 2 is a cross section of such apparatus taken on the line 2—2 of Fig. 1, showing the rotor of the pulverizing chamber;

Fig. 3 is also a cross section of such apparatus, taken on the line 3—3 of Fig. 2, showing the rotor in the upper classification zone;

Fig. 4 is a longitudinal section of a classifier, showing a modified form of rotor; and

Fig. 5 is a longitudinal section of a further modified form of classifier.

The embodiments of my invention shown in the drawings have been successfully operated, but they are shown here purely by way of illustration of the principles involved, my invention not being limited to such forms.

Referring to Figs. 1, 2 and 3, the combined pulverizing and classifying machine comprises a base 11, upon which is mounted a cylindrical casing 12, the casing being closed at its top by a plate 13. A rotatable shaft 14, driven by any suitable source of power, is mounted in bearings 15 and 16, respectively located in the base and top plate. Secured within the casing 12 and spaced above the base 11 is a dish-shaped bottom plate 17 having a central opening 18 therein. The casing has an air inlet opening 19, communicating with the space between the base 11 and bottom plate 17. Either the opening 18 or the opening 19 is to be provided with suitable means for controlling the amount of air which can be drawn into the machine, as hereinafter described, one such means being illustrated by the slide 21 movable in guides 21A to vary the size of opening 18.

A pulverizing rotor is carried by the shaft 14 adjacent the plate 17, and is of the closed end type. The rotor frame comprises a hub 22, fast upon the shaft 14, to which are secured upper and lower discs 23 and 24 and between which are mounted a plurality of radially extending supports 25. The disc 24 is of larger diameter than the upper disc 23 and these discs are slotted to receive the radial supports 25, which extend beyond the bottom of the plate 24 to form fan blades 27 between the disc 24 and plate 17. The lower edges of the blades 27 are shaped to conform to the inclination of the bottom plate 17. It will be noted that the supports 25 do not extend beyond the edges of the plates 23 and 24. Bolted to each of the supports 25 are removable blades 28 which constitute the blades of the pulverizing rotor. The outer edges of the blades 28 are inclined as indicated at 29, so as to form a tapered rotor. As explained above, various materials require different degrees of pulverizing vortex action created by the rotor and it is con-

templated in this connection blades 28 having other angles of inclination may be interchanged upon the rotor frame as may be best adapted for the particular use of the machine, or that the positions of the blades 28 upon the radial supports 25 may be varied so as to vary the angle of inclination of the rotor blades. In Fig. 1, the blades 28 are wider than the radial supports, and extend slightly beyond the outer edges of the discs 23 and 24. This projection may be more or less than indicated, both for the entire blade, or for either end thereof. However, I prefer to have the rotor function as a closed end rotor to produce a violent vortex action almost entirely in the annular zone around the rotor, and neither the air or material passes through the rotor.

In this latter connection, air is fed to the vortex area through the opening 31, and material is fed directly to the vortex zone through the opening 32. Any suitable feeding means may be used, there being illustrated in the drawing a conventional screw feed mechanism 33. Preferably, the feed mechanism will be such that the rate of feed will be controllable in accordance with the requirements of the particular machine.

The inner surface of the casing 12 has at the lower portion thereof, in the pulverizing zone, a corrugated liner 34, which is shown as removable. For most purposes I prefer to use such a liner to retard the material circulating in the outer portion of the annular vortex so as to create a greater differential of movement between the particles of suspended material circulating therein. To this end the depth of the corrugations may vary with different materials, but in all cases, the corrugated liner may be omitted entirely and in some cases it may even be preferable to omit it.

In the operation of the pulverizer as described, the material is fed into the vortex of air created by the rotor, and is carried in suspension in that vortex while being whirled around at high speed. The centrifugal forces acting upon the particles will cause a rubbing of particles upon each other as well as an impact between particles with a corresponding shifting of the particles about in the vortex as they are reduced in size, thus creating further impacts and further attrition, all as is well known.

However, the upwardly inclined rotor will produce a more violent vortex in the narrow space toward the bottom of the pulverizing zone where there is a tendency for the greatest concentration of material to be pulverized, and as the area of the vortex zone increases, by reason of the taper of the rotor, the vortex action is a little less violent and more space is provided for the material as it becomes pulverized. Furthermore, the component of the forces produced by the upwardly inclined rotor are such as to cause a more complete and equal distribution of the material throughout the vortex zone. Additional advantages arising from use of the inclined rotor occur with respect to the return of the oversize material from the classification zone or chamber, the prompt intermingling of the returned material with the vortex, and in the thorough, complete and prompt removal from the pulverizing zone of the sufficiently pulverized material, all of which matters will be more fully discussed hereinafter.

In the embodiment shown in Figs. 1 and 3, the classification chamber is defined by a smooth-surfaced inner casing 35 which is of less diameter than the outer casing 12 and is held spaced

therefrom by any suitable means, such as the spacing rings 40. The chamber comprises a free zone 41 at one end thereof, in which there is no mechanism, and a zone 42 at the other end of the chamber in which is located a rotor 43. The upper end of the classification chamber is closed by a ring shaped plate 44 having a central opening 45 therein which constitutes the outlet from the classifier.

This outlet communicates with the chamber 46 between the ring shaped plate 44 and the top plate 13 from which is a discharge opening into an outlet pipe 47 for the finished material.

The rotor in the classification chamber consists of a lower disc 48 having a central inlet opening 49 therein, a top disc 51 having a central outlet opening 52 therein, and a plurality of radially disposed blades 53 which are mounted upon a hub 54. The discs 48 and 51 and blades 53 are secured together in any appropriate manner, as by welding, and the hub 54 is fast upon the shaft 14 so as to rotate therewith.

The top disc 51 of the rotor 43 is larger in diameter than the bottom disc 48 and extends very close to the inner casing 39 as well as close to the ring-shaped plate 44. In order to prevent any leakage of air and material to the outlet 45 through the space between the plate 44 and disc 51, the top surface of the disc may be provided with small radial ribs 55 to act as fan blades exerting a centrifugal pressure outwardly toward the inner casing 39.

The chamber 46 is, in this embodiment, a fan chamber as well as an outlet chamber. The chamber has two fans therein, the fan 56 and the fan 57. The fan 56 has a plurality of blades 58 which, in the structure indicated in Fig. 1, are reduced extensions of the blades 53 of the classifier rotor, the hub 54 also being extended upwardly to carry the blades 58. At the upper end of the blades 58 is a top disc 59 to which the blades are secured in any suitable manner. The fan 57 comprises a plurality of blades 61 mounted radially upon a ring shaped plate 62 which in turn is secured to the disc 59. The fans 56 and 57 act as suction fans to draw the air and the material suspended therein through the pulverizing and classifying chambers, but such suction apparatus need not be located in the casing at all, and may be a suitable suction device entirely separate and distinct from the pulverizing or classifying mechanism as shown, for example, in my prior Patent No. 1,760,245, issued May 27, 1930, the showing of the drawings being a present preferred arrangement that is satisfactory for most materials.

The operation of the classifier can be described as follows: The high speed vortex created by the pulverizing rotor discharges or spirals upwardly from the annular pulverizing zone into the lower chamber 41 carrying with it pulverized and some partially pulverized or oversize material. In the vertical vortex type of machine shown in Fig. 1, the vortex action continues in the chamber 41 but in that chamber the vortex is free to expand into the entire zone and is substantially free from turbulence. Under the centrifugal action occurring in such a vortex, the heavier or coarse particles are thrown outwardly toward or against the inner casing 39, and the lighter particles segregate toward the center of the vortex adjacent the shaft 14.

Under the influence of the suction fans 56 and 57 the vortex spirals upwardly in the free zone 41 toward the eye or inlet opening 49 of the

rotor 43 during all of which time this separation or removal of the oversize particles by the vortex is continuing progressively so that by the time the material-laden air in the vortex reaches the opening 49, the greater portion if not all of the oversize material has been thrown out toward the outside of the casing and beyond the limits of the opening 49. The air and the remaining material carried therein enters the opening 49 where the air and material is given a whirling motion by the rotor 43 and is subjected to the centrifugal forces generated by the rotating fan blades 53.

The action and proportioning of the various parts of the machine is such that the material which has been pulverized to the desired size remains nearer the hub of the rotor and is light enough to be carried through the outlet 52 of the rotor 43 into the chamber 46, from which it is discharged, while any particles which are not sufficiently reduced in size, having a larger mass than the desired particles, will be acted upon by the additional centrifugal force imparted by the rotor 43 to be thrown outwardly toward the inner casing 39 at right angle to the normal path through the rotor. Furthermore, the proportioning is such that most of the air leaves the classifier through the outlet 52 of the rotor.

Such air as is thrown laterally by the rotor passes around the edge of the bottom disc 48 and recirculates through the opening 49. Hence any sufficiently pulverized material which may have been thrown out accidentally by the rotor 43 is carried back into the opening 49 and finds its way out of the machine with the upwardly rising currents of air. In this connection, it will be noted that the blades 53 of the rotor do not extend to the edge of the disc 48, which arrangement I prefer so as to overcome any tendency for turbulences at the edge of the rotor. Also, the size of the disc 48 may be different, which will vary the amount of recirculation, and is a desirable control. However, since the action of the rotor 43 is in the same direction as the vortex in the free zone 41, the air and material discharged radially from the rotor is receiving an impetus from the fan blades in the direction of the vortex thus tending to maintain the vortex action in the classification chamber.

The discharge pipe 47 of the machine may be connected either to a collector, such as a cyclone collector, or directly to some point of use for the pulverized material.

The classifier action and operation has been described in connection with the mechanism as shown, in which the inlet opening 49 to the rotor 43 is approximately the same size as the outlet openings 52 and 45. The velocity of the material laden air moving through the fan 43 can be controlled by controlling the relationship of these inlet and outlet openings from a relationship where the inlet opening is considerably smaller than the outlet, to the relationship where the inlet would be considerably smaller than the opening 49. In this latter case the air and material might even enter the rotor 43 principally from its periphery.

The oversize material in the classification chamber is forced to the outside thereof and gravitates to the pulverizing chamber for further pulverization. In this connection it is important that the return of the rejected material be substantially continuous or at least in such manner as not to impose intermittent loads upon the pulverizing rotor. The tapered pulverizing rotor heretofore discussed provides a wide area

at the top of the pulverizing chamber so that there is a wide space for the entrance of the rejected material. This wide space is likewise useful to allow ready removal of the pulverized material from the vortex zone without being impeded by the returning rejected material. Furthermore, this permits of aeration of the returning material by the upwardly moving air so that any completely pulverized particles which may be clinging to the oversize material will be removed and carried back into the classification chamber. Additionally, the inclination of the rotor blades permits of a better distribution of the returning material in the pulverizing vortex because it will be subjected to the action of a larger part of the blades than if the rotor were of uniform diameter.

In the arrangement and proportioning of this entire apparatus large volumes of air may be carried through both the pulverizing chamber and the classification chamber so that the material that is sufficiently pulverized is promptly carried out of the pulverizing chamber, through the classification chamber, and out of the machine with the result that the delivered product is of a more uniform size, i. e., with a smaller percentage of fines than has theretofore been obtained. Moreover, such large amount of air allows the whole machine to operate at considerably lower temperatures, which is important with some materials.

Before describing the alternate classifier shown in Figs. 4 and 5, the classifier arrangements and principles may be used in conjunction with other types of pulverizing mechanism, such as the horizontal rotor type of machine shown for example in my Patent No. 1,838,560, issued December 29, 1931, or in conjunction with a machine where a vortex is created by air jets as shown in my prior Patents Nos. 1,756,254 and 1,768,621, issued respectively April 29, 1930, and July 1, 1930, or with any other pulverizer mechanism. Also, the air-suspended material may be caused to whirl in the classifier by other means than the pulverizing rotor as, for example, being introduced into the classifier mechanism in such direction as to create a vortex in the free zone 41, as indicated in my prior Patent No. 1,753,437, issued April 8, 1930.

The casing of the apparatus illustrated in Figs. 1, 2 and 3 is approximately fifty-four inches high and twenty-four inches in diameter, and pulverizes several hundred pounds of materials per hour using a rotor speed of approximately twenty-two hundred revolutions per minute. The free zone 41 is shown as having considerable height, but I have used successfully a machine of this construction having twelve inches less height, as well as machines of greater dimensions. Likewise, the drive for the shaft 14 may be either through the top or the base of the machine, as indicated in the co-pending application of Lykken and Lykken, Serial No. 285,484, filed July 20, 1939. I prefer to drive the shaft through belts and pulley, such as pulley 65 shown in Fig. 1, as will be understood. It will be evident that any other form of drive and method of speed variation could be used. Also, in some instances the inner casing 39 may be omitted.

Also, the pulverizing rotor is shown with eight blades and the classifier rotor as having four blades but the number of blades used on each of these rotors may be varied as may be found necessary or desirable for the particular problem in hand.

It should be pointed out that the present invention contemplates a drive for the classification rotor that is independent of the drive for the pulverizing rotor so that the speed of the classifier rotor may be varied from the speed of the pulverizing rotor as one means of regulating the degree of classification or separation in accordance with the requirements of the particular case in hand.

Fig. 4 illustrates a classifier such as may be used with other types of pulverizing mechanisms than the vertical rotor type shown in Fig. 1, although, of course, the principles may also be used in that construction also. In this case there is shown a modified form of classification rotor.

The classification apparatus comprises a casing 71 having a lower entrance portion 72, with an inlet opening 73 at the bottom thereof, and a top plate 74. The classification chamber itself is closed by a ring-shaped plate 75, corresponding to the ring-shaped plate 44, and is spaced from the top plate 74 so as to form a combined fan and outlet chamber 76. The classification chamber has a free vortex zone 77 at the lower end thereof, and an upper zone 78 in which is located the rotor 79. The rotor 79 is mounted upon a shaft 81 which is driven by any suitable source of power (not shown). Air-suspended pulverized material enters the classification chamber through the opening 73 and preferably in a manner to produce a vortex in the air and material. In the lower portion of the free zone 77 a rotor in the form of a flat disc 82 may be mounted upon the shaft 81 so as to be rotated therewith. The disc 82 performs two offices, first, it prevents a direct entrance of the air-suspended material into the opening or eye 84 of the rotor 79 and, secondly, it imparts an impetus to the vortex of air and material so as to increase or maintain the speed thereof in the zone 77 without imparting any turbulence thereto.

The rotor 79 comprises a lower disc 85, in which is the inlet opening 84, and an upper disc 86, in which is an outlet opening 87 that communicates with the outlet opening 88 from the classification chamber to the fan and outlet chamber 76. It will be noted that the bottom disc 85 of the rotor 79 extends more closely to the inner surface of the casing 71 than does the bottom disc 48 of the rotor shown in Fig. 1. The rotor 79 has a plurality of radial blades 89 which are mounted upon a hub 91 and to which the discs 85 and 86 are secured. Again in this structure a reduced portion of the blades 89 extend through the openings 87 and 88 into the fan chamber 76 to form the fan 92. The fan chamber also has a fan 93 corresponding to the fan 57 shown in Fig. 1.

In the form shown in Fig. 4, the rotor blades 89 are slotted horizontally for the reception of a flat disc 94 which is secured to the blades and also to the hub 91. The disc 94 extends transversely of and a substantial distance across the openings 84, 87 and 88. The material to be delivered from the classifier enters the chamber 76 through the opening 88 and is delivered from the machine through the outlet 85 to a collector or to a place of use as the case may be.

The operation of the classifier is somewhat similar to the operation of the classifier described in Fig. 1, in that there is a free vortex zone 77 in which the primary classification takes place and the coarser material is thrown outwardly, while the finer material and air enters the eye 84 of the rotor 79 where it is subjected

to the centrifugal throw-out action of the blades 89 to remove any oversize particles which may not be eliminated in the vortex action in the free zone 77. However, in the modification shown in Fig. 4, the purpose of the disc 94 is to force all of the air and material away from the axis of the fan 79 so as to be subject to the greater centrifugal force exerted by the outer ends of the fan blades 89. That is to say, the centrifugal action along the hub 91 is very slight or substantially zero, and the centrifugal action increases toward the outer edges of the blades 89. The diameter of the disc 94 may be varied for different materials and for different sizes of particles to be delivered from the classifier.

By the use of this modified form of rotor, I am able to obtain with relatively low speeds of rotation of the rotor 79, classification equivalent to that obtained with much higher speeds of rotation with the type of classifier rotor shown in Fig. 1 for example, or by other forms of vortex classifiers heretofore used in the art. Additionally, there is even less likelihood of any stray particles of oversize material escaping from the classification chamber through the outlet 88. Conversely, by the addition of such a disc as illustrated at 94 in Fig. 4 to the higher speed rotors, such as shown in Fig. 1, it is possible to deliver from the classifier practically impalpable powder free of any oversize particles.

Fig. 5 illustrates a further modification of the arrangement in the classification chamber, the same being shown applied to a classifier similar to that shown in Fig. 4, and duplicate parts of operation and use will not be described. In the form shown in Fig. 5, the classifier rotor comprises a bottom disc 101 having an inlet opening 102 therein, a top disc 103, and a plurality of radial blades 104 mounted upon a hub 105 that is fast upon the rotatable shaft 106. Mounted below the bottom disc 101 of the classifier rotor is a disc 107 carried by a hub 108 which is fast upon the shaft 106, as by means of a set screw, but which may be adjusted vertically along its length to be closer to or more removed from the inlet 102. The purpose of this disc 107 is three-fold in that (1) it prevents a direct vertical entrance of the air-suspended material into the rotor blades 104 along the shaft 106, and for a considerable distance laterally thereof, (2) it imparts a higher rotative speed to the vortex as it is about to enter the eye 102 of the classifier rotor so as to reject oversize material just prior to entering that rotor; and (3) it controls the amount of air entering the classifier rotor and hence the amount of air that is recirculated between the zone 111 of that chamber and the free zone 112. That is to say, the less amount of air that is permitted to enter the classifier rotor, the less there will be discharged laterally therefrom and recirculated, because of the demands of the suction fan 113 which corresponds in operation to the fan 56 of Fig. 1 and 92 of Fig. 4.

This recirculation can be controlled from the instance where the disc 107 is very close to the bottom disc 101, to the condition where it is so far removed therefrom that substantially the full quantity of air and material can enter the eye 102 of the fan. The use of this disc 107 also enables the obtaining of desired fine classification with relatively low speeds of rotation of the classifier rotor, and controlling the recirculation of air between the zone 111 and zone 112 has proven a desirable control for regulating the size of the particles delivered from the classifier.

Other and further 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. A pulverizing and classifying chamber comprising a casing, air and material inlets thereto, a closed end rotor operating adjacent one end of the casing to produce a pulverizing vortex of air-suspended material, the rotor having radial blades arranged to form a tapered rotor, an outlet at one end of the casing, means for drawing air and pulverizing material through said casing and outlet, and a classifying zone having two communicating portions, one having a substantially smooth wall in which the vortex of air and pulverized material rotates substantially free from turbulence, and the other receiving the air and suspended material from the first portion and having therein adjacent the outlet means for subjecting the air and pulverized material to a further centrifugal action on its passage to the outlet, to reject oversize material and return the same to the casing for further pulverization.

2. A pulverizing and classifying chamber comprising a tubular casing, air and material inlets thereto, a closed end rotor operating adjacent one end of the casing to produce a pulverizing vortex of air-suspended material, the rotor having radial blades arranged to form a tapered rotor, an outlet at one end of the casing, means for drawing air and pulverized material through said casing and outlet, and a classifier for the pulverized material having a bladed rotor mounted adjacent the outlet end of said casing, said rotor having axial inlet and outlet openings, there being a substantially uninterrupted portion of said casing between said rotors in which portion the vortex of air and pulverized material rotates, the classifier rotor communicating at its periphery with the intermediate portion of the casing.

3. A pulverizing and classifying machine comprising a casing, air and material inlets thereto, a closed end rotor operating adjacent one end of the casing to produce a pulverizing vortex of air-suspended material, the rotor having radial blades arranged to form a tapered rotor, an outlet at one end of the casing, means for drawing air and pulverized material through said casing and outlet, and a classifying zone having a substantially uninterrupted portion into which the vortex of air and pulverized material is introduced and rotates substantially free from turbulence, and a second portion having therein a rotor mounted adjacent the outlet, said rotor comprising spaced apart top and bottom discs having axial openings therein, a hub, and radial blades extending between said discs, the blades having a shorter radius than the bottom disc.

4. A pulverizing and classifying chamber comprising a casing, air and material inlets thereto, a closed end rotor operating adjacent one end of the casing to produce a pulverizing vortex of air-suspended material, the rotor having radial blades arranged to form a tapered rotor, a plate dividing the casing into a classifying zone and a fan-containing zone, the plate having a central outlet opening therein, and a rotor mounted adjacent the outlet opening and having a hub and a plurality of blades mounted thereon extending through said outlet opening and both above and below said plate.

5. A classifier for pulverized material comprising a cylindrical casing of substantial height,

means for producing in the lower part thereof a vortex of air-suspended pulverized material, an outlet at the top of the casing, means for drawing air and material through said outlet, and a rotor mounted in the casing adjacent the outlet and of less diameter than the casing, said rotor having an axial opening communicating with the center portion of the vortex to receive air and material therefrom, an axial outlet opening communicating with the casing outlet for the discharge of selected material, and a plurality of blades between said openings, the blades discharging unselected material and some air about the periphery of the rotor, the air recirculating into the casing beneath the rotor and into the inlet opening.

6. A classifier for pulverized material comprising a casing, means admitting air and material thereto for classification of the material, an outlet therein, a hub mounted in the casing, and a rotor mounted on said hub, said rotor comprising bottom and top discs respectively having axial inlet and outlet openings, and a plurality of blades extending across the openings and between the discs, the rotor communicating about its periphery with the interior of the casing, and a plate mounted in said casing and operatively associated with said rotor, said plate extending transversely of said openings.

7. A classifier for pulverized material comprising a casing, means admitting air and material thereto for classification of the material, an outlet therein, a hub mounted in the casing, and a rotor mounted on said hub, said rotor comprising bottom and top discs respectively having axial inlet and outlet openings, a plurality of blades extending across the openings and between the discs, the rotor communicating about its periphery with the interior of the casing, and a plate mounted between the top and bottom discs and extending a substantial distance transversely of said openings.

8. A classifier for pulverized material comprising a casing, means admitting air and material thereto for classification of the material, an outlet therein, a hub mounted in the casing, and a rotor mounted on said hub, said rotor comprising bottom and top discs respectively having axial inlet and outlet openings, a plurality of blades extending across the openings and between the discs, the rotor communicating about its periphery with the interior of the casing, and means cooperating with the rotor to divert material a substantial distance toward the periphery of the rotor as it passes through the openings.

9. A classifier for pulverized material comprising a casing, means admitting air and material thereto for classification of the material, an outlet in the casing, a hub mounted in the casing, and a rotor mounted on said hub, said rotor comprising bottom and top discs respectively having axial inlet and outlet openings, a plurality of blades extending across the openings and between the discs, the rotor communicating about its periphery with the interior of the casing, and an adjustable plate positioned to control admission of air and material to said inlet opening.

10. A classifier for pulverized material comprising

a casing, means admitting air and material thereto, an outlet therein, and a rotor mounted in the casing, said rotor comprising bottom and top discs respectively having axial inlet and outlet openings and a plurality of blades extending across the openings and between the discs, the rotor communicating about its periphery with the interior of the casing, and a plate spaced from but arranged to rotate with the rotor and extending radially across the inlet opening, said plate also being adjustable with respect to the rotor to control the amount of air admitted to the inlet opening.

11. A classifier for pulverized material comprising a casing, means admitting air and material thereto for classification of the material, an outlet in the casing, a hub mounted in the casing, and a rotor on said hub, said rotor comprising bottom and top discs respectively having axial inlet and outlet openings, a plurality of blades extending across the openings and between the discs, the rotor communicating about its periphery with the interior of the casing, and means cooperating with the inlet and outlet openings of the rotor to control the amount of air discharged into the casing peripherally of the rotor and recirculated to the inlet opening.

12. A classifier for pulverized material comprising a casing, means for producing a vortex of air-suspended pulverized material in the lower portion thereof, an outlet in the casing, means for drawing air and material through said outlet, a rotor mounted adjacent the outlet, said rotor having radial blades, an axial inlet communicating with the center portion of the vortex, and an outlet opening, and means mounted adjacent the rotor inlet for increasing the speed of the vortex as it is about to enter the rotor inlet and to control the amount of air admitted to said inlet.

13. A classifier for pulverized material comprising a tubular casing, an outlet therefrom, a hub mounted for rotation in said casing, and a rotor carried by the hub near said outlet and of less diameter than said casing, said rotor comprising a bottom disc having an axial opening, and a plurality of blades extending radially from said hub across said outlet opening in proximity thereto and a substantial distance along said hub forming pockets communicating with said outlet and said opening, the undesired material entering the rotor through said opening and being discharged peripherally of said rotor.

14. A classifier for pulverized material comprising a tubular casing having two zones therein, means for producing a vortex of air-suspended pulverized material in one of said zones, the zone being substantially unobstructed so that the vortex operates therein substantially free from turbulence, a rotor mounted in said second zone, the rotor having a bottom disc with a central opening therein forming an axial inlet communicating with the center portion of said vortex the rotor also having an axial outlet and communicating with said zone about its periphery, and an outlet from said casing for pulverized material.

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