Jan. 8, 1946. H. G. LYKKEN ET AL 2,392,331

PULVERIZING AND CLASSIFYING MACHINE

Filed Nov. 27, 1940 3 Sheets-Sheet 1

FIG. 1

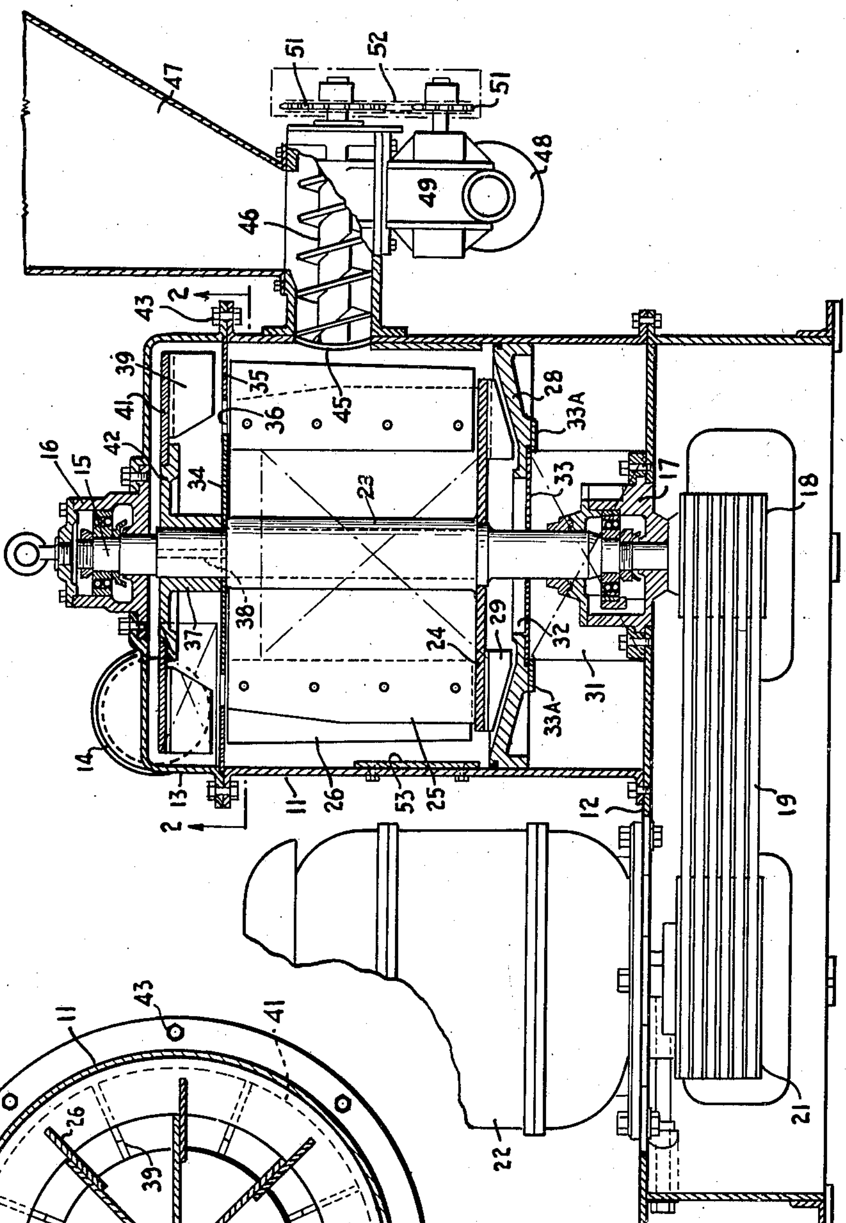

FIG. 2

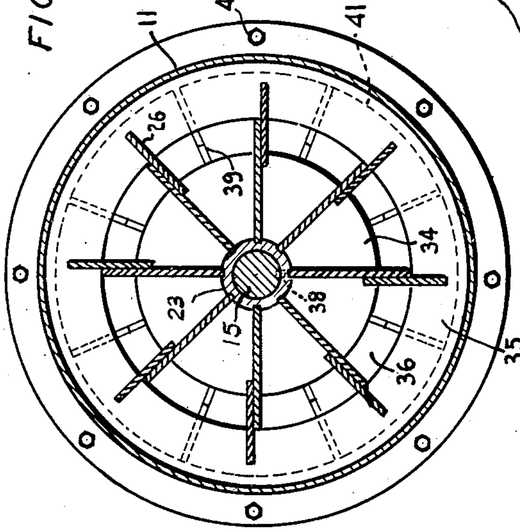

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FIG. 3

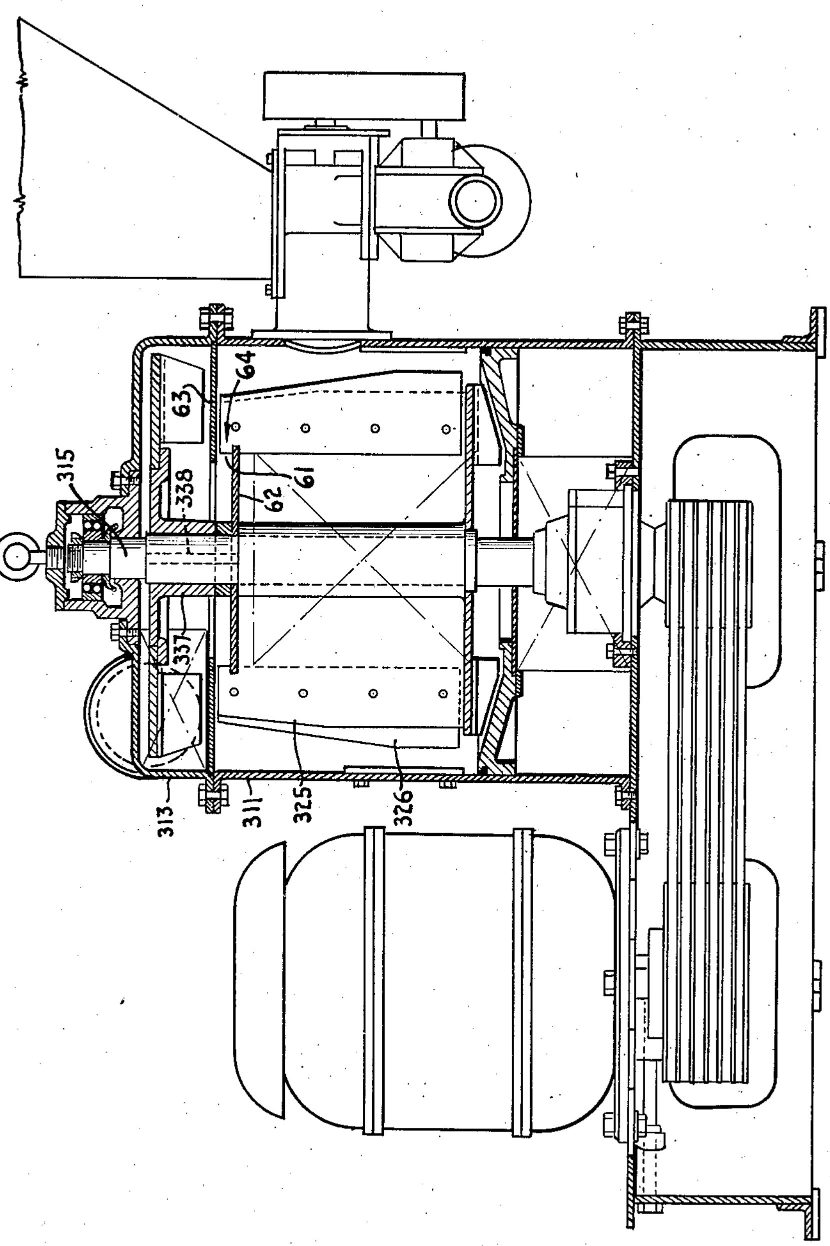

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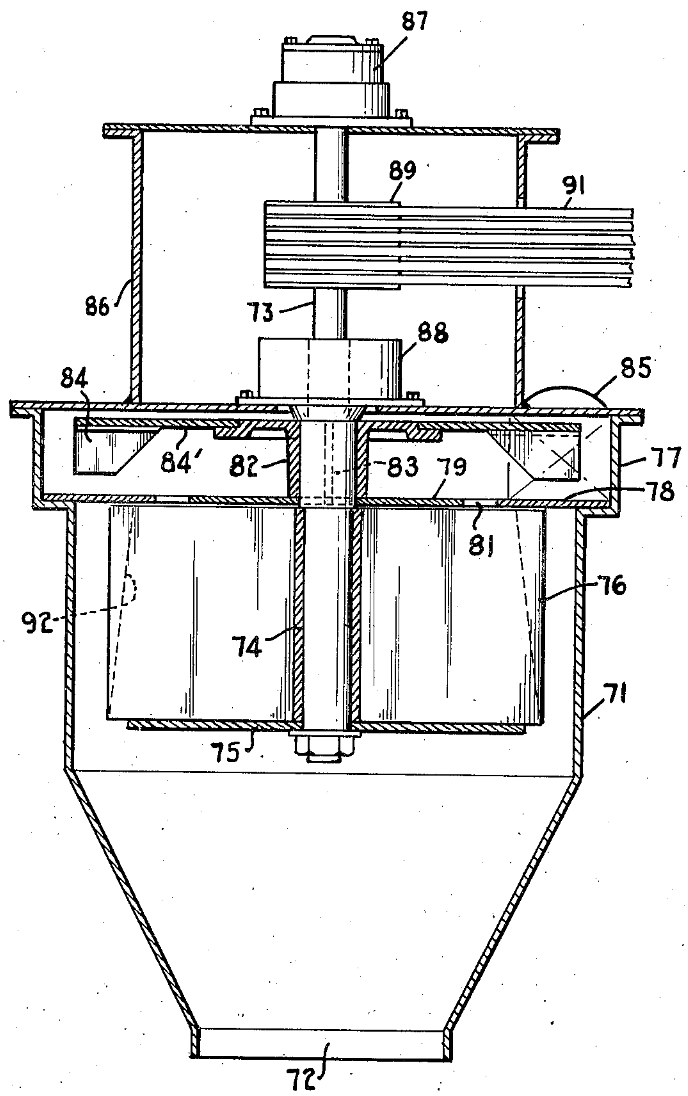
FIG. 4



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PULVERIZING AND CLASSIFYING MACHINE

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Application November 27, 1940, Serial No. 367,314

8 Claims. (Cl. 241—56)

The present invention relates to mechanisms for pulverizing and classifying friable materials.

In pulverizing material by the interaction of particles of material suspended in air and moved in a vortex, as, for example, in the patent of Henry G. Lykken No. 1,838,560, issued December 29, 1931, or of his Patent No. 1,768,621, issued July 1, 1930, pulverization of the material to a greater degree than necessary is to be avoided because (1) such is not an efficient use of the power used to operate the machine, (2) an undesired quantity of superfines are produced in the finished product, and the superfines also interfere with the pulverization of over-size material by acting as a cushion between the interacting particles in the vortex. The same considerations are true, to a more or less extent, in other types of pulverizing equipment. At the same time it is important that the classification of the pulverized material be such that no over-size material escapes from the machine. In other words, it is desirable that the material delivered from the machine be as near a uniform size as possible, so that as soon as the material attains the selected particle size it should be gotten out of the machine as soon as possible.

It is also important from a commercial standpoint that the maximum quantity of finished material be delivered so that a given machine will have a maximum capacity per unit of power, or unit of time. Again, from a commercial standpoint, it is desirable that the same basic mechanism be useable for a wide variety of materials and of particle sizes, such as delivered material of 100 or 200 screen mesh or of 5 microns or less, or other selected sizes, with only slight and readily made changes for either the different materials or the different particle sizes.

In our application Serial No. 285,484, filed July 20, 1939, which has matured into Patent No. 2,362,142 granted Nov. 7, 1944, there is disclosed a machine in which pulverization and classification of the pulverized material is done in a single chamber or a single pulverizing and classifying vortex. The vortex creating element in that case is a bladed rotor. In the top of the casing, above the rotor chamber, is a fan or discharge chamber into which the finished material is delivered, but the outlet or communication between the rotor and fan chambers is axial or around the shaft of the rotor. In the application of Henry G. Lykken, Serial No. 337,742, filed May 29, 1940, which has matured into Patent No. 2,329,208 granted Sept. 14, 1943, certain improvements are disclosed, particularly in connection with the arrangement of the blades of the rotor to obtain greater efficiency in the pulverization and particularly in the classification of the material in the rotor or vortex chamber. Here again the outlet from the rotor chamber is at the center of the machine. The machines disclosed in those applications are in successful commercial use, but apparently a recirculation of the outgoing material occurs in and around the axial inlet which retards discharge of the material from the vortex zone, and also results in some excess of superfines. The present machine is an improvement over the machines of these applications, and eliminates such recirculation as occurred therein, but retains the features of the changeable tapered rotor contour for control of discharged particle size, the taper being between 12° either side of the vertical.

While the improvements are shown as applied to a mechanism of the type disclosed in the aforesaid applications, the principles thereof are applicable to classifiers which are separate from pulverizing mechanisms, or which are combined with other types of pulverizing mechanisms than the air vortex type. However, the improvements increase the efficiency of the pulverizing mechanism as well as the classification of the pulverized material.

Briefly, in the machine of the present application the outlet from the rotor chamber is an annular or ring-shaped slot-like opening, with the central and outer portions of the outlet end of the vortex chamber closed. By this arrangement the material which is pulverized in the vortex around the rotor does not have to enter the rotor to so great an extent to reach the outlet, as in the cases of the structures in said applications, so that the finished material passes through the machine at a faster rate, and a substantially less volume of superfines are produced. However, the material does enter the rotor far enough that the particles are subjected to the centrifugal forces thereof to eject the over-size particles, forcing them to the wall of the casing where they return to the pulverizing vortex for a further reduction in size. Again, by having the outlet adjacent the edge of the rotor, or at an intermediate portion of the vortex, there is a more efficient use of the air immediately carrying the sufficiently reduced material directly to the outlet from all parts of the annular pulverizing vortex.

In the machines of the prior applications and patents, fineness of delivered particle size is controlled in several ways, as by the speed of the rotor or vortex, the number and construction of the rotor blades, where used, the area of the axial outlet opening, and the volume of air passing through the machine. With the present arrangement, other factors are introduced for the control of delivered particle size, viz., the size and the radial position of the annular outlet opening; although it should be noted that either of these factors may vary also for materials of different specific gravity which have the same particle size. These other factors may be substituted for the other variable controls, or they may be used in conjunction with some or all thereof, with the advantage of the prompt and uninterrupted discharge of the finished material.

Other advantages of the principles of our invention will be apparent to those skilled in this field from this specification and the accompanying drawings in which there is disclosed, by way of example, the best modes of applying those principles which are now known to us. In the drawings—

Figure 1 is a vertical section of a pulverizing and classifying machine;

Fig. 2 is a horizontal section, on the line 2—2 of Fig. 1, parts being omitted to facilitate the illustration;

Fig. 3 is a vertical section of a pulverizing and classifying machine showing a modification of the mechanism of Fig. 1; and

Fig. 4 is a vertical section of a classifier attachment embodying the principles of our invention.

Referring to Fig. 1 of the drawings, a cylindrical casing **11** is mounted upon a base **12**, and is closed at its upper end by a recessed cover **13** which has a discharge outlet **14** at one side thereof through which finished material is delivered to a collector system or a place of use, as may be desired. A shaft **15** is rotatably mounted in bearings **16** and **17** carried by the cover **13** and base **12**, respectively. The shaft **15** carries at its lower end a pulley **18** which is connected by belts **19** to a drive pulley **21** on the shaft of an electric motor **22**, which is also mounted upon the base **12**.

Secured to the shaft intermediate its ends is a hub **23** of a rotor which also comprises a base plate **24** and a plurality of radial blades **25** which extend upwardly substantially to the top of the casing **11** and carry removable plates **26**. The rotor is of less diameter than the casing leaving an annular space around the rotor in which the vortex action is set up. The plates **26** may be shaped along their outer edges in accordance with the nature of the material being fed to the machine and the fineness of particle size desired, all as more fully explained in the aforesaid application Serial No. 337,742. That is to say, the blade-plates **26** may have the same radial depth from top to bottom or they may be tapered inwardly or outwardly particularly in the upper portions thereof. With an upwardly and outwardly tapered contour of the blade-plate shown in Fig. 1 the machine will successfully pulverize sugar and classify the same to a particle size of approximately ten microns.

Spaced below the bottom plate **24** of the rotor the casing has a ring-shaped, dished bottom member **28** closing the rotor or vortex chamber at the bottom, and on the lower surface of the plate **24** are a plurality of fan blades **29**, the lower edges of which conform to the dished shape of the bottom member **28**, the blades extending to the edge of the rotor plate **24**. Air is admitted to the casing **11** through the opening **31**, passing upwardly through the central opening **32** of the bottom member **28**, and is ejected by the fan blades **29** into the casing **11** in the annular space around the rotor. The size of the air inlet **32** is controlled by a pair of plates, one of which is shown at **33**, operating in guides **33A** on the bottom member **28**.

The upper end of the rotor is closed for a portion of its diameter by a circular disc **34** which fits upon the shaft **15** and extends radially outwardly therefrom. This disc **34** is removable to be readily interchangeable for purposes hereinafter explained. Supported between the casing **11** and cover **13** is a ring-shaped diaphragm **35** which is mounted in substantial alignment horizontally with the disc **34** and extends radially inwardly toward the same with an annular outlet opening **36** between the disc **34** and diaphragm **35**. The diaphragm is also arranged to be readily interchangeable for purposes to be hereinafter explained.

The space inside the cover **13** may be termed the discharge chamber which communicates with the outlet **14** and has mounted therein a discharge fan. The fan comprises a hub **37** fitting upon the shaft **15** and driven thereby through a key **38** which key also engages a key-way (not shown) in the disc **34** to rotate the same with the shaft **15** and the rotor and fan. The same key may or may not be extended into the hub of the rotor. Fan blades **39** are carried by a ring-shaped plate **41** which is secured to the flange **42** of the hub **37**. The fan blades **39** may be of any desired shape or number and according to our experience to date may or may not overlap the annular outlet opening **36** although theoretically it is desirable to taper the heels of the blades **39** toward the wall of the casing so that the same terminates at the lower ends at least partially over the outlet opening **36**.

In order to replace the disc **34** and diaphragm **35**, the bolts **43** bolting together the flanges of the cover **13** and casing **11** are removed permitting the cover **13** with the bearing **16** to be lifted off the machine, which then exposes the fan. The fan is lifted off the shaft **15** whereupon the disc **34** and the diaphragm **35**, or either of them, may be lifted out and replaced with other sizes of disc and diaphragm. This will be done when it is desired to vary the size of the annular outlet opening **36** or its radial location, or both. Thereupon the fan will be replaced upon the shaft, the key **38** will be re-inserted in place, and the cover **13** and bearing **15** will be replaced, and the parts again connected together including the connection between the machine outlet **14** and the apparatus to which it leads.

Material to be pulverized is fed to the casing **11** through the opening **45** by means of a feed screw **46** from a hopper **47**, the screw being driven by a motor **48** through a reduction gearing **49**, sprockets **51** and chain **52**. In this way there is a regulated feed of material, and the rate of feed may be changed by changing one or both of the sprockets **51**. The feed opening **45** is located above the pulverizing zone and the feed is directly into the annular pulverizing vortex set up by the rotor in the lower portion of the rotor chamber. This lower portion of the chamber may be provided with a corrugated or ribbed lining **53**, which is removable, as shown, and will increase the differential movement between the layers of air suspended material in the pulverizing vortex.

In operation, air is admitted to the pulverizing and classifying chamber through the opening **32**, and the motor is set into operation to rotate the rotor at high speed to set up a vortex of air in the annular zone around the rotor. The rotor being of the closed end type, this vortex will be maintained in that space. Material is fed into the pulverizing vortex through the opening 45, at a rate such that the material to be pulverized will be maintained suspended in the vortex so that violent interaction of the particles upon each other is set up as they move about in the vortex under the centrifugal forces acting upon them, which will cause reductions in particle size. As the particles are reduced in size, they will seek new locations in the vortex, setting up further interactions. The pulverized material will move upwardly in the rotor chamber toward the outlet 36. Since the diaphragm 35 covers the annular vortex zone, the pulverized material will enter the rotor part way in its progress toward the annular outlet, whereby the particles will be subjected to the additional centrifugal action of the rotor blades. This action is proportioned so as to eject the oversize particles to the outer wall of the casing 11 where they will fall by gravity back into the pulverizing zone for further reduction in size.

The particles which are sufficiently reduced in size will be carried by the air through the annular outlet 36 under the withdrawing action of the fan blades 39 and will be ejected from the machine through the machine outlet 14. By locating the annular outlet near the inner diameter of the entire vortex zone, the sufficiently pulverized material will be free to get out of the machine immediately and continuously so that the pulverizing vortex is cleared of those particles with the production of a minimum of superfines. Such superfines as may be produced will, under the centrifugal action of the rotor, enter the rotor inwardly of the outlet opening 36, but will be held closer to that opening and will be immediately taken out of the rotor chamber. Thus, the sufficiently pulverized material and the superfines, if any, will not interfere with the pulverization taking place in the lower portion of the chamber. The rotation of the disc 34 at the center of the rotor will aid in removal of any superfines, but this disc need not rotate but may be integral with the diaphragm 35 being joined thereto by small webs (not shown).

The action may also be described that during the converging of the pulverized material toward the annular outlet 36, the material will be constantly subjected to the transverse centrifugal forces of the rotor blades so that over-size particles are kept from entering the outlet 36. As soon as the pulverized material passes through the outlet 36 it immediately expands into the air currents produced by the fan blades 39 and will be discharged from the machine without further reduction in size.

It is difficult to set down any definite rules for fixing either the size of the annular outlet opening 36 or its radial position, which matters are determined by the relative sizes of the disc 34 and diaphragm 35, because the specific gravity of the material as well as its other characteristics such as whether the particles being removed from the rotor or vortex chamber are flat and flaky or substantially round must be taken into consideration also. However, a few examples determined from past experience with machines constructed according to our invention will suffice to guide those wishing to duplicate this invention and apply the principles thereof.

Generally speaking, the rotor disc 34 will be from one-half to two-thirds the diameter of the rotor and the annular outlet opening will vary between one and two and one-half inches in width. With a rotor twenty-two inches in diameter at the bottom, the rotor disc 34 may be either thirteen or fourteen inches in diameter. In coarser pulverizing, this variation does not seem to make much difference. With this disc a diaphragm 35 having a central opening of eighteen inches may be used so that the annular outlet opening 36 will have a width of two or two and one-half inches. When material such as sugar having a size to pass a 350 screen mesh (approximately thirty-five microns) the diaphragm in this construction may have a center opening of seventeen inches, thus reducing the width of the annular outlet 36 to one and one-half inches, and moving the effective outlet toward the center of the machine. For finer material, of say five or ten micron size, the center opening of the diaphragm 35 may be sixteen inches leaving an annular outlet one inch in width.

In the foregoing examples, the central disc 34 has remained the same diameter and the width of the outlet was varied by changing the width of the diaphragm but this is by no means a fixed practice. For example, with a light, flaky material the disc 34 will be smaller in diameter and at the same time the narrow outlet opening will be used so that the outlet is nearer to the axis of the rotor. While with heavier, non-flaky material, the same particle size will be delivered from the machine with the outlet opening nearer to the edge of the rotor.

In general, with any given material, the finer the particle size desired, the nearer to the axis will the outlet 36 be located, and the narrower will be that opening, and contrary-wise, the coarser the particle size desired the nearer the edge of the rotor will be the outlet opening and the wider it will be. It should be observed that decreasing the size of the opening or locating the same nearer the rotor axis decreases the output capacity of the machine. The size of the opening will be determined by the particle size desired and its location will be chosen to afford maximum capacity, taking into consideration the nature of the material being worked upon.

Referring now to Fig. 3 in which a modified form of mechanism is shown, the construction and operation of the casing and cover, air inlet, material feed, rotor drive and mounting are the same as in connection with Fig. 1, as will be apparent from a comparison thereof, so that the same need not be described in detail. Where like parts in the two constructions are referred to in connection with Fig. 3, they will be prefixed with the numeral 3.

In Fig. 3, the central portions of the rotor blades 325 are cut away at the top thereof, as indicated at 61, and the hub of the rotor is cut away a corresponding amount. Seated in the cut away portions of the blades is a disc 62 which fits upon the shaft 315. The hub 337 of the fan is lengthened, as by the addition of a collar, to rest upon the top of the disc 62, and the key 338 is likewise extended so as to engage in a key-way in the disc to rotate the same with the shaft 315. A ring-shaped diaphragm 63 is supported with one edge between the casing 311 and the cover 313 as shown, and the rotor blades 325, with the attached rotor blade plates 326, operate close to the diaphragm 63. In this case the diaphragm 63 is of greater radial extent than in Fig. 1, and in fact overlaps the outer edge of the disc 62, but the diaphragm being spaced above the disc leaves an annular outlet opening 64 for the escape of material from the rotor chamber into the fan chamber.

By this arrangement, the material, or a substantial part of it, will follow a reverse curve path to reach the outlet 64 so that the material will be subjected to a centrifugal action both above and below the disc 62, as an added precaution against over-size particles getting out of the machine with the desired material.

Here again, the size of the annular outlet opening 64 may be varied in size and radial location, and the extent of the overlap between the diaphragm 63 and the disc 62, may be varied, according to the particle size wanted and the nature of the material, but following in general the principles set forth above. With the inwardly tapered rotor plates, etc., shown in this figure the average delivered particle size will be about 200 screen mesh, according to present experience. These adjustments will usually be made in the factory of the manufacturer of the pulverizing apparatus, whereas in the construction of Figs. 1 and 2, the disc 34 and diaphragm 35, as well as the discharge fan and the rotor blade plates 26, may be changed either at the factory or by the customer for use with different materials or for variations in delivered particle size.

Fig. 4 illustrates the principles of our invention applied to a classifier attachment for pulverizing machines. It comprises a casing 71 having an open mouth 72 which may serve both as the inlet for the pulverized material and as the outlet for the rejected over-size material flowing in opposite directions. Extending into the casing from the top thereof is a shaft 73 on the lower end of which is a rotor comprising a hub 74 on the shaft, a bottom disc 75 and a plurality of radial blades 76. A recessed cover 77 rests upon the casing 71 and has a ring-shaped bottom plate 78 which extends radially inwardly so as to overlie the edges of the rotor blades, and the rotor blades operate in proximity thereto.

Mounted upon the shaft 73 is a disc 79 which is in substantially horizontal alignment with the bottom plate 78 of the cover but is spaced therefrom so as to form an annular outlet 81. The recessed cover 77 has a discharge fan mounted therein comprising a hub 82 which fits upon the shaft 73 and rests upon the top of the disc 79, the two being rotated with the shaft by means of a key 83. The flange of the hub 82 has mounted upon it a ring-shaped plate 84' which carries the fan blades 84. An outlet 85 from the fan chamber provides a discharge port to the pulverized material to a collection system or a place of use, as the case may be. Over the cover 77 is a support 86 for the upper bearing 87 for the shaft 73, the shaft also having a lower bearing 88. The shaft is rotated from any suitable source of power indicated by the pulley 89 and belts 91.

As will be understood, the classifier will operate in the same manner as described in connection with the machine of Fig. 1, namely, the fan blades 84 will draw air and the suspended material through the casing 71 where it will be acted upon by the rotor 76 to set up a classifying vortex which will reject the over-size material and allow the material of the proper size to pass through the annular outlet 81 and from thence through the outlet 85. The bottom plate 78 and the disc 79 may be of any selected sizes so as to either vary the size of the annular outlet 81 or the radial location thereof. Also, the blades of the rotor may have any selected outer contour as, for example, tapered, as indicated by the dotted lines 92.

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

We claim:

1. In a pulverizing and classifying machine, a casing, means for feeding air and material to said casing, a vertical shaft rotatably mounted in said casing, a bladed rotor of less diameter than said casing and mounted on said shaft, a disc of less diameter than the rotor and mounted upon the shaft adjacent the upper end of the rotor so as to partly close the spaces between said blades, the disc being approximately one-half the diameter of the rotor, a diaphragm mounted upon the casing and extending radially inward therefrom in position to form with said disc a narrow annular outlet for air and material acted upon by said rotor, a fan mounted upon said shaft on the opposite side of said outlet from said rotor, an outlet from the casing in the area where said fan is mounted, and means for driving said shaft.

2. In a pulverizing and classifying machine, a casing, means for feeding air and material to said casing, a vertical shaft rotatably mounted in said casing, a bladed rotor of less diameter than said casing and mounted on said shaft, a disc of less diameter than the rotor and mounted upon the shaft adjacent the upper end of the rotor, so as to partly close the spaces between said blades, the disc being approximately one-half the diameter of the rotor, a diaphragm mounted upon the casing and extending radially inward therefrom in position to form with said disc a narrow annular outlet for air and material acted upon by said rotor, and means for driving said shaft.

3. In a pulverizing and classifying machine, a casing having an air inlet at one end thereof and a material and air outlet at the other end thereof, said casing also having a rotor chamber, a bladed rotor of less diameter than said chamber and mounted therein, the rotor being arranged to set up a pulverizing vortex of air and suspended material in the space around said rotor, means for feeding into said vortex at a regulated rate material that is to be pulverized, means closing the spaces between the blades of said rotor at one end, a disc partly closing the spaces between the blades of the rotor at the other end thereof and rotatable therewith, the disc constituting part of an end closure for the rotor chamber, a diaphragm also partly closing the rotor chamber and spaced from said disc to form therewith an annular outlet from the rotor chamber for the sufficiently pulverized material, and means for driving said rotor.

4. In a pulverizing and classifying machine, a casing, means for feeding air and material to said casing, a bladed rotor of less diameter than the casing and mounted vertically for rotation therein to set up a vortex of air and material in said casing, a disc mounted at the central portion of the upper end of said rotor so as to be readily removable and replaceable, a diaphragm mounted at the same end of said rotor as said disc so as to be readily removable and replaceable and cooperating with the disc to form an annular outlet from the portion of the casing in which the rotor is mounted, the disc and dia-

phragm being readily replaceable so as to select the location and width of said outlet, and means for driving said rotor.

5. In a pulverizing and classifying machine, a casing, means for feeding air and material to said casing, a shaft vertically mounted for rotation in said casing, a bladed rotor of less diameter than said casing and mounted upon said shaft to set up a vortex of air and material in said casing, the central portions of the blades of said rotor being cut away at the upper end thereof, a radial disc mounted upon said shaft in the cut-away portions of said rotor and partly closing the spaces between said rotor blades, a diaphragm mounted upon said casing and extending radially inward close to the uncut-away portions of said blades and into the vicinity of said disc to form a narrow annular outlet therewith, and means for driving said shaft.

6. In a pulverizing and classifying machine, a casing, means for feeding air and material to said casing, a vertical shaft rotatably mounted in said casing, a radially bladed rotor of less diameter than said casing and mounted on said shaft, the rotor setting up and maintaining a pulverizing vortex of air and suspended material and the outer edges of said blades being tapered upwardly to govern the fineness of the particle size of pulverized material delivered from the machine, means adjacent the upper end of said rotor providing an annular outlet for the sufficiently pulverized material, the radial position of the annular outlet of said opening being in the region between one-half and two-thirds of the diameter of the rotor and being chosen in accordance with the taper of said rotor blades, a fan for inducing a current of air in the space between the rotor and casing and through said annular outlet, and means for driving said shaft.

7. In a pulverizing and classifying machine, a casing, means for feeding air and material to said casing, a vertical shaft rotatably mounted in said casing, a radially bladed rotor of less diameter than said casing and mounted on said shaft, the rotor setting up and maintaining a pulverizing vortex of air and suspended material and the outer edges of said blades being tapered upwardly to govern the fineness of the particle size of pulverized material delivered from the machine, means adjacent the upper end of said rotor providing an annular outlet for the sufficiently pulverized material, the size of the annular outlet of said opening being between one and two and one-half inches and being chosen in accordance with the taper of said rotor blades, a fan for inducing a current of air in the space between the rotor and casing and through said annular outlet, and means for driving said shaft.

8. In a pulverizing and classifying machine, a casing, means for feeding air and material to said casing, a vertical shaft rotatably mounted in said casing, a radially bladed rotor of less diameter than said casing and mounted on said shaft, the rotor setting up and maintaining a pulverizing vortex of air and suspended material and the outer edges of said blades being tapered inwardly and upwardly in an area between 12° either side of the vertical, means adjacent the upper end of said rotor providing an annular outlet for the sufficiently pulverized material, the radial position of the annular outlet being in an area between one-half and two-thirds of the diameter of the rotor, and the width of the annular opening being between one and two and one-half inches, a fan for inducing a current of air in the space between the rotor and casing and through said annular outlet, and means for driving said shaft.

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