March 12, 1968 W. H. LYKKEN ETAL 3,372,805

FINE PARTICLE CLASSIFIER

Filed Dec. 29, 1965 4 Sheets-Sheet 1

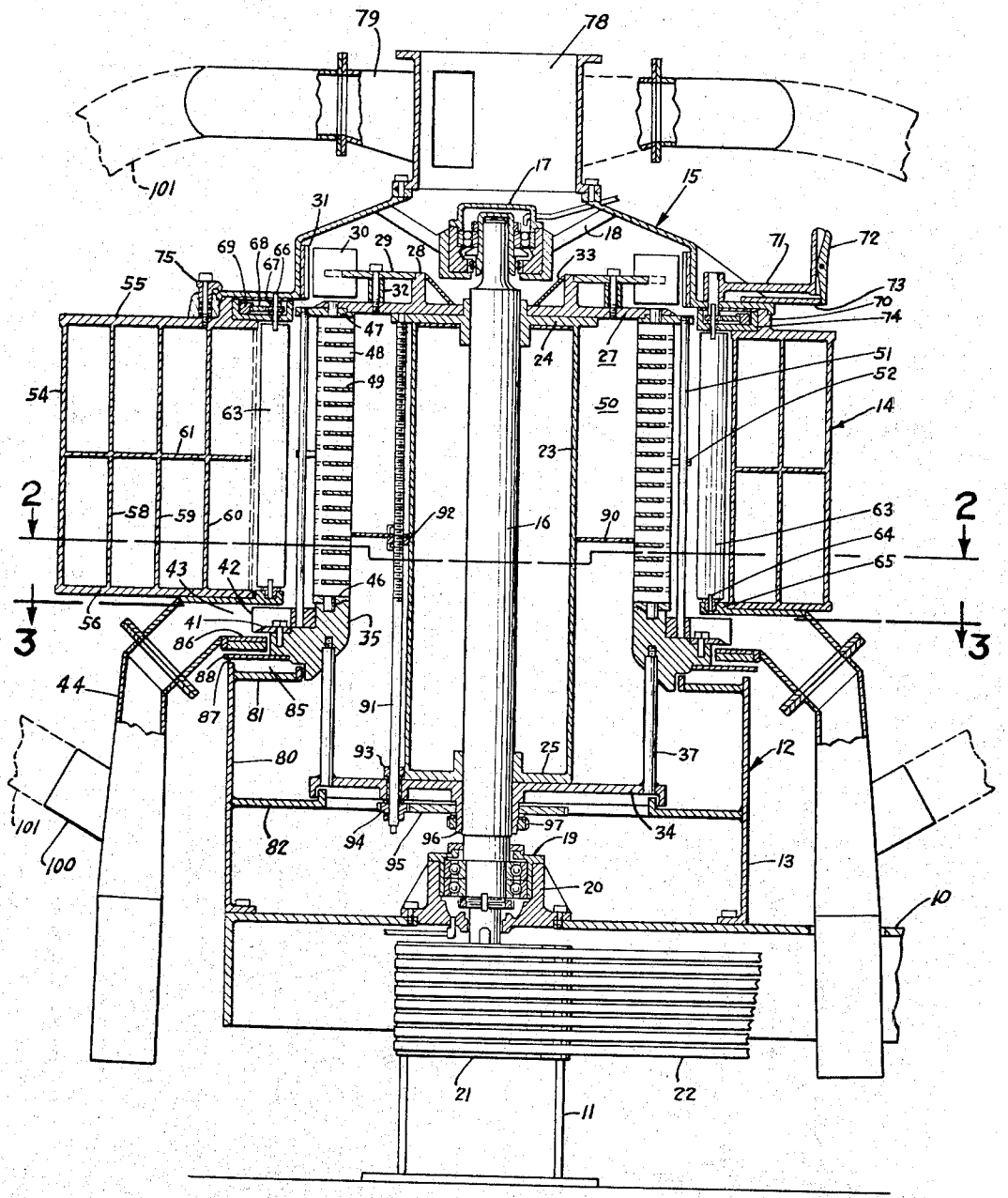

FIG. 1

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Filed Dec. 29, 1965 4 Sheets-Sheet 2

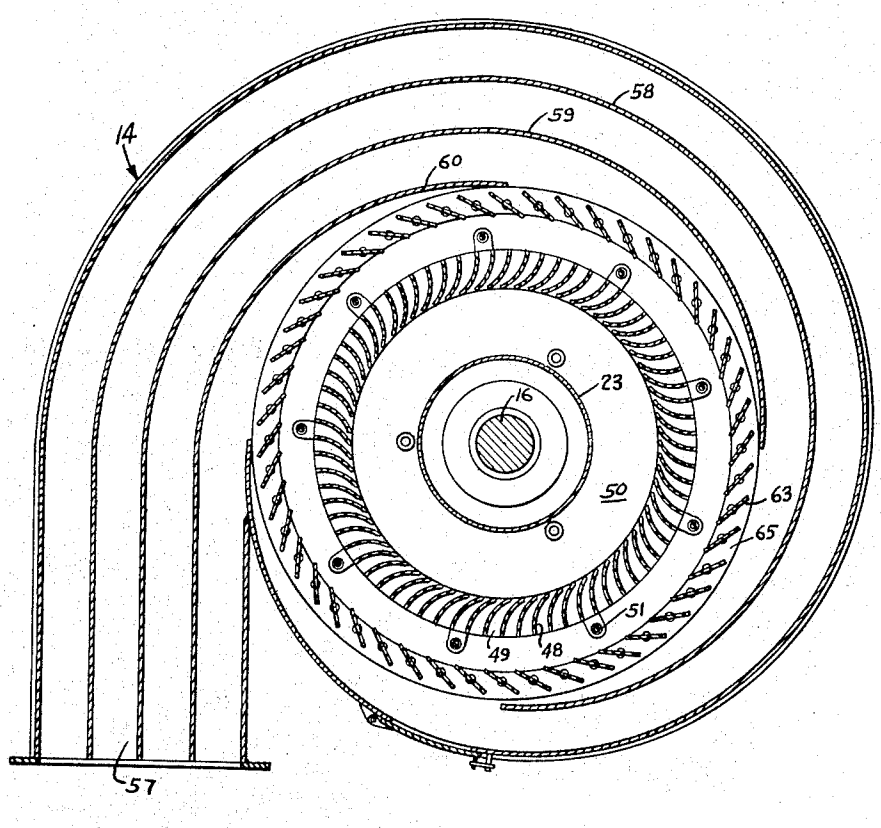

FIG. 2

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FINE PARTICLE CLASSIFIER

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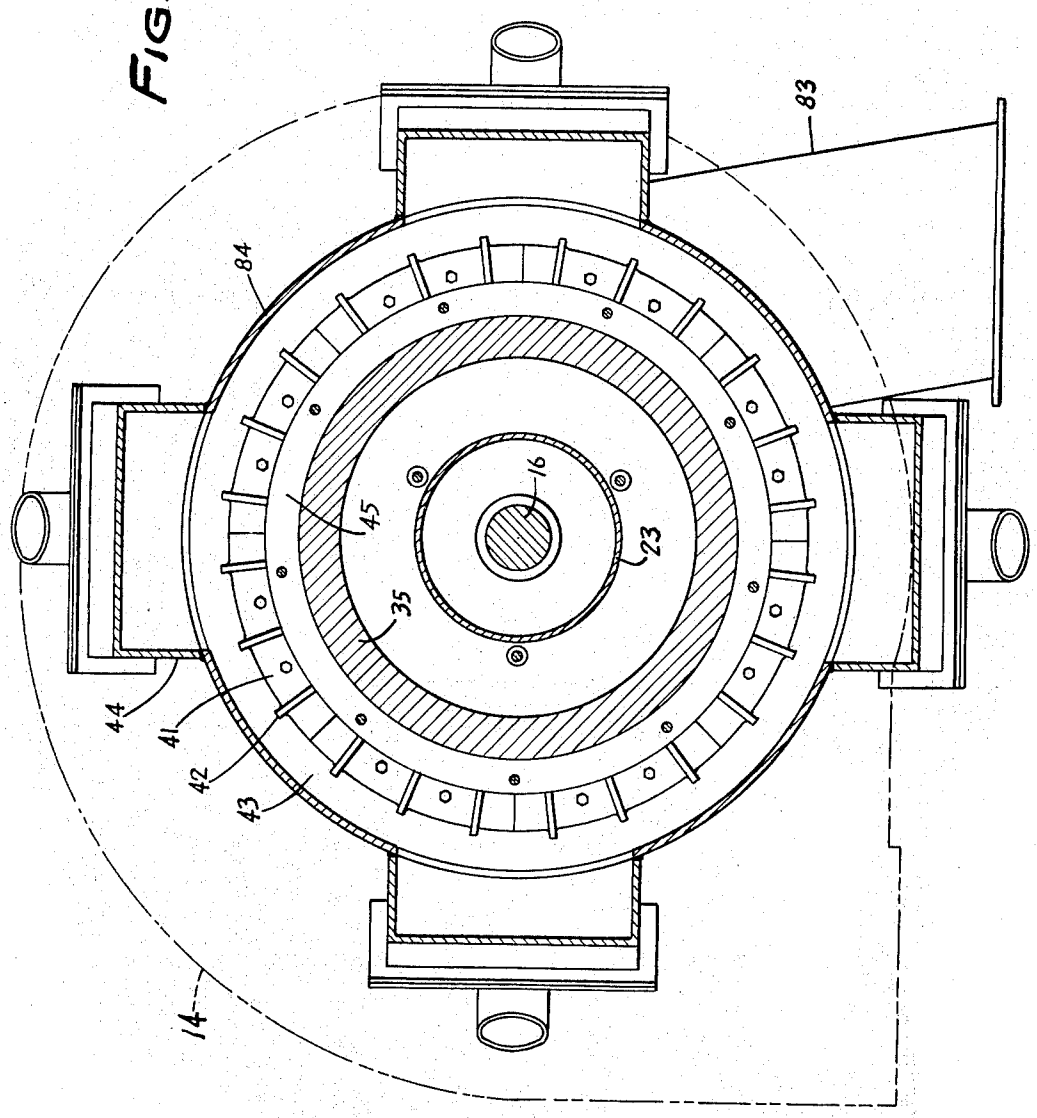
FIG. 3



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Filed Dec. 29, 1965 4 Sheets-Sheet 4

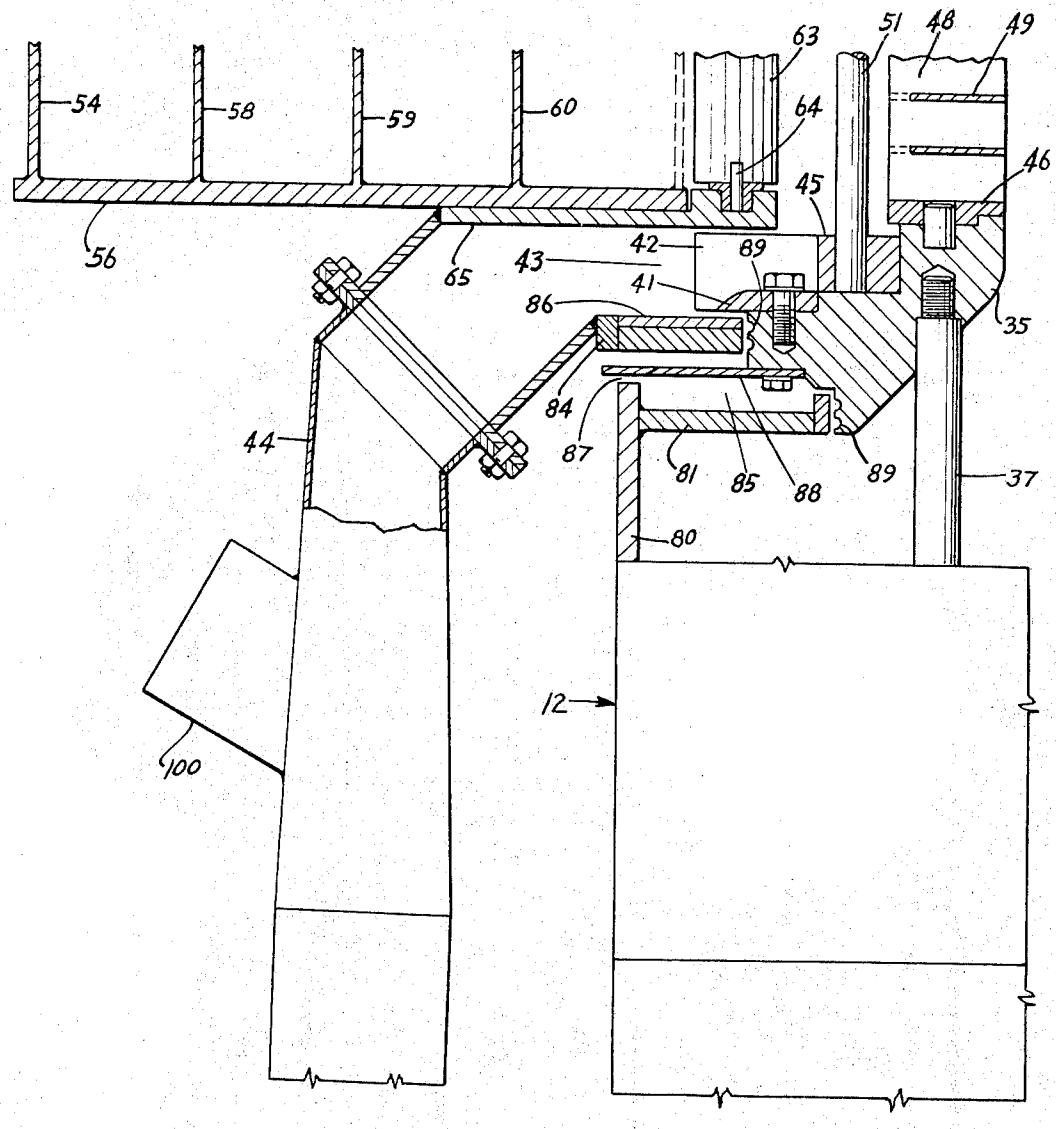

FIG. 4

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3,372,805

FINE PARTICLE CLASSIFIER

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Filed Dec. 29, 1965, Ser. No. 517,387
7 Claims. (Cl. 209—144)

This invention relates to an improved vertical axis classifying apparatus and method for the sharp separation of fractions of finely divided dry pulverulent material in the subsieve range of the type generally described in United States Patent No. 3,015,392. The present invention is directed specifically to means for insuring against the intermingling of the two sharply defined fractions of dry powdered material produced in the apparatus before they can be discharged from the machine. The invention resides primarily in the provision of positive separation and pneumatic seal means between the centripetal finer particle discharge and centrifugal coarser particle discharge to prevent any intermingling of the two.

The invention is illustrated by the accompanying drawings in which the same numerals refer to the corresponding parts and in which:

FIGURE 1 is an elevation in section through the center of the vertical classifier of the invention;

FIGURE 2 is a horizontal section on the line 2—2 of FIGURE 1 and in the direction of the arrows with underlying structure omitted for clarity;

FIGURE 3 is a horizontal section on the line 3—3 of FIGURE 1 and in the direction of the arrows showing that underlying structure in part; and

FIGURE 4 is an enlarged fragmentary elevation in section through the discharge portion of the classifier showing improved positive pneumatic seal means to prevent intermingling of particles from the coarse and fine discharge passages.

Referring to the drawings, the vertical classifier of this invention comprises generally a base platform **10** mounted on supports **11**; a fan housing **12** spaced above base platform **10** and enclosed within an annular plate **13**; an air inlet scroll **14** whose inside periphery forms a housing for the classifier rotor; and a top cover and material feed housing indicated generally at **15**. A vertical shaft **16** extends generally from the top to the bottom of the apparatus through the classifying and fan housing sections. The top end of shaft **16** is journaled in a suitable bearing structure **17** supported in a spider structure **18** mounted within the top cover and material feed housing **15**. The lower end of shaft **16** is journaled in a suitable bearing structure **19** supported in a ring mount **20** on platform **10**. A multiple drive pulley **21** is keyed to the lower end of shaft **16** adapting the shaft to be driven by belts **22** from any suitable motor means.

Vertical shaft **16** is enlarged and reinforced through the part of its length that extends through the classifying and fan housings by a cylindrical tube **23** supported by annular rings **24** and **25** secured to the shaft. An annular top plate **27** is mounted on the top annular ring **24** around the shaft. The top surface of plate **27** is provided with an annular flange **28** having a shoulder at its upper and outer edge which supports the inner periphery of an annular ring **29**. The outer periphery of ring **29** is fitted with a plurality of vertical radiating blades **30** adapted to distribute material feed uniformly for introduction to the classifying zone and, in cooperation with a corrugated lining **31** of housing **15**, to break up and reduce agglomerated masses of pulverulent material. Annular ring **29** is maintained rigid and stable by means of a plurality of spacer blocks **32** through which the annular ring is secured to top plate **27**. A conical shield **33** is provided to prevent accumulation of material within flange **28** and possible unbalance of the rotor thereby.

An annular bottom plate **34** is disposed about the shaft **16** secured to annular ring **25**. A flanged ring **35** is disposed about the shaft **16** and tube **23** between the top and bottom plates **27** and **34**. A plurality of vertical pegs or rods **37** are disposed about the shaft **16** and tube **23** to form fan means in the fan housing **12**. The pegs or rods **37** support the ring **35** in order to aid in driving the honeycomb portion of the rotor.

An annular ring **41** is supported on the upper surface of the flange of ring **35**. A plurality of vertical radiating blades **42** are carried by the ring **41**, in part for the purpose of inducing a slight negative pressure in the annular chamber **43** below the air scroll housing **14** in which the ring and blades rotate. Chamber **43** serves as a positive coarse discharge means, as explained in greater detail hereinafter, and is provided with coarse particle discharge ducts **44**. Ring **41** and blades **42** are desirably formed integrally in segments, cast or otherwise formed of hard wear resistant metal, for easy replacement.

A heavy mounting ring **45** is disposed about the outer periphery of flanged ring **35** supported by the upper surface of the flanged ring **35** inwardly of the blades **42** carried on top of the ring **41**. An annular end plate **46** which forms the bottom plate of the rotor classifying section is supported by and secured to the top of mounting ring **35**. An annular plate **47**, which forms the top plate of the rotor classifying section, is supported on the bottom surface of rotor top plate **27**. The rotor classifying section supported between the bottom rotor plate **46** and the top rotor plate **47** includes a plurality of slotted vertical blade members **48** interlocked with a plurality of slotted horizontal spaced-apart annular disc members **49**. The vertical classifier blades may be flat and disposed to radiate out generally from the axis of the rotor or they may be disposed at an angle between radial and tangential.

The intersecting edges of the classifier blades and classifier discs present the appearance of a cylindrical drum having generally a grilled or honeycombed surface. The inner edges of the vertical classifier blades and the inner peripheries of the horizontal classifier discs define the outer periphery of an annular chamber **50** around tube **23** which serves as an axial discharge duct through which classified fine particles are conveyed after separation by the classifying section of the rotor to the fan housing for discharge. A plurality of vertical rod members **51** are supported between the ring **45** and top rotor plate **47** to form a cage structure surrounding and spaced outwardly from the grill structure of the classifier drum formed by the vertical blades and horizontal discs. Addition rigidity is imparted to the cage structure by means of intermediate support brackets **52** spaced about the periphery of the drum structure between the classifying section top and bottom plates.

The air inlet scroll housing **14** surrounds the classifier section of the rotor and is substantially co-extensive in height with it. The air inlet housing comprises an outer scroll housing wall **54** held between a top housing wall **55** and a bottom housing wall **56**. A tangential air inlet opening **57** to the scroll housing is provided. A plurality of interior vertical scroll baffle members **58**, **59** and **60** disposed within the air inlet housing and extending successively lesser distances within the housing effectively divide the inner periphery of the inlet housing into a plurality of substantially equal areas to insure simultaneous and substantially equal delivery of air to all portions of the classifying zone surrounding the periphery of the classifier section of the rotor. One or more horizontal baffle members **61** similarly divide the air inlet housing into vertical sections to insure simultaneous and substantially

equal distribution of air vertically along the classifying zone and classifying section of the rotor.

In order that the flow of air from the air inlet housing to the classifying area surrounding the classifying section of the rotor may be uniformly directed, an annular louver curtain wall is disposed in the space between the inner periphery of the air inlet housing and the outer periphery of the classifying section of the rotor. The louver curtain wall comprises a plurality of individual louvers 63 which may be stationary or, preferably, as shown in the drawings, adjustable as to pitch. The bottom end of each vertical louver element is provided with a pivot or pin structure 64 by which it is journaled for rotation in an annular ring 65 supported by the inner periphery of the air inlet housing bottom wall 56. The upper end of each louver element 63 is provided with a top pin 66.

The top pin of each louver element is provided with a small spur gear 67 each of which meshes with the teeth of a ring gear 68 journaled for rotation in a ring bearing 69 supported within a ring flange 70 on the top of the top plate 55 of the air inlet housing. One of the louver elements is fitted with a crank 71. Rotation of crank 71 causes rotation of the gear 67 which in turn causes rotation of the ring gear 68 and a corresponding rotation of each of the other louver elements. Crank 71 is provided with a pivoted latch 72 adapted to engage a notched latch plate mounted on the top housing 15. The notches in the latch plate 73 correspond to predetermined pitch angles and permit locking the louver members in the desired predetermined positions.

The classifier top housing 15 rests upon the ring flange 70 on the top wall 55 of the air inlet housing 14 secured by a plurality of clamping fastening means 75 for easy removal when desired. The classifying section of the rotor is designed for easy removal for repair, replacement, inversion to change the direction of the classifier blades, etc. by removal of the top housing without disturbance to the remainder of the apparatus. The top housing is provided with a material feed inlet 78 fitted with any conventional material feeding mechanism (not shown) and preferably one or more coarse particle return ducts 79.

The fan housing 12 is in the form of a scroll housing having a vertical outer housing wall 80 held between a top housing wall 81, and a bottom wall 82. The top plate 81 of the fan housing is provided with a circular opening in which the flanged ring 35 of the rotor is disposed for rotation and the bottom plate 82 is provided with a similar circular opening in which the flanged bottom plate 34 of the rotor is disposed for rotation. A tangential discharge duct 83 exits from the fan housing (FIGURE 3).

A vertical cylindrical housing wall 84 etxending between the top plate 81 of the fan housing and the bottom plate 56 of the air inlet housing forms the outer housing wall for the coarse discharge chamber 43. An annular horizontal plate 86 extends inwardly from housing wall 84 toward flanged ring 35 so as to leave running clearance between the inner periphery of plate 86 and the outer periphery of ring 35. Ring 41 carrying blades 42 projects outwardly beyond the outer periphery of ring 35 and overlaps the top surface of plate 86. The bottom surface of ring 41 is closely spaced from the top surface of plate 86 so as to provide running clearance. The horizontal plate 86 forms a common wall separating the coarse discharge chamber 43 from a positive pneumatic seal chamber 85. The pneumatic seal chamber 85 shares common wall 81 with fan housing and fine particle discharge chamber 12. The inside periphery of pneumatic chamber 85 is defined by the outer periphery of ring 35. An air inlet slot 87 extends around the periphery of the machine.

An annular separator or barrier disc 88 is secured to the bottom surface of the flange of ring 35 so as to rotate with ring 35 and the classifier rotor within pneumatic chamber 85. The outer periphery of disc 88 preferably extends beyond the outer periphery of housing wall 80 and preferably is closely spaced from the top of that wall so as to just provided running clearance. Disc 88 functions as a positive barrier or separator between the coarse discharge chamber 43 and fine discharge chamber which is fan housing 12.

Reduced pressure exists within each of those chambers. This causes some atmospheric air to be drawn from pneumatic seal chamber 85 and air inlet slot 87. Because of the larger capacity of the fan structure in housing 12 and the suction applied by auxiliary fan means, the pressure in chamber 12 is lower than that in chamber 43. Under some conditions this greater reduced pressure in the fine discharge chamber has in the past caused some coarse particles to be withdrawn from the coarse particle discharge chamber 43 and sucked into the fine discharge chamber 12 to contaminate the classified fine particle product. This danger is successfully eliminated by the present structure. The reduced pressure within chamber 12 can only result in air being drawn from the pneumatic seal chamber 85 because there is no communication within that chamber between the coarse discharge chamber and fan housing, this being effectively prevented by barrier disc 88.

The outer periphery of flanged ring 35 which is adjacent the inner periphery of horizontal plate 86 and that which is adjacent the inner periphery of fan housing top wall 81 are both provided with one or more peripheral turbulence creating grooves or channels 89. These grooves or channels 89 provide further effective pneumatic sealing in the narrow spaces provided for running clearance between adjacent moving parts by setting up eddy currents in the air flow being drawn into chambers 43 and fan housing 12 from pneumatic seal chamber 85.

In the event of accidental escape of coarse particles from chamber 43 through the space between ring 41 and the top surface of plate 86 and through the turbulence between the inner periphery of plate 86 and outer periphery of the flange of ring 35, the particle would then fall on the top surface of disc 88 and be thrown centrifugally outwardly through air inlet slot 87 without any possibility of it being drawn into the fine discharge chamber.

Preferably the coarse discharge chamber 43 is pro- with a plurality of discharge ducts 44, as best seen in FIGURE 3. In this manner the coarse particles are discharged from the apparatus rapidly as they are separated and thrown outwardly from the bottom of the classifying zone without prolonged circulation along the inner surface of wall 84. The coarse particles are discharged through ducts 44 in a highly dispersed state. The lower ends of ducts 44 are sealed by a flap valve, rotary valve or equivalent means to prevent air suction in reverse. The particles are passed into a cyclone separator or similar gas separation means. Desirably each coarse discharge duct 44 is provided with a side outlet 100 connected by means of flexible tubing or similar duct or conduit means 101 to coarse return duct 79 at the feed inlet 78 to balance the pressure to permit fan 42 to be effective at low speeds, to supply air to help disperse the feed stock, and for recycling of any finer particles intermingled with the coarse discharge. In this way in the course of a second pass through the apparatus a further separation and classification of those recycled particles may take place.

In order to increase the versatility of the classifier of this invention, it is preferably provided with a deck selector means as described in United States Patent No. 3,015,393. The deck selector means makes it possible for the operator to utilize as much or as little of the axial height of the classifying section of the rotor as necessary or desirable for the particular operating conditions or the particular desired product characteristics. The deck selector means includes an annular ring disc 90 disposed in and adapted to be moved vertically with a sliding fit in the annular axial chamber 50 between the outer surface of shaft tube 23 and the inner periphery of the classifier drum structure. The deck selector disc 90 is sup-

ported horizontally for vertical travel within the axial duct **50** by a plurality of threaded shafts **91** disposed symmetrically about and spaced from the shaft tube **23**.

The deck selector disc **90** is mounted for movement along the threaded shafts **91** by virtue of threaded collars **92** supported on or in the deck selector disc in number and position corresponding to the number and location of the threaded shafts **91**. The upper end of each threaded shaft **91** is journaled for rotation adjacent the outer periphery of annular ring **24**. The lower end of each of the threaded shafts **91** passes through the bottom rotor plate **34** but is held against dropping through the bottom plate by virtue of a collar **93** on the shaft immediately above the top surface of the bottom plate **34**. To minimize friction, bottom plate **34** is preferably provided with sleeves of bearing material in which the shafts **91** rotate and collar **93** preferably bears against a collar or washer of bearing material. A small pinion gear **94** is keyed to the end of each of the shafts **91** which extends below the bottom plate **34**. A sun gear **95** is carried by the collar or sleeve **96** extending from the bottom surface of the bottom rotor plate **34** and is secured by a locking nut or threaded collar **97**. The gear **95** is journaled for rotation with the end plate **34** and the rest of the rotor structure but at the same time is adapted for rotation with respect to the rotor for adjustment of the level of the deck selector disc. The teeth of each of the pinion gears **94** mesh with the teeth of the sun gear **95** to form a planetary gear system. Thus when the sun gear **95** is rotated relative to the main shaft **16**, each of the planetary pinion gears **94** is rotated to cause rotation of the vertical threaded shafts **91**. By virtue of the rotation of the threaded shafts the threaded collars **92** on those shafts supporting the deck selector disc are caused to move vertically up or down along the shaft depending upon the direction of rotation and carry the deck selector disc along with them. The rotation of one threaded shaft causes uniform and simultaneous rotation of each of the other shafts.

When the deck selector disc is at the proper desired level, it is maintained at that level by locking one of the planetary pinion gears **94** against rotation by virtue of any suitable latching means. When pinions **94** are thus locked in position, the gear **95** rotates with the main shaft **16** but since there is no relative movement between the gears **95** and **94**, the deck selector disc remains at the predetermined height. The deck selector disc is solid and imperforate. When it is in position, all of the classifying section of the rotor above the deck selector disc is rendered non-operating. By use of this means, the rotor capacity can be varied without dismantling the apparatus. For a given set of operating conditions, the classification cut can be varied to permit the separation of smaller or larger particles by moving the deck selector upwardly or downwardly.

A further pneumatic seal is created at the bottom of the fan housing **12**. The reduced pressure within the fan housing causes a small positive air flow through the circular opening in the bottom wall **82** of the fan housing around the flanged periphery of the bottom rotor plate **34** sufficient to prevent loss of any wanted fine particles.

In the operation of the classifier of this invention, reduced pulverulent material is introduced into the feed inlet **78**. This material falls by gravity past the spider support for the top shaft bearing and onto the annular ring **29**. The rotation of ring **29** causes the material to be thrown centrifugally outwardly. The blades **30** assist in uniformly distributing and dispersing the particles and in cooperation with a corrugated lining ring **31** on the interior of the top housing reduces and separates any agglomerated masses of particles. The dispersed feed material then enters the classification chamber passing through the anular space around the top rotor plate **27** and the classification section top plate **47** and the inner periphery of the channel ring member **74** to drop into the annular chamber between the louver curtain wall and the vertical cage rods of the rotor.

The air inlet surrounds the classifying area surrounding the classifying portion of the rotor and by virtue of the construction of the air inlet housing, air is introduced simultaneously and substantially uniformly to all portions of the classifying zone and the periphery of the classifying section of the rotor. The incoming air is given direction by virtue of the pitch of the louver members **63** comprising the louver curtain wall. The incoming particles are thus subjected to the effect of gravity and the directional air flow from the air inlet. At the same time the rotation of the rotor sets up a circular air flow about the periphery of the rotor. The vertical cage members **51** induce a plurality of loose intra-rod vortices and the vertical classifier blades **48** induce a plurality of intra-blade vortices about the periphery of the rotor.

The functioning of intera-blade vortices in the classification of fine particles has been amply explained elsewhere and need not be described here. Suffice it to say that vortices are formed betwen the blades comprising the classification rotor by which coarser particles are circulated within the rotor sections defined by the blades and discs to a predetermined distance determined by the shape and mass of the particles and finer particles are similarly carried to a greater depth into the rotor. The normal centrifugal throwout effect of the rotor upon the particles of predetermined wanted size is overcome by the application of centripetal drag created by an induced air flow through the rotor and out through the axial duct **50** and out through the fan housing and product discharge duct. The induced centripetal drag is balanced with the centrifugal throwout effect of the rotor at the place within the rotor that the fine particles of desired size are carried by the intra-blade vortices and into which no particles of larger size are carried.

The increased air inlet capacity permits rapid, tthorough and uniform dispersion of the solid particles in air with the effect that the capacity of a classifier of given size is greatly increased. At the same time separation of particles is greatly facilitated because the particles are exposed to a uniform and optimum display of opposing forces. Formerly in classifiers of this type, the material to be separated and air entered the classification in counter-current flows which met in the classification zone. The result was that coarser particles had to fight their way through the counter-current flow of air before they could be discharged from the classification zone and hence were detained unnecessarily long in the classification zone before discharge. According to the method of the present invention, the coarser particles drop by gravity through the classification zone and in the course of their downward travel encounter the entering side flow of air which has the effect of separating finer particles from coarser particles without materially detaining the coarser particles in the classification zone. The coarser particles drop by gravity onto the ring **41** below the classification zone and are positively thrown out by the centrifugal effect of the rotating ring into the coarse particle discharge chamber **43** and withdrawn through the ducts **44**.

The peg fan in the fan housing **12** functions primarily to keep the desired fine particles dispersed and airborne. Air flow through the apparatus is induced by conventional means, such as a fan, in communication with the discharge duct **83** to withdraw the desired particles and transport them to an air separator, such as a cyclone separator, or the like.

Reduced air pressure is created in the coarse particle-discharge chamber **43** by blading **42** carried by ring **41** and reduced pressure exists in the fan housing both by virtue of rotation of the peg fan and the outside suction source. Coarse particles might ordinarily be drawn from the coarse particle discharge chamber into the fan housing and fine particle discharge were it not for the presence of the intervening pneumatic seal chamber **85**. This pneu-

matic seal operates by virtue of air drawn into the pneumatic seal chamber through the slot inlet **87** and an opposite sides of the separator disc **88** rotating within the pneumatic seal chamber into the coarse discharge chamber and the fan housing to create an effective air barrier against the accidental contamination of the fine particle product by coarse particles.

We claim:

1. A vertical classifier apparatus for dry pulverulent material which comprises:

(A) a peripheral inlet-axial outlet centripetal extraction classifier rotor journaled for rotation on a vertical axis within a rotor housing, said rotor comprising a plurality of spaced apart horizontal annular discs and a plurality of vertical blades between the discs,

(B) an annular axial discharge duct extending through said rotor,

(C) a material feed inlet at the top of said housing,

(D) means for distribution of feed for gravitational flow about the cylindrical periphery of said rotor,

(E) an air inlet to said rotor housing,

(F) a fan housing and fine product discharge in communication with the axial discharge duct of said rotor,

(G) fan means on said rotor within said fan housing,

(H) an annular coarse particles discharge chamber disposed about said rotor between the bottommost of said annular discs and said fan housing and in direct communication with the annular space surrounding the cylindrical periphery of the rotor,

(I) a vertically bladed horizontal ring extending from said rotor for rotation in said coarse discharge chamber,

(J) at least one coarse particle discharge duct in communication with said chamber,

(K) an annular pneumatic seal chamber disposed around said rotor between said coarse particle discharge chamber and said fan housing,

(L) an air inlet to said pneumatic seal chamber, and

(M) a horizontal barrier disc extending from said rotor for rotation in said pneumatic seal chamber, said disc dividing said chamber into a top portion in communication with said last named air inlet and said coarse particle discharge chamber and a bottom portion in communication with said air inlet and said fan housing, whereby passage of particles from said coarse particle discharge chamber to said fan housing is effectively prevented.

2. A vertical classifier according to claim **1** further characterized in that said air inlet to said pneumatic seal chamber is a circumferential slot extending around the apparatus and the outer periphery of said barrier disc extends through said slot for rotation therein.

3. A vertical classifier according to claim **1** further characterized in that said classifier is provided with a plurality of coarse discharge ducts uniformly spaced about the periphery of said annular coarse particle discharge chamber, each of said ducts including a downwardly depending portion and a port in said depending portion, and duct means communicating between said port and the material feed inlet for recycling a portion of the coarse particle discharge.

4. A vertical classifier according to claim **1** further characterized in that said vertically bladed horizontal ring extending from said rotor for rotation in said coarse discharge chamber is formed in a plurality of arcuate segments from wear resistant metal, the vertical blades on each ring segment being formed integrally with the ring segment.

5. A vertical classifier according to claim **1** further characterized in that said pneumatic seal chamber includes spaced apart top and bottom walls formed from annular plates extending inwardly from the outer housing wall to close proximity with said rotor to provide running clearance therebetween and at least one of the facing surfaces between said annular plates and rotor is provided with peripheral turubulence-creating channels.

6. A vertical classifier according to claim **5** further charactrized in that said rotor includes a flanged mounting ring adjacent the coarse particle discharge and pneumatic seal chambers, the flange of said ring extending outwardly, said bladed ring being supported on the upper surface of said flange and said barrier disc being supported from the bottom surface of said flange and the annular top wall of said pnuematic seal chamber extending horizontally into close proximity with the end of said flange and lying between said bladed ring and barrier disc.

7. A classifier according to claime **6** furthr characterized in that said end of said flange is provided with at least one circumferential turbulence-creating channel.

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