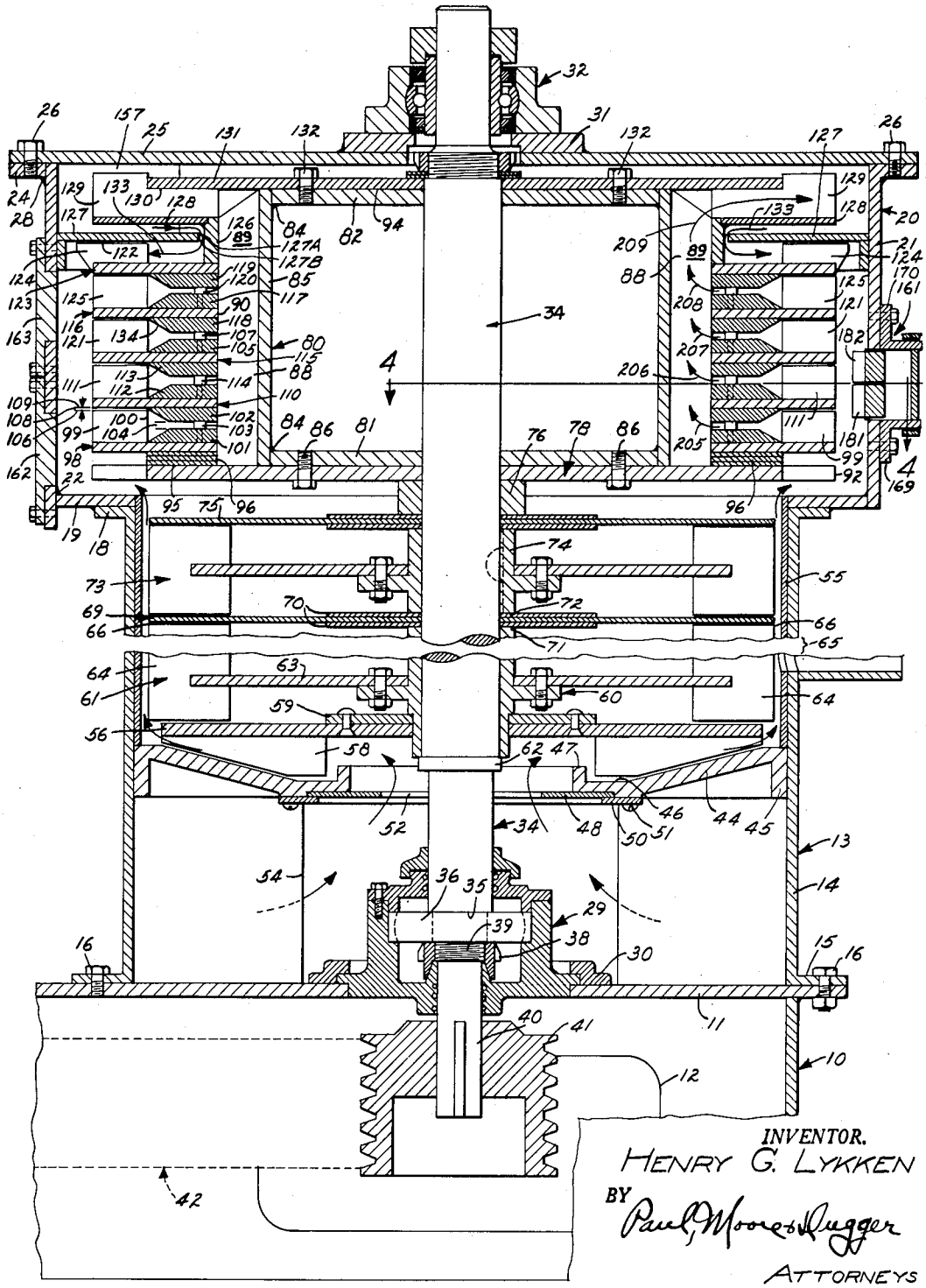
July 17, 1956 H. G. LYKKEN 2,754,967

CENTRIPETAL CLASSIFIER

Filed March 24, 1952 4 Sheets-Sheet 1

FIG. 1



INVENTOR.
HENRY G. LYKKEN
BY Paul, Moore & Dugger
ATTORNEYS

July 17, 1956 H. G. LYKKEN 2,754,967

CENTRIPETAL CLASSIFIER

Filed March 24, 1952 4 Sheets-Sheet 2

FIG. 3

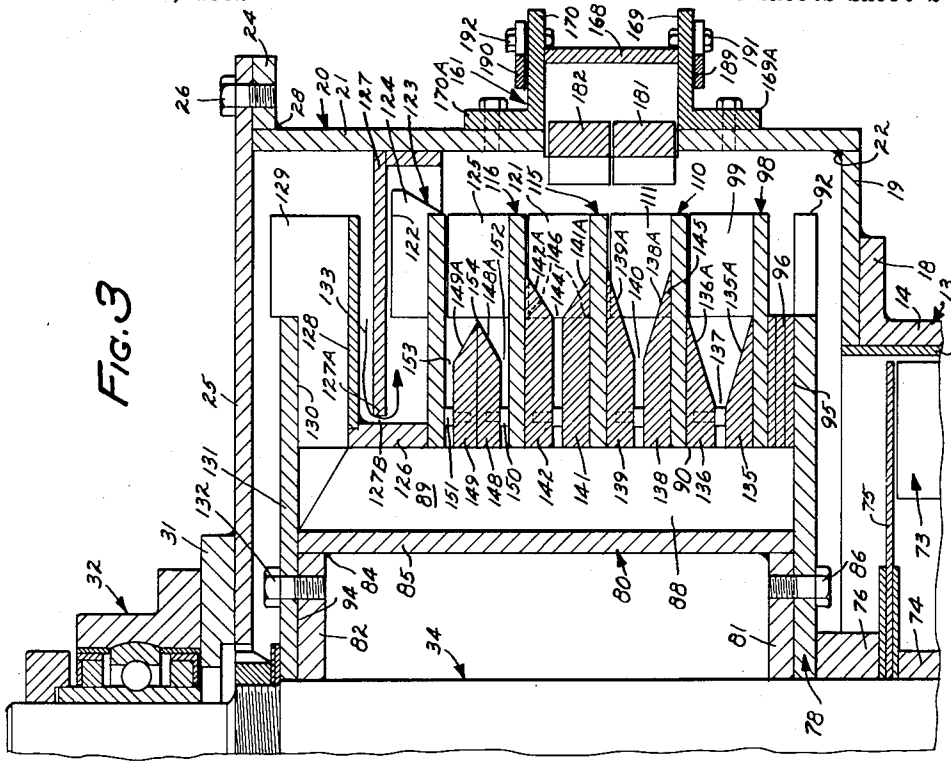
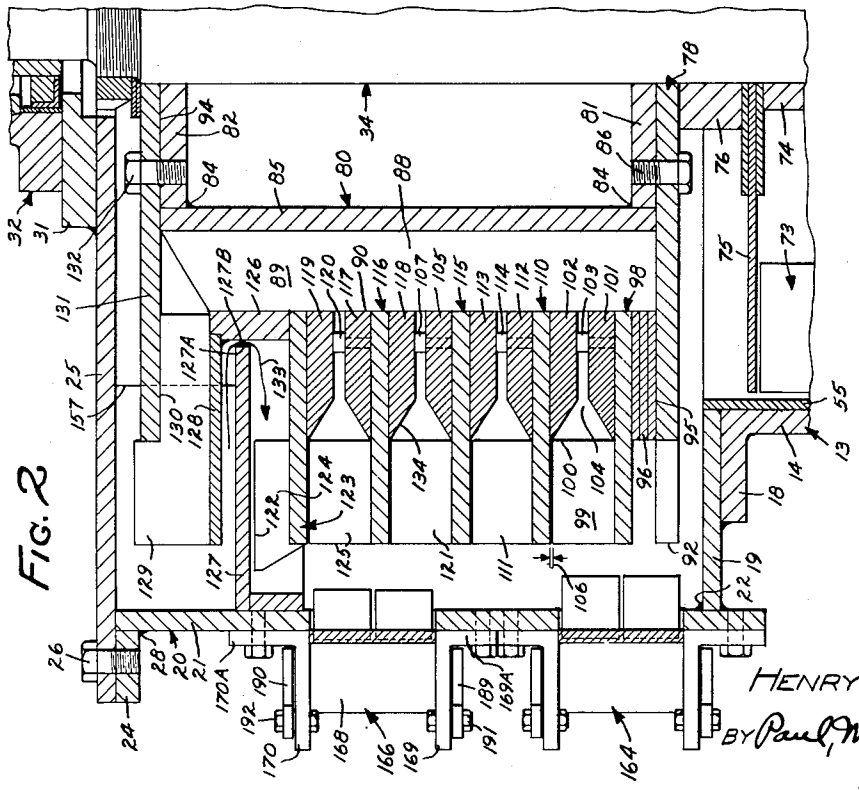


FIG. 2



INVENTOR.

HENRY G. LYKKEN

BY Paul, Moore & Rugger

ATTORNEYS

July 17, 1956 H. G. LYKKEN 2,754,967

CENTRIPETAL CLASSIFIER

Filed March 24, 1952 4 Sheets-Sheet 3

FIG. 4

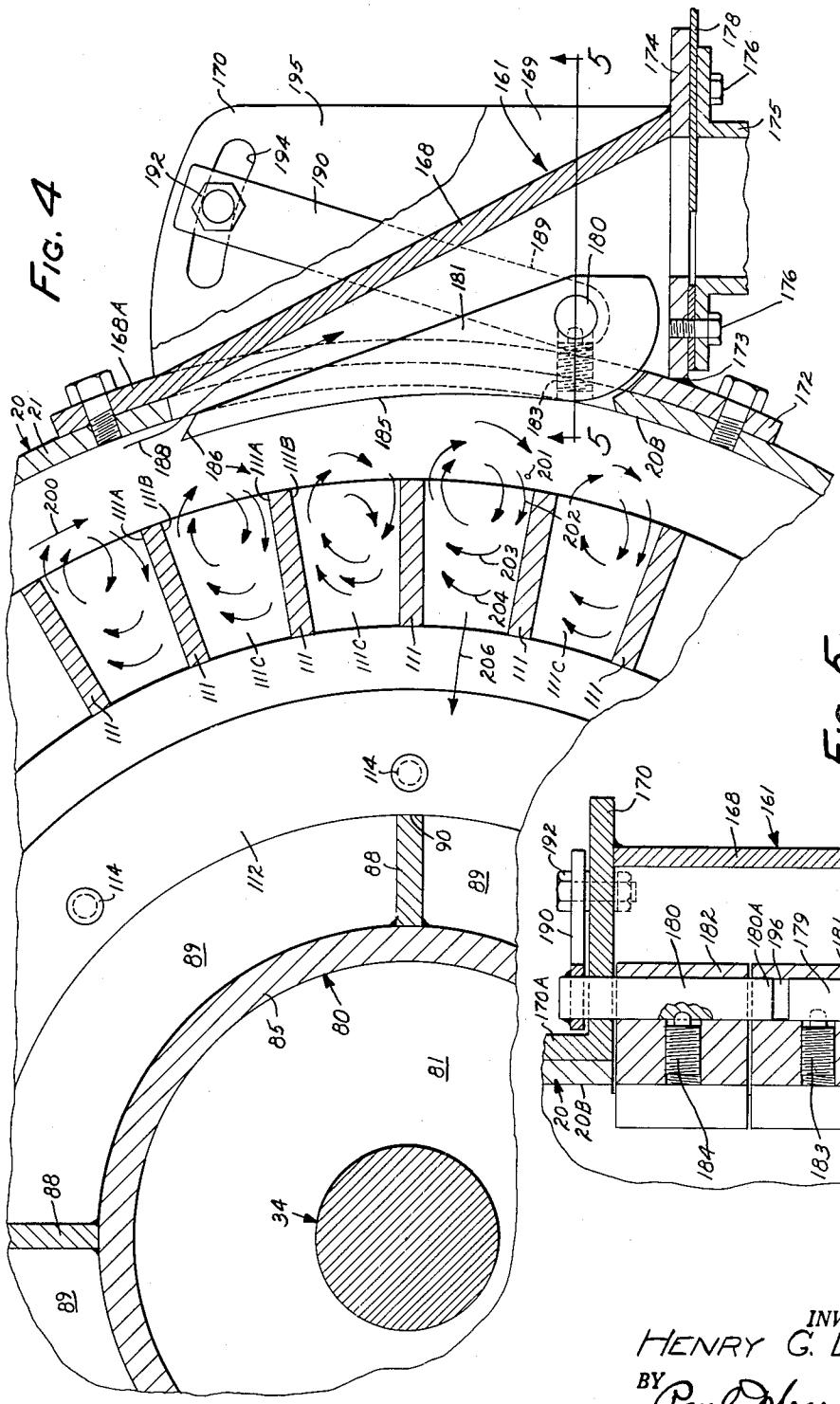


FIG. 5

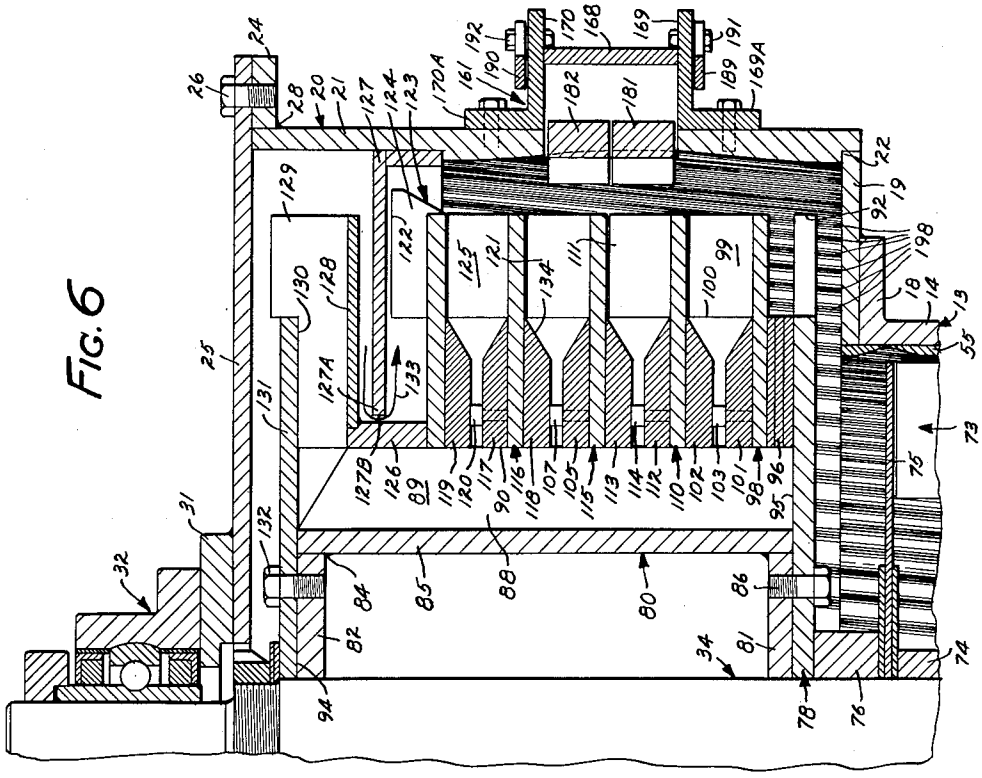
INVENTOR.
HENRY G. LYKKEN
BY Paul, Moore & Rugger
ATTORNEYS

July 17, 1956 H. G. LYKKEN 2,754,967

CENTRIPETAL CLASSIFIER

Filed March 24, 1952 4 Sheets-Sheet 4

FIG. 6



INVENTOR.
HENRY G. LYKKEN
BY Paul, Moore & Rugger
ATTORNEYS

United States Patent Office

2,754,967

Patented July 17, 1956

2,754,967

CENTRIPETAL CLASSIFIER

Henry G. Lykken, Minneapolis, Minn., assignor to The Microcyclomat Co., Minneapolis, Minn., a corporation of Delaware

Application March 24, 1952, Serial No. 278,239

24 Claims. (Cl. 209—144)

This invention relates to apparatus for classifying and/or segregating pulverulent materials. In the production of finely divided solid material or powders, it is desirable, and in many cases essential that the material be classified on the basis of particle size so that the finished product will have in it particle sizes of only prescribed size ranges. Thus, in the milling of solid materials the milling operation may produce a wide variety of particle sizes ranging from sizes which may be sieved in excess of fifty microns through the fine particle ranges, one to fifty microns and even ultrafine material below one micron are produced. The separation of the relatively coarser materials of sieve sizes above fifty microns may be accomplished with comparative ease, but the separation of the ultrafines from fines, and particularly the production of narrow ranges of particle sizes, is exceedingly difficult. The difficulty increases as the particle size decreases.

In centrifugal classifiers the airborne material is rotated at a velocity required to throw the coarser materials radially outward and out of an axial flow. The oversize, as it strikes and rotates on confining walls, can be removed by various means, and the fines remain in the air or other gaseous stream by which they are carried and are removed axially along with the gaseous stream, being thereafter subsequently collected as by means of a bag house, etc.

The so-called cyclone collector is in fact a centrifugal classifier designed to classify as between solid material and air. This it does only partially because a percentage of fine and superfine material remains in the air stream and goes out with the air. Other classifying apparatus has been proposed but they are subject to the difficulty that in commercial applications they are unable to make a classification as between a wanted particle size, such as two microns, and an unwanted particle size, such as three microns. In such prior apparatus a large percentage of the wanted smaller sizes will be thrown out with the undesired oversize, and, conversely, particles only slightly larger than the wanted size are frequently collected with the smaller wanted size.

It is therefore an object of the present invention to provide an improved centripetal classifier capable of providing precise classification of particle sizes.

It is a further object of the invention to provide an improved centripetal classifier capable of providing on a commercial scale, precise classifications of materials in the fine and ultrafine ranges.

It is another object of the invention to provide a classifier apparatus which admits of complete recovery of a desired particle size from the mill load and is capable of providing a precise classification on a particle size basis, even in ranges below one micron, such as a separation of particles of minus one micron size.

It is a further object of the invention to provide a classifying apparatus which is relatively independent of rotative speed, except as is required to maintain ample centrifugal stresses.

Other objects of the invention include the provision of an improved rugged classifier unit capable of being used

independently or built in conjunction with a rotary mill; the provision of an improved classifier capable of being readily revised without redesign for setting up precise classification on individual specification basis; to provide a classifier wherein the classifying elements are stacked and readily interchangeable so as to allow a basic classifier design to be fitted to particular classification needs; to provide a classifier assembly capable of being rearranged on the job by inexperienced mechanics so as by testing of particular materials to permit the selection of the best classifier element assembly for such materials; and to provide an improved classifier structure wherein the coarser material is positively prevented from mixing with the classified finer materials without running seals.

Other and further objects of the invention are those inherent in the apparatus herein illustrated, described and claimed.

The invention is illustrated with reference to the drawings in which corresponding numerals refer to the same parts and in which—

Figure 1 is a vertical sectional view showing the improved classifier of the present invention combined with a rotary mill;

Figure 2 is an enlarged fragmentary vertical sectional view showing a portion of the mill to the left of the center line, corresponding generally to that shown in Figure 1, but illustrating another place around the circumference of the mill at which additional skimmer boxes may be placed;

Figure 3 is a fragmentary, vertical, sectional view corresponding roughly to that shown in Figure 2, but showing a portion of the mill to the right of the center line, and illustrating various forms of classifier elements assembled or "stacked" for a particular classifying operation;

Figure 4 is a fragmentary horizontal sectional view, somewhat enlarged, taken along the line 4—4 of Figure 1;

Figure 5 is an enlarged fragmentary vertical sectional view taken along the line 5—5 of Figure 4; and

Figure 6 is a fragmentary vertical sectional view to the right of the center line corresponding roughly to those shown in Figures 2 and 3, showing a slightly modified form of the invention.

In Figure 1 of the accompanying drawings the classifier is shown combined with a rotary mill. It is to be understood, however, that a rotary mill need not be combined with the classifier, and that the classifier can be used as a separate unit. However, when so combined, the classifier is preferably positioned over the rotary mill and the mill may be supported upon a suitable base shown comprising a horizontal plate **11** secured to an upright wall **10** which may be supported upon a suitable foundation, not shown. The base **10—11** may be extended to one side of the mill or classifier to form a common base for a motor, not shown. In Figure 1 the base is shown extending to the left from the axis of the mill, and has an opening **12** in one of its upright walls to permit servicing of the belt drive, which may be conveniently housed within the base structure.

The rotary mill, generally designated **13**, is shown comprising a cylindrical shell or wall **14** provided with a bottom flange **15** that may be secured to the base by means of bolts or cap screws **16**. The upper end of the cylindrical shell **14** is provided with a similar flange **18** which, for convenience, may be welded to a ring-like plate **19**, forming the bottom wall of the classifier unit or section generally designated **20**. The classifier unit **20** comprises a cylindrical outer wall **21** which extends upwardly from the annular plate **19** and has its lower edge welded thereto, as indicated at **22**. A horizontal flange **24** is welded to the upper end of wall **20**, as indicated at **28**, and serves to support a top plate or wall **25**, shown secured thereto by cap screws **26**.

A suitable bearing structure, generally designated **29**, is shown mounted upon the base plate **11** and may be held in place thereon by a retaining ring **30**. The top plate **25** of the classifier unit is provided with a central pad **31**, upon which a top bearing generally designated **32** is mounted. The bearings **29** and **32** need not be described with particularity, other than to say that they are usually of the preloaded ball bearing type and may utilize self-aligning bearings. Bearings of sufficient size and ruggedness are used, so as to carry the rotating parts at their intended speeds, and adequate lubrication and dust seals are also provided. The particular design of the bearings is within the province of mechanical engineering and many satisfactory step bearings, as used at **29**, and journals, as used at **32**, may be obtained in the market.

Bearings **29** and **32** serve to support a central rotating shaft, generally designated **34**, which serves as a common shaft for both the mill and classifier unit or section. At the bottom end of the shaft **32** there is a shoulder **35** which is seated against the bearing portion **36**, the bearing **36** being held in place by the nut **38** that is threaded onto the threaded portion **39** of the shaft. The lower end **40** of the shaft has keyed to it a pressed on multiple V-belt pulley **41**, which may be driven by a suitable belt **42** indicated on dotted lines in Figure 1. Belt **42** may be driven by a motor mounted within the base structure **10** of the apparatus.

Above the bearing **29** there is a diaphragm wall **44** having a flange **45** that is attached to the cylindrical casing **14** of the mill section. The diaphragm **44** is of a slight conical shape and extends down to a central flat spot **46** terminating at an upwardly extending lip or flange **47**. Beneath this central flat spot **46** there is detachably mounted a ring **48** held in place by a clamping plate **50** and screws **51**, whereby the size of the central aperture **52** of the mill may readily be varied. Thus, by replacing the plate **48** with other plates having different sizes of apertures, the total area around shaft **34** that is available for the entrance of air into the mill may be decreased or increased in size, up to the size determined by flange **47**. It may be noted that the cylindrical shell **14** of the mill section is provided with a window opening at **54** so as to permit air to enter towards the aperture **52**.

Within the cylindrical shell **14** of the mill there is usually provided a liner at **55** which may be of hard or soft material, depending upon the particular milling operation. For the milling of hard materials the liner may be made of extremely hard materials, such as Stellite, Carborundum, etc., and in certain instances the lining can be put on by the use of hard surface welding rods. In other instances, as where particles of given size are to be rounded, the lining may actually be made of rubber compositions.

Within the mill housing adjacent to the diaphragm wall **44** there is placed a fan section **56** having radial fan blading **58** thereon. The fan section **56** has a stiffening central plate **59** to which it is riveted, and the entire unit is pressed onto a hub, generally designated **60**, which also carries the lowest milling stage generally designated **61**. The hub **60** is pressed against an integral flange or collar **62** on the shaft **34**, and serves to carry a disk **63** having a plurality of radial blades **64** thereon. Within the mill section, which is illustrated as broken away at **65** in Figure 1, there are a plurality of milling stages. Thus, if it is assumed that the mill has only two stages, the lower stage **61** would terminate at the line **66**, but it may also be assumed that the mill might have two or more such stages **61** terminating at **66**. Between each stage there may be mounted, if desired, a vibratory disk, generally designated **69**, which is preferably supported adjacent its center by a plurality of smaller disks **70**, the entire disk assembly being held between the adjacent surfaces **71** and **72** of adjacent hubs **60** and **74** of the adjacent milling sections. The top milling stage **73** is secured to hub **74** and may, if desired, be capped by a further vibratory disk **75**, which is similar to disk **69**.

The aforesaid specifically described mill structure is built in accordance with the pending application Serial No. 242,390 filed August 17, 1951, by Joseph Lecher, and, per se, forms no part of the present invention. It is described merely to illustrate one form of rotary mill which may be used. It is to be understood that any other suitable type of rotary mill may be used or that the classifier may be used separately.

Above the top milling stage of the rotary mill **13** there is mounted on the shaft **34** a collar **76** upon which a plate **78** is supported which constitutes the bottom wall of the classifier assembly. Plate **78** serves to support a drum assembly generally designated **80** comprising an outer shell **85**, which has top and bottom walls **81** and **82**, respectively, welded thereto as indicated at **84**. The entire drum assembly **80** is secured to the bottom plate **78** by a plurality of cap screws **86**. Upon the outer shell **85** of the drum assembly there are welded a plurality of circumferentially spaced mounting ribs **88** which serve to define axial passageways **89—89** as shown in Figure 4, for the delivery of the separated fine or superfine material from the classifier. The outer edge surfaces **90** of the mounting ribs **88** have the same radius in respect to the axis of shaft **34** and thereby serve as a means for axially supporting the classifier elements subsequently to be described.

The lower clamping plate **78** of the classifier extends out to the maximum diameter **92** of the classifier rotary elements, or nearly so, and its outer periphery is preferably provided with a plurality of slots **92'** so that its outer edge will serve somewhat as a fan to promote suction through the mill. The portion of the plate **78** which extends out beyond the edges **90** of the mounting ribs **88** also serves as an annular mounting surface for the stack of classifier elements. The classifier elements may be stacked up in various combinations, of which one stacking combination of particular elements is shown in Figure 1, and since the total vertical dimension of the classifier unit from the top surface of plate **19** to the upper surface **94** of the plate **82**, is preferably kept constant for a given range of sizes of classifiers, the stacking arrangement of the classifier elements may not always come out "even," and in that case spacers are put on. Such is the condition in Figure 1. Hence, upon the extending surface **95** of the plate **78** there are first mounted a plurality of filler rings **96**, in this case three. These are preferably simple punchings from sheet metal and as many are used as are required.

Next, there is placed in the stack a fan element generally designated **98** which is simply a ring having its outer periphery provided with a plurality of radial blades **99** and having an enlarged central aperture therein. The blades terminate at an inner line **100** and between this line and the outer surfaces **90** of the ribs **88** is a space that is then filled by a ring **101** of smaller diameter or throat. Above the throat ring **101** is a similar throat ring **102** and to one of said throat rings **101** or **102** there are screwed spacer studs **103**, the heads of which determine the spacing between the throat rings of each pair of such rings as indicated at **104** in Figure 2.

The spacing **104** between adjacent throat rings **101** and **102** constitutes an important factor determining the size classification, and therefore such spacing must be accurately determined which is readily accomplished by the heads of the studs or spacers **103** as will readily be understood. The combined thickness of the throat rings **101** and **102** is such that when the two rings are stacked together and spaced apart, as shown at **104** by the heads of the studs or screws **103**, their combined thickness plus the thickness of the bolt heads **103** will be slightly in excess of the height of the radial blades **99**, thus providing a very slight clearance between the top edges of blades **99** and the bottom surface of the next fan element **110**, as indicated at **106** in Figure 2. The fan element **110** is exactly like fan element **98** and likewise carries a plurality of radial blades **111**, these being in turn surrounded by

throat rings 112 and 113 spaced apart by the heads of studs 114. The upper surface of throat ring 113 in turn serves as a support for the next fan element generally designated 115, which in turn supports throat rings 105 and 118 which are spaced apart by stud heads 107. Seated upon the upper surface of throat ring 118 is another fan element 116, which is the same as fan elements 98, 110 and 115. The upper surface of the annular plate of fan element 116 serves to support similar throat rings 117 and 119 spaced apart by the heads of studs or screws 120.

Thus, the entire stack of fan elements 98, 110, 115 and 116 carrying the radial blades 99, 111, 121 and 125, and the intervening throat rings 101, 102, 112, 113, 105, 118, 117 and 119 form a complete stack which completes the classifier unit. Above the last throat ring 119 there is a fan element generally designated 123 having fan blades 124 and upon the annular plate of fan element 123 there is seated a spacing collar 126 which is welded to a ring-like 128 having fan blades 129 thereon. The upper edges of the fan blades 129 are recessed as shown at 130 to receive a clamping plate 131 that is seated upon and secured to the top wall 52 of classifier drum assembly by bolts or by cap screws 132. All of the parts above described are thus secured together for operation as an integral unit and can be readily manipulated to allow replacement or rearrangement of the fan elements 98, 110, 115 and 116 and to allow the rearrangement and use of other sizes of throat rings 101, 102, etc. for various classifying operations.

The throat rings 101 and 102 and the corresponding throat rings 112, 113, 105, 118, 117 and 119 have their forward edges chamfered as at 134. The particular slant of this chamfer and its radial position may be varied, as desired. Thus, referring to Figure 3, there are shown a plurality of different slants and radial positions for the chamfered edges of the throat rings. In Figure 3 the stacking arrangement, in general, is the same as previously described with reference to Figure 1, but this figure illustrates the manner in which throats or passageways of different sizes may be made. Thus, between the lower fan elements 98 and 110 there is provided a pair of throat rings 135 and 136, which it will be observed, have much more gradual slanting surfaces 135A and 136A than the corresponding surfaces of the throat rings shown in Figure 1. The radial position of the entrance 137 of the throat is thus less than at the throat entrance 104 in Figure 1, and this has an effect upon the classification that is accomplished.

Above the blade element 110 of Figure 3 there are illustrated another size of throat rings 138 and 139. These rings have about the same slant at 138A and 139A as for the throat rings 135 and 136, but the radial width of the throat rings 138 and 139 is greater, and hence the throat entrance at 140 is radially farther out than throat entrance 137. As the radial width of the throat rings is increased, they tend to intersect the inner edge of the radial blades 111 as in the area 145, and in order to prevent interference at such point the throat rings are notched so that they slip down over the radial blades 111. Above the fan element 115, Figure 3, there is shown still another form of throat ring as at 141 and 142. In this instance the radial width of the throat ring is the same as for 138—139, but the slant 141A and 142A is much more abrupt than at 138A and 139A, and hence the throat 144 is brought still farther out radially. As in the case of throat rings 138 and 139, those at 141 and 142 are notched in the area 146—146 so as to allow the throat rings to be slipped down over the radial blades 121.

Above the blade element 116 of Figure 3 there is illustrated a manner in which relatively greater throat area may be obtained. In this case each of the throat rings 148 and 149 are equipped with spacing studs 150 and 151, thus forming two throats as at 152 and 153. The chamfered edges 148A and 149A are brought together at a point 154, and the flow thus divides as it proceeds to the throats 152 and 153. If greater throat area is desired at 104 in Figure 1, or at 137, 140 or 144 in Figure 3, it may be accomplished by using somewhat thinner throat rings and by using spacing studs having relatively thicker heads. Changes may thus be very conveniently made. Even increasing the thickness of the stud heads, without a corresponding decrease in the thickness of the throat ring does not have any especial disadvantage since it will only increase the clearance as at 106 in Figure 1. Thus, many variations may be made on the job without redesign of the equipment, by simply having a supply of spacing studs 103 of varying head thicknesses, and a liberal supply of fillers 96 to make up the total thickness of the stack. This design accordingly permits on-the-job experimentation for the classification of materials offering especial difficulties.

Attention is next directed to the fan assembly 123 of Figures 1, 2 and 3. This assembly carries radial fan blades 124, the upper edges 122 of which are quite closely spaced relative the bottom of a surface of the annular separator plate 127. The inner edge 127A of plate 127 is spaced from the periphery of collar 126 to provide a passage 127B therebetween for the flow of air in the direction of arrow 133 from the housing space of fan 129, back through passage 127B, and thence radially outwardly through the radial blades 124 of fan 123. The pressure differential from the top to the bottom of plate 127, through the passage 127B, is determined by the design of the fan 123—124, but the amount of flow through passage 127B is determined by the restriction offered by passage 127B, and between the bottom surface of plate 128 and the upper surface of plate 127. Accordingly, the design permits an excess of pressure differential without excessive flow, merely by varying the size of passage 127B, and this therefore prevents excessive back flow of the already classified fine material while at the same time completely preventing the outflow of coarse material in a direction opposite to arrow 133. The outlet from the fan housing is indicated at 157 in Figure 2.

The removal of the coarse material from the classifying unit chamber is accomplished by the use of one or more skimmer units or boxes, but illustrated in Figures 4 and 5. One such unit generally designated by the numeral 161, is shown in Figures 4 and 5 and provision is made for additional skimmer boxes, as indicated at 162 and 163 in Figure 1, should it become necessary to utilize more than one to effect the desired classification of the material, but in the instant classifier these are capped, as shown.

Referring to Figures 4 and 5 there is illustrated the form of construction used in the skimmer box generally designated 161. This construction consists of a housing composed of a back wall 168 welded to a bottom plate 169 and a top plate 170. Wall 168 terminates at flange 168A and the plates 169 and 170 have flanges 169A and 170A, respectively. A flange at 172, Figure 4, is also provided and this is welded at 173 to the outlet plate or wall 174 to which a flanged outlet tube 175 is secured by means of bolts 176. If desired, a gate 178 may be interposed between the flange of the outlet tube and the wall 174 for controlling the flow of air and burden of coarse material through the skimmer box. The plates 169 and 170 serve as mountings for shafts 179 and 180 which carry skimmer fingers 181 and 182, respectively, which are held on by means of set screws 183 and 184. Each skimmer finger may be provided with an arcuate surface 185 corresponding to the inner curve of the classifier housing, and the terminals 186 of the skimmer fingers are preferably sharpened as shown in Figure 4 to provide a slicing effect for the entrance of some flow of air and coarse material in the direction of arrow 188.

For adjusting the fingers 181 and 182 there are provided handles 189 and 190 that are welded onto the shafts 179 and 180, respectively. The handles are pro-

vided at their outer ends with holes through which locking bolts **191** and **192** extend and which are received in arcuate slots **194** in the outwardly extending portions **195** of the plates **169** and **170**, as indicated in Figure 4. Thus, by loosening the bolts **191** and **192** and by swinging the arms **189** and **190**, the shafts **179** and **180**, respectively, may be rotated to any desired position within the limits of slots **194**. Slots **194** are made of such a length so as to prevent the sharpened terminal **186** of the skimmer finger **181** from engaging the rotating elements of the classifier.

In Figure 2 the caps **162** and **163** have been removed and additional skimmer units or boxes, identical with the one shown at **161** in Figure 1 have been provided as generally indicated at **164** and **166**. In Figure 3 the skimmer box **161** is shown. Thus, depending upon the needs of the particular classifying job to be done, there may be utilized one or more skimmer boxes located either at a low level, an intermediate level, or a high level. If desired, a plurality of skimmer boxes may be utilized around the shell of the classifier all located at one level, or a plurality of skimmer boxes at each level may be utilized. Usually one skimmer box at each level is sufficient.

It will be noted that one of the shafts **179** is cut short so as to provide a socket **196** into which the protruding end **180A** of shaft **180** extends. Thus, the shafts **179** and **180** may be rotated independently, but by virtue of the construction shown each serves to steady the other.

In Figure 6 the construction is identical with that shown in the previous figures except that the cylindrical housing of the classifier **20** is fluted on its interior as by flutes **198**. These flutes may be corrugations of relatively shallow depth, or larger and sharper corrugations with greater retarding effect. They are for the purpose of slowing down the peripheral velocity on the wall, reducing the MV^2 effect of the particles and stirring up the mass of material rotating against the wall of the classifier **20**, so as to permit the fine materials to be continuously drawn inwardly into the turbulent flow at the periphery of the rotor.

In operation the classifier rotor revolves in the direction of arrow **200**, Figure 4, and in so doing the blades **99**, **111**, **121** and **125**, of which blades **111** are shown in Figure 4, produce behind their trailing edges **111A**, a negative pressure and inward air flow, and the leading edges **111B** build up a positive pressure and outward air flow, with the result that a cyclonic swirl is produced in each space **111C** between adjacent blades. These cyclonic swirls serve to produce intense vortex action in annular clearance between the rotor and wall. Since the centrifugal force on any particle is determined by its mass, as well as its velocity, the larger particles of a given density tend to be thrown against the inner surface **20B** of the mill housing with greater force than for the smaller sizes of particles having the same density. Accordingly, an intense mixture of fine and coarse particles is continuously thrown out against the mill housing, and at the same time cyclonic swirls of the mixture of fine and coarse particles occur as illustrated in Figure 4. However, the centrifugal effect of a coarse particle **201** moving in the direction of arrow **202** is greater than for a fine particle of the same density moving in the same direction, and accordingly there is a tendency for the fine particles more readily to enter the swirls of cyclonic motion than for larger particles to do so. By the same token, when the particles are in the swirl, the coarser particles always tend to be farther out than the finer particles, and hence particles moving in the path of arrow **203** are larger in size than those moving in the path of arrow **204**, which is closer to the axis of the classifier.

Due to the action of the fan **128—129**, a definite draft or differential pressure is established in the spaces **89—89** between the ribs **88—88** and air, or other gaseous fluid in the classifier accordingly moves through the throats **104**, **114**, **107** and **120** between the throat rings of the classifier, as shown by the arrows **205**, **206**, **207** and **208**. These flows combine and move upwardly in the spaces **89**, Figures 1 and 4, and then join and flow outwardly as indicated by the arrow **209**, through the fan **128—129**. Since the velocity through the throat openings **104**, **114**, **107** and **120** may be accurately controlled, and since the position of the throat may likewise be accurately placed by appropriate selection of the throat plates, see Figure 3, it has been found that very accurate selection of particle sizes may be made from the cyclonic swirls between the blades **11**, Figure 4. Thus, particles in moving in particular paths such as **203** or **204**, may, due to the velocity of movement of the gaseous fluid at arrow **206**, be caused to take these particles inwardly through the throat **114**, and thence outwardly through the passageways **89**. In this way an accurate selection, even as between particles of fractional micron size may be achieved.

In assembly, a preferred design and width of throat is selected for a given range of particle sizes of a material having a given specific gravity. At any given rotative speed the particle size which passes through the classifier can then be regulated by the velocity of the centripetal air flow at or through the discharge throat. This velocity may in turn be conveniently regulated by the quantity of air which is allowed to pass through the classifier chamber by adjusting dampers (not shown) in the inlet **54** or outlet **157**, or by varying the size of opening **52** in disk **48**. Therefore, any given throat design and width of throat may be adapted selectively to pass particles of a comparatively wide range of sizes by controlling the velocity of flow through said throat.

Variation in width of discharge throat becomes important in considering the matter of "material to air ratio." In fine grinding operations a much higher proportion of air to unit weight of material is required, and this ratio increases as the desired particle size decreases. Therefore, it is a feature of this invention to provide a multi-unit structure. Each unit section of the classifier is a classifier in itself, and hence this unit in passing a given amount of air at a given velocity will pass a given quantity of material at a given specific gravity, said quantity of material being of the desired fineness.

Since in the classification of finely ground materials it is necessary to have more air than is correspondingly necessary for the same weight of coarser materials, there are proportionately more classification units required in fine grinding than are required in coarse grinding. For example, in the coarse ranges three or four units may be sufficient, whereas in the fine ranges (below 5 microns) twenty or more units may be required to pass the same weight of material in the same length of time. The number of units is further conditioned upon the percentage of fines which are in the mixture entering the classifier. The percentage of fines may vary from 10% or less to 80% or more, and hence the number of units and the design of these units must be correspondingly adapted to fit the needs of the situation. This is easily accomplished by this invention.

Each unit is a complete two-stage classifier. The radial fan blades **99**, **111**, **121** and **125** serve to maintain a highly turbulent and fluidal condition in the peripheral mixture of air and pulverulent materials, from which mixture the unit constantly withdraws the wanted fines and near fines, while segregating and rejecting the coarser and undesired material. Therefore, the radial blading of the classifier serves three purposes: (*a*) to maintain the peripheral fluidity so that all the fines are put in a position where they may be captured; (*b*) as a preclassifier by preventing oversize material from entering the final classifier stage. (In very fine grinding, closer set blading is used, which allows only material which is of the desired fineness to pass through to the secondary zone);

and (c) to transfer the wanted material from the mixture which is circulating near the wall to the secondary zone or stage of classification.

By utilization of the corrugations on the inside of the classifier housing, the fluidal dispersion of particles held against it by the blade plates may be stirred up. This is desirable since the selection of particles in the cyclonic swirls, as aforementioned, cannot be made unless the material is brought into the swirl. The use of corrugations enhances the mixing of the material against the wall, but in many cases a sufficient stirring up of the various sizes of particles is accomplished even in a smooth wall casing.

In many instances materials may be agglomerates or may be fouled by containing other materials of greater density. Thus, sand or stone mixed into cereals may conveniently be separated even though the actual particle sizes are the same, due to the greater density of the stones.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments herein.

What I claim is:

1. An apparatus for classifying pulverulent material comprising a generally cylindrical housing having closed ends, a classifier unit of generally cylindrical shape and of a diameter somewhat less than the diameter of the inside of said housing mounted for rotation in said housing, said classifier unit being provided with at least one axial passageway and with at least one thin space extending from said axial passageway and thence radially outwardly through the unit, said space being oriented generally normal to the axis of the unit and terminating at the cylindrical surface thereof, the axial dimension of said space adjacent said cylindrical surface being greater than the axial dimension thereof within said unit, radial blades set in said space adjacent the cylindrical surface of the unit, and means for inducing movement of gaseous fluid radially inwardly through said space and thence axially through said passageway.

2. An apparatus for classifying pulverulent materials comprising a generally cylindrical housing having substantially closed ends, inlet and outlet ports in opposite ends of said housing, said housing being divided axially by a diaphragm into a fan section and a classifier section, said diaphragm being provided with a central coaxial opening, a generally cylindrical classifier unit mounted for rotation in said housing concentrically with said central opening, said unit extending from said classifier section into said fan section, at least one axial passageway in said unit extending between said sections, fan blading extending from said unit outwardly from said passageway in said fan section for inducing a flow of gaseous fluid axially through said passageway and thence outwardly through said fan section and through the outlet port therefrom, said classifier unit being formed with at least one passageway in that portion of the unit which is within the classifier section, said passageway extending from said axial passageway and thence in a plane substantially normal to the axis of rotation of the classifier unit outwardly therethrough to the substantially cylindrical surface thereof terminating in spaced relation to the inside of said cylindrical housing and having a greater axial dimension adjacent said cylindrical surface than adjacent said axial passageway, and generally radial blades set in said outwardly extending passageway and terminating substantially at said cylindrical surface.

3. An apparatus for classifying pulverulent material comprising a substantially cylindrical housing closed at the ends and having an inlet opening at one end and an outlet opening at the other end, a generally cylindrical classifier unit mounted in said housing for rotation about an axis substantially coincidental with the axis of the housing, said unit including a central framework having radially spaced mounting surfaces thereon, each of said radially spaced surfaces having the same radius in respect to the axis of rotation of the unit, said unit also including a plurality of rings, each having a central aperture of a size such as to fit snugly on said radially spaced surfaces and be supported thereon, means for clamping said rings to said central framework for forming the outer surface thereof, the diameter of at least some of said rings being such that the outer surface of the unit is spaced inwardly from the inner surface of the housing, certain of said rings having a lesser diameter, said rings being spaced axially from adjacent rings so as to form passageways in said generally cylindrical classifier unit extending in a plane substantially normal to the axis of said unit and thence axially therethrough and terminating adjacent the outlet end of said housing.

4. An apparatus for classifying pulverent material comprising a substantially cylindrical housing closed at the ends and having an inlet opening adjacent one end and an outlet opening adjacent the other end, a generally cylindrical classifier unit mounted in said housing for rotation about an axis substantially coincidental with the axis of the housing, said unit including a central framework having a plurality of radially spaced mounting surfaces thereon, each of said radially spaced surfaces having the same radius in respect to the axis of rotation of the unit, an end plate on the frame, said unit also including a plurality of rings stacked in succession on the end plate, each ring having a central aperture of a size such as to fit snugly on said radially spaced mounting surfaces and being supported thereon, means for clamping said rings to said central framework for forming the outer surface of the classifier unit and for rotation with the framework, the diameter of at least some of said rings being such that the outer generally cylindrical surface of the classifying unit is spaced inwardly from the inner surface of the housing and certain of said rings having a lesser diameter, said rings of varying outer diameters being spaced axially from adjacent rings so as to form passageways in said classifier unit extending in a plane substantially normal to the axis of said unit and thence axially therethrough and terminating adjacent the outlet end of said housing, said passageways being thicker in an axial direction adjacent the outer surface of the classifier unit than adjacent said radially spaced mounting surfaces, and generally radial fan blading mounted on at least some of the rings adjacent said outer generally cylindrical surface.

5. In an apparatus for forming and classifying pulverulent solid material having a generally cylindrical housing, said housing including a grinding section of one diameter and connected axially to a classifying section of a larger diameter, said housing being provided with end closures and an opening in said grinding section for introducing a gaseous flow and solid material to be comminuted thereinto, and an outlet from said classifier section, said grinding section communicating with said classifying section adjacent their point of connection, and a rotary shaft mounted in said aparatus for rotation about an axis substantially coincidental with the axis of said cylindrical grinding and classifier sections, said shaft having grinding means mounted thereon for rotation therewith in said grinding section, the improvement comprising a generally cylindrical classifier unit mounted on said shaft for rotation therewith in said classifying section, said classifier unit being formed so as to have passageways spaced axially from each other in said classifying section and each extending generally normal to the axis of the cylindrical housing and thence axially along said shaft to adjacent the outlet of said classifying section, said classifier unit having a generally cylindrical surface adjacent said outlet and a seal extending from the cylindrical wall of said classifying unit inwardly into proximity with said surface, said passageway axially terminating beyond said seal adjacent the outlet of the classifier section and radial blading in the spaced passageways adjacent the cylindrical surface of said rotary classifier unit.

6. A rotary classifier for separating dry solid particles of varying sizes or densities while borne in admixture in a gaseous fluid comprising a generally cylindrical housing having an inlet and an outlet axially disposed therealong, a generally cylindrical unit mounted in said housing for rotation about an axis substantially coincidental with the axis of said cylindrical housing, said unit having a generally cylindrical surface of a diameter such that it is spaced from the inner surface of said housing, said unit being formed with a plurality of thin passageways at axially spaced intervals along said unit, said passageways being of increased dimension in a direction axially of said unit adjacent the cylindrical surface thereof, radial blade means in said portions of increased dimension and at least one axial passageway through said unit connecting to each of said radial passageways and extending to adjacent the outlet of said housing.

7. The apparatus of claim 6 further characterized in that said axially spaced thin passageways through said unit are gradually increased in dimension in an axial direction, and then continue at said increased dimension to adjacent the cylindrical surface of said unit.

8. A rotary classifier including a housing having a generally cylindrical inner surface, said housing being closed at the ends and provided with an inlet adjacent one end and an outlet adjacent the other end, a shaft mounted coaxially in said housing for rotation therein, frame means mounted on said shaft for rotation therewith, said frame means being provided with substantially radially extending fins providing edge mounting surfaces extending generally from adjacent one end and thence toward the other end of the shaft and at a uniform radial distance from the axis thereof, and forming axial passageways therebetween, end plates on said frame means extending substantially outwardly from said mounting surfaces and a plurality of rings each having a hole therein of a size so as to fit on said mounting surfaces, said rings being stacked and clamped between said end plates, the rings having varying outside diameters, the rings of larger outer diameter being spaced by rings of smaller outer diameter and said rings of smaller outer diameter being spaced from each other for forming passageway spaces therebetween communicating with said axial passageways between said mounting surfaces, and radial blade means mounted on the rings of larger diameter and in a position for the most part outwardly beyond said rings of smaller diameter.

9. In a classifier device a shaft having a cylindrical drum mounted coaxially on said shaft for rotation therewith, said drum having ends substantially normal to the axis of the shaft, clamping plates of an outer diameter larger than that of the drum mounted on the end thereof, radial fins on said drum extending in a generally longitudinal direction therealong, and spaced from each other so as to form generally axial passageways between them, said fins being of uniform outer radial dimensions so as to form mounting surfaces, at least two large rings having central apertures therethrough of a size so as to fit on said mounting surfaces and each having a large outer diameter, at least two throat rings between said larger rings, said throat rings having an inner diameter so as likewise to fit upon said mounting surfaces and outer chamfered edges, said throat rings being spaced from each other so as to form a passageway therebetween extending from said chamfered edges toward said mounting surfaces and connecting with the axial passageways between said fins, and radial blades on said larger ring generally positioned outwardly beyond said throat rings, and a cylindrical housing which has an inner diameter greater than the outer diameter of said larger rings enclosing said classifier device.

10. The apparatus of claim 9 further characterized in that said radial blades are mounted on one of said larger rings and extend axially and terminate in slightly spaced relation with reference to the adjacent surface of the next larger ring.

11. The apparatus of claim 9 further characterized in that there are provided a plurality of large rings, adjacent large rings being separated by pairs of throat rings spaced to form passageways therebetween, the entire stack of large rings and throat rings being clamped between said end plates.

12. The apparatus of claim 9 further characterized in that towards one end of said mounting surfaces there is provided a spacing collar and beyond that a fan ring, said fan ring having fan blading thereon, the whole stack, including said large rings, throat rings, spacing collar and fan ring, being clamped between said end plates, and a partition extending inwardly from said housing and terminating closely adjacent said collar and subsidiary fan blading on at least one of the large rings, said subsidiary fan blading being on the opposite side of said diaphragm from the fan ring for inducing a balancing counterflow from adjacent said fan blading through the space between said partition and collar.

13. In a classifier device a shaft having a cylindrical drum mounted coaxially on said shaft for rotation therewith, said drum having ends substantially normal to the axis of the shaft, clamping plates of an outer diameter larger than that of the drum mounted against the ends thereof, radial fins on said drum extending in a generally longitudinal direction therealong, and spaced from each other so as to form generally axial passageways between them, said fins being of uniform outer radial dimensions so as to form mounting surfaces, a stack of rings, each having an inner diameter so as to fit on said mounting surfaces, the rings being of varying outer diameters, said rings being stacked in succession with a ring of larger outer diameter, then a ring of smaller outer diameter, a spacer, another ring of smaller diameter, a second ring of larger diameter and so on until the complete stack with fillers and spacers as may be needed may be clamped between said clamping plates, radial fin blading mounted on successive larger rings and extending towards the next larger ring, and positioned generally outwardly in respect to said smaller rings, a cylindrical housing which has an inner diameter greater than the outer diameter of said larger rings enclosing said classifier device.

14. In a classifier device a shaft having a cylindrical drum mounted coaxially on said shaft for rotation therewith, said drum having ends substantially normal to the axis of the shaft, clamping plates of an outer diameter larger than that of the drum mounted against the ends thereof, radial fins on said drum extending in a generally longitudinal direction therealong, and spaced from each other so as to form generally axial passageways between them, said fins being of uniform outer radial dimensions so as to form mounting surfaces, a stack of rings, each having an inner diameter so as to fit on said mounting surfaces, the rings being of varying outer diameters, said rings being stacked in succession with a ring of larger outer diameter, then a ring of smaller outer diameter, a spacer, another ring of smaller diameter, a second ring of larger diameter and so on until the complete stack with fillers and spacers as may be needed may be clamped between said clamping plates, the outer peripheral portion of mutually adjacent surfaces of the rings of smaller diameter being beveled, radial fan blading mounted on successive larger rings and extending towards the next larger ring, and positioned generally outwardly of said smaller rings, a cylindrical housing which has an inner diameter greater than the outer diameter of said larger rings enclosing said classifier device.

15. In a classifier device a shaft having a cylindrical drum mounted coaxially on said shaft for rotation therewith, said drum having ends substantially normal to the axis of the shaft, clamping plates of an outer diameter larger than that of the drum mounted against the end

thereof, radial fins on said drum extending in a generally longitudinal direction therealong, and spaced from each other so as to form generally axial passageways between them, said fins being of uniform outer radial dimensions so as to form mounting surfaces, at least two rings each having a central aperture therethrough of a size so as to fit on said mounting surfaces and having an outer diameter of larger radius and at least one ring of smaller diameter between said larger rings, said smaller ring having an inner diameter so as likewise to fit upon said mounting surfaces, said smaller ring being spaced from at least one of said larger rings so as to form a passageway therebetween extending from the outer circumference of said smaller ring toward said mounting surfaces and connecting with the axial passageways between said fins, and radial blades on said larger ring generally positioned outwardly beyond said smaller ring and a cylindrical housing which has an inner diameter greater than the outer diameter of said larger rings enclosing said classifier device.

16. In an apparatus for forming and classifying pulverulent solid material comprising a generally cylindrical housing, said housing including a grinding section of one diameter and connected axially to a classifying section of a larger diameter, said housing being provided with end closures, an inlet opening in said grinding section and an outlet opening in said classifying section, said grinding section commuicating with said classifying section adjacent their point of connection, a rotary shaft mounted in said apparatus for rotation about an axis substantially coincidental with the axis of said cylindrical grinding and classifer sections, rotary grinding means mounted on said shaft for rotation therewith in said grinding section, the improvement comprising a generally cylindrical classifier unit mounted on said shaft for rotation therewith in said classifying section, said classifier unit being formed so as to have radial passageways spaced axially from each other in said classifying section and each extending in a plane substantially normal to the axis of the cylindrical housing and axial passageways along said shaft connected to said radial passageways and extending to adjacent the outlet of said classifying section, said classifier unit including a generally cylindrical surface adjacent said outlet and a partition seal extending from the cylindrical wall of said classifying unit inwardly into proximity with said surface, said axial passageways terminating beyond said partition seal adjacent the outlet of the housing and radial blading in the spaced radial passageways adjacent the cylindrical surface of said rotary classifier unit, at least one skimmer unit mounted externally of said cylindrical housing, said unit including an inwardly projecting blade and means mounting said blade so as to intercept and skim off a portion of the solid material passing along the inner surface of said housing.

17. The apparatus of claim 16 further characterized in that said blade is mounted so as to be adjustable inwardly from the inner surface of said housing.

18. An apparatus for classifying pulverulent materials comprising a generally cylindrical housing having an inlet and an outlet for the passage of an admixture of gaseous fluid and pulverulent materials therethrough, a classifier unit of generally cylindrical shape and of a diameter somewhat less than the diameter of the inside of said housing mounted for rotation in said housing, at least one skimmer unit mounted externally of said cylindrical housing, said unit comprising at least one inwardly projecting blade, means mounting said blade for movement from a position substantially flush with the inner surface of the housing to a position inwardly in respect to said surface so as to intercept and skim off a portion of the material passing adjacent the inner housing surface, and means for removing the material thus skimmed off from said skimmer box.

19. The apparatus of claim 18 further characterized in that a plurality of blades are superimposed in an axial direction, one on the other in said skimmer unit, each of said blades being independently adjustable.

20. A classifying apparatus for pulverulent materials according to claim 2, further characterized in that there are provided a plurality of flutes on the inner surface of said housing, said flutes being extended generally from one end to the other end of said classifier unit for retarding movement of air and pulverulent material within said housing adjacent the inner surface thereof.

21. A classifying apparatus for pulverulent materials according to claim 2, further characterized in that there are provided a plurality of generally spiral flutes on the inner surface of said housing, said flutes being oriented so as to provide a component of movement of air and pulverulent material towards the inlet of said housing.

22. In a grinding and classifying apparatus at least one skimmer unit, said skimmer unit mounted externally of the housing of said apparatus adjacent the classifying section thereof and including a passage in said housing wall, an inwardly projecting blade through said passage and means mounting said blade so as to intercept and skim off a portion of the solid material passing along the inner surface of said housing.

23. In a grinding and classifying apparatus at least one skimmer unit, said skimmer unit mounted externally of the housing of said apparatus adjacent a passage in said housing wall to the classifying section of the apparatus, said skimmer unit including a blade projecting through said passage and mounted so as to be adjustable from a position substantially flush with the inner surface of said housing to a position inwardly with respect to said surface so as to intercept and skim off a portion of the material passing adjacent the inner housing surface, and means for removing the material thus skimmed off from the skimmer box.

24. The apparatus of claim 23 further characterized in that a plurality of blades are superimposed in an axial direction, one on the other in said skimmer unit, each of said blades being independently adjustable.

References Cited in the file of this patent

UNITED STATES PATENTS

1,933,606	Sturtevant	Nov. 7, 1933
2,206,981	Sturtevant	July 9, 1940
2,269,412	Sturtevant	Jan. 6, 1942
2,294,921	Lykken	Sept. 8, 1942
2,304,264	Lykken	Dec. 8, 1942
2,350,737	Eiben	June 6, 1944

FOREIGN PATENTS

694,739	Germany	Aug. 7, 1940
1,003,288	France	Nov. 14, 1951