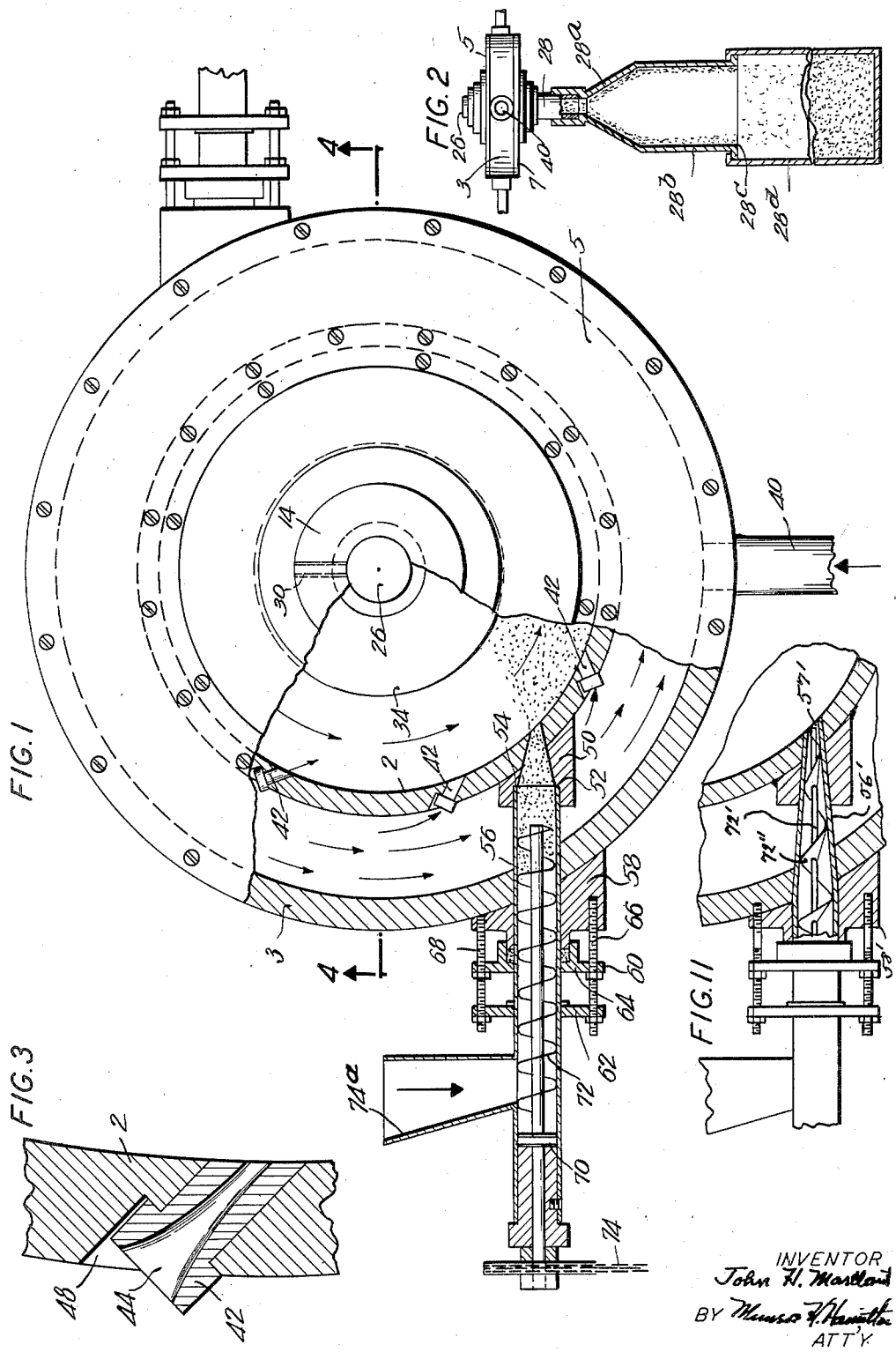
Sept. 18, 1956 J. H. MARCHANT 2,763,437

APPARATUS FOR GRINDING

Filed Jan. 16 1953. 5 Sheets-Sheet 1



Sept. 18, 1956 J. H. MARCHANT 2,763,437

APPARATUS FOR GRINDING

Filed Jan. 16 1953 5 Sheets-Sheet 2

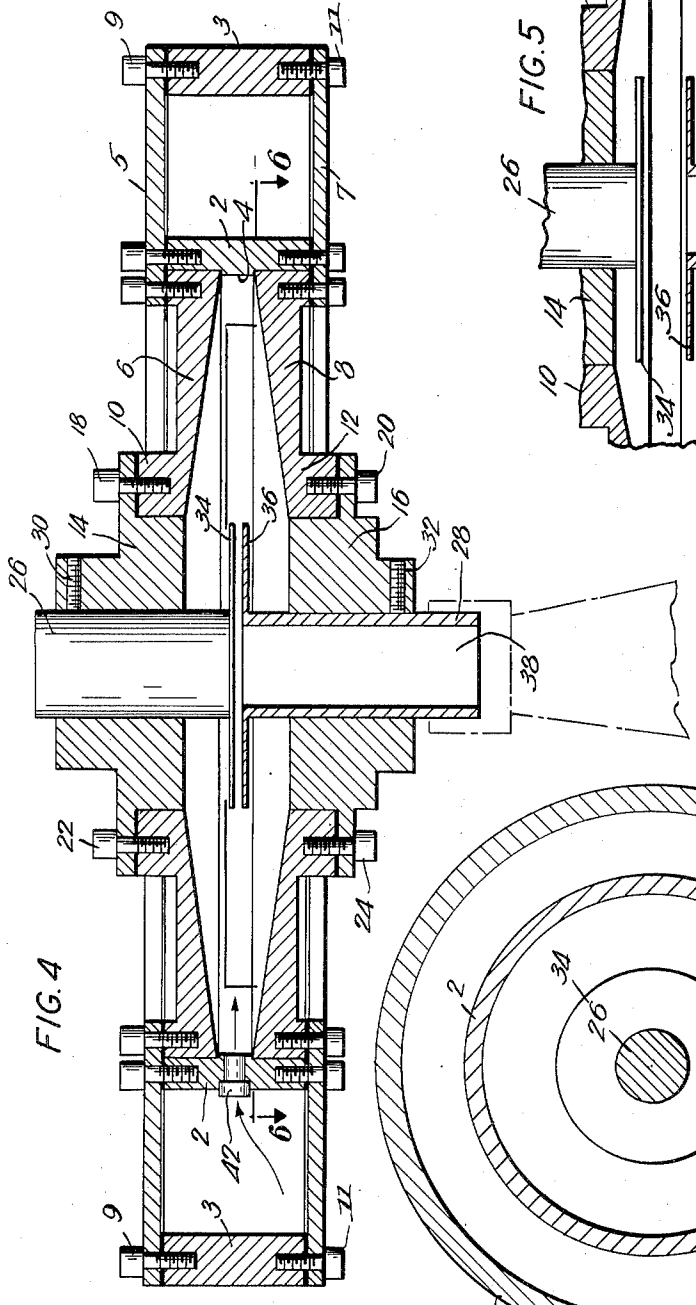


FIG. 4

FIG. 5

FIG. 6

INVENTOR
John H. Marchant
BY Munn & Hamilton
ATTORNEY

Sept. 18, 1956 J. H. MARCHANT 2,763,437

APPARATUS FOR GRINDING

Filed Jan. 16 1953 5 Sheets-Sheet 3

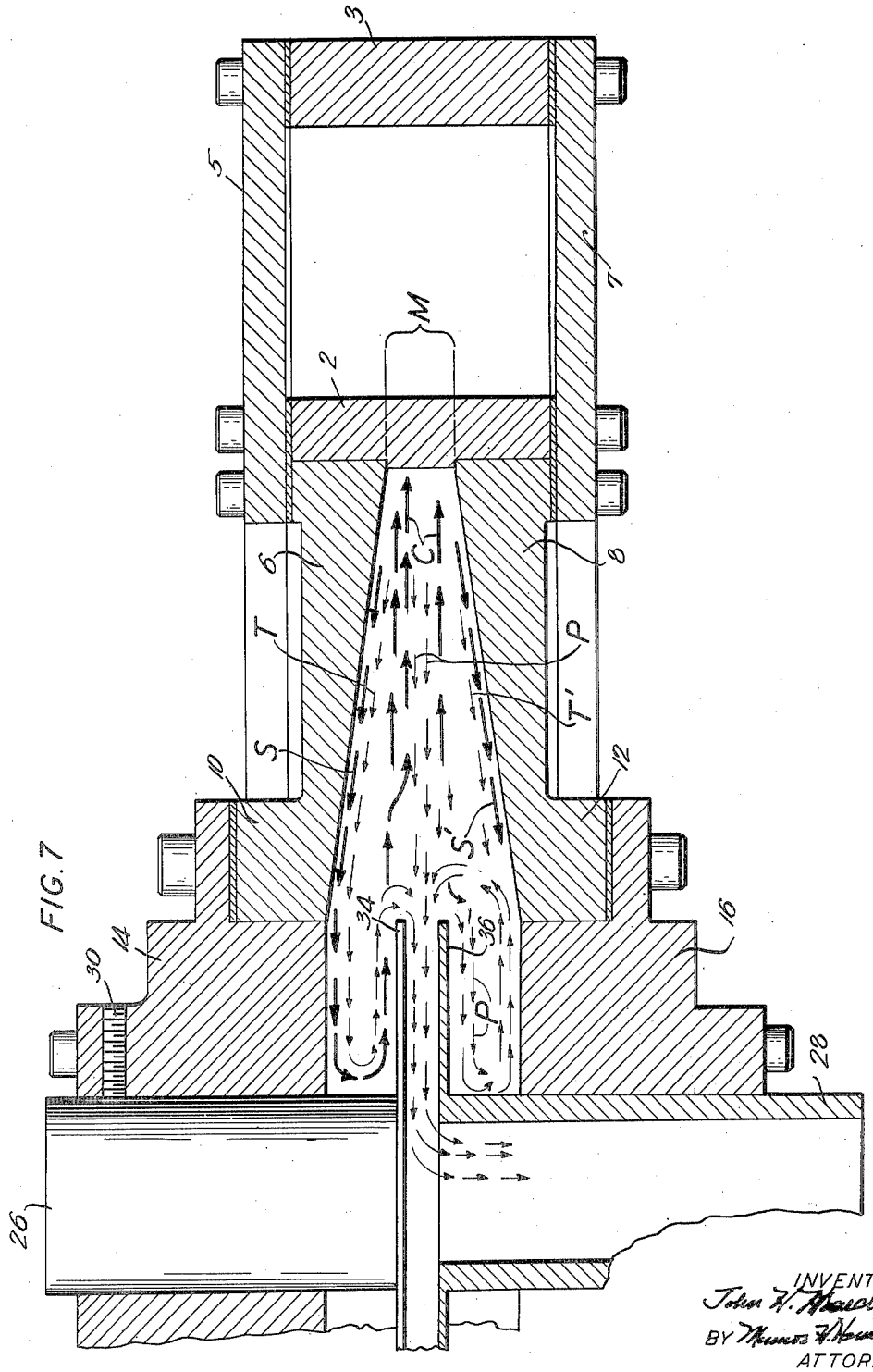


FIG. 7

INVENTOR
John H. Marchant
BY Thomas H. Hamilton
ATTORNEY

Sept. 18, 1956 J. H. MARCHANT 2,763,437

APPARATUS FOR GRINDING

Filed Jan. 16 1953 5 Sheets-Sheet 4

FIG.8

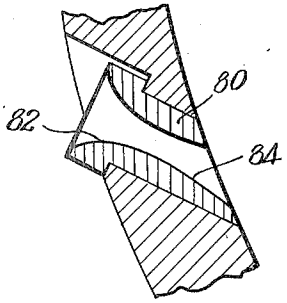
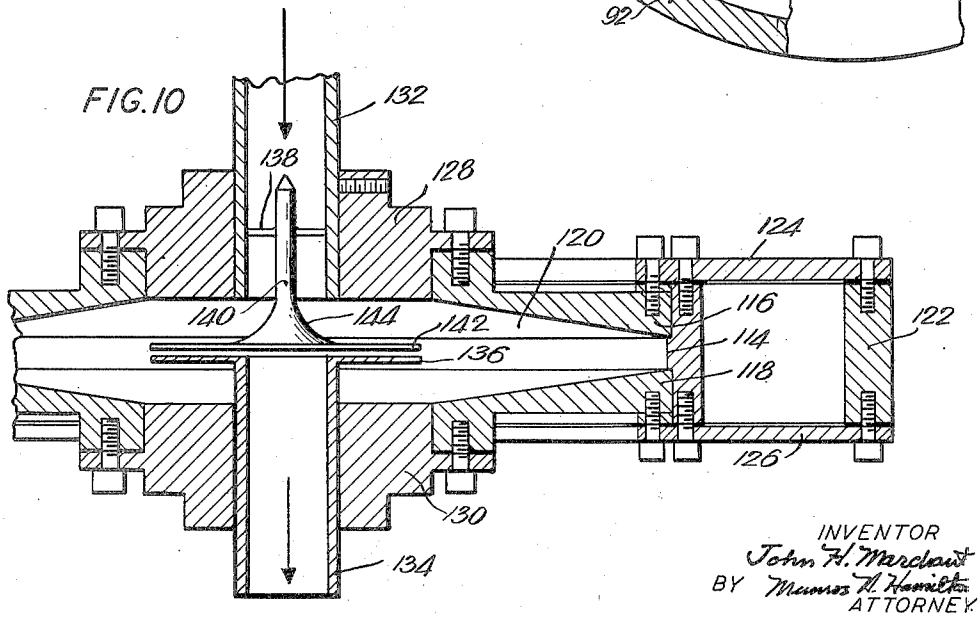


FIG.9

FIG.10



INVENTOR
John H. Marchant
BY Marcus A. Hamilton
ATTORNEY

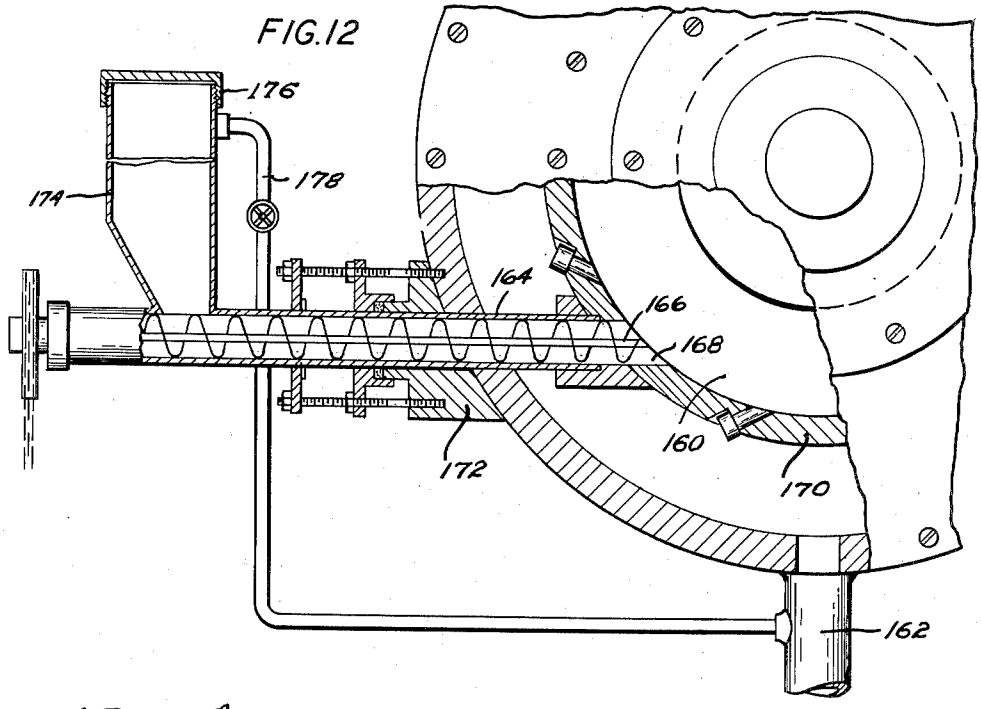
Sept. 18, 1956 J. H. MARCHANT 2,763,437

APPARATUS FOR GRINDING

Filed Jan. 16 1953

5 Sheets-Sheet 5

FIG.12



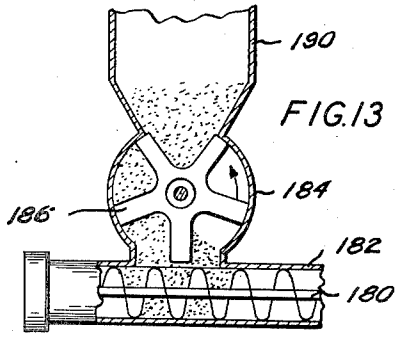


FIG.13

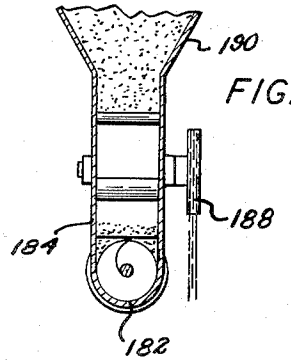


FIG.14

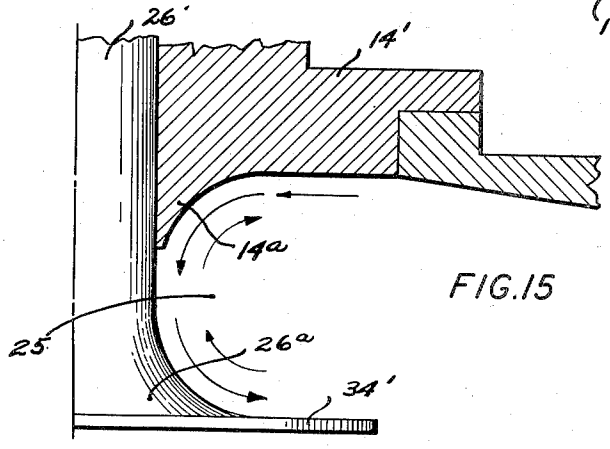


FIG.15

INVENTOR
John H. Marchant
BY Munro & Hamilton
ATTORNEY

United States Patent Office 2,763,437 Patented Sept. 18, 1956

2,763,437

APPARATUS FOR GRINDING

John H. Marchant, Providence, R. I., assignor to Sturtevant Mill Company, Boston, Mass., a corporation of Massachusetts

Application January 16, 1953, Serial No. 331,689

4 Claims. (Cl. 241—39)

This invention relates to an improved grinding machine of the fluid energy type in which a force field is developed in an annular grinding chamber and wherein particles of a material to be ground are introduced and pulverized and ground into a very fine state of subdivision.

Fluid energy type grinding machines of several different forms are well known to those skilled in the art and have been utilized with considerable success. However, these prior art structures are definitely limited in the extent to which subdivision of particles in appreciable quantities can be carried out, and there also develops in the course of using these prior art machines various problems involving the feeding of material to be ground, classification of particles, rate of recovery of finely ground material, separation of one range of particle sizes from another, and various other efficiency factors.

It is an object of the present invention to provide an improved grinding machine of the general class indicated and to devise a centrifugal type grinding apparatus which is capable of more efficiently grinding particles of material with a view to producing in substantial quantity particles of a relatively small micron size. Another object is to devise a special classifier device for use in a grinding chamber of the fluid energy type whereby a greater degree of selectivity may be realized with respect to particles of very small micron size. Still another object is to devise a grinding machine which is of simple construction, relatively cheap to manufacture, and capable of more economically carrying out certain types of grinding operations.

These and other objects and novel features will be more fully understood and appreciated from the following description of a preferred embodiment of the invention selected for purposes of illustration and shown in the accompanying drawings, in which:

Fig. 1 is a plan view showing the improved grinding machine of the invention, one side of which figure has been partly broken away to more clearly reveal portions of the device in cross-section, and also illustrating two feeding mechanisms, one of which comprises a screw feed mechanism also shown in cross-section;

Fig. 2 is a side elevational view of the grinding machine shown in Fig. 1 and further indicating a particle collector apparatus arranged at the lower side of the grinding machine;

Fig. 3 is a fragmentary detail plan section of an injector tip for intrducing a fluid into one section of the grinding chamber of the grinding machine shown in Fig. 1;

Fig. 4 is a cross-section taken on the line 4—4 of Fig. 1;

Fig. 5 is a fragmentary cross-sectional view showing a portion of the clasifier device of the invention in a position of adjustment different from that shown in Fig. 4;

Fig. 6 is a cross-sectional view taken on the line 6—6 of Fig. 4;

Fig. 7 is an enlarged fragmentary cross-sectional view of the grinding chamber of the invention further illustrating diagrammatically possible paths of flow of particles in the grinding chamber;

Fig. 8 is a fragmentary plan cross-sectional view of a modified form of injector tip;

Fig. 9 is a plan view, partly in cross-section, illustrating another form of feed means involving the use of a compressed fluid;

Fig. 10 is a cross-sectional view of a modified form of grinding chamber having a central feeding means;

Fig. 11 is a fragmentary detail view showing a modified form of screw mechanism for feeding material;

Figs. 12, 13 and 14 are views showing a modified type of feed mechanism; and

Fig. 15 is a fragmentary detail cross-sectional view showing another modification of the invention.

The principal parts of the grinding machine of the invention include a casing having an annular grinding chamber formed therein; means for furnishing a supply of air or other fluid to the grinding chamber in generally tangential directions; a feed mechanism for delivering particles of material to be ground into the grinding chamber; a particle classifier device in the grinding chamber; and a particle collector arranged to receive and contain material discharged from the grinding chamber.

The above noted grinding chamber and means for furnishing a supply of compressed fluid constitute an improved apparatus for pressurized grinding in a confined stream of fluid material to produce finely divided particles. In this improved apparatus material is selectively reduced in size by means of attrition, impact and explosive rupture due to thermal stresses to which the particles are subjected when they are within the grinding chamber.

Particles which have been ground in this manner sufficiently small can be selectively removed from the chamber by reason of the fact that these particles in the force field of the confined fluid stream are acted upon by radially inwardly directed drag force components which are greater than centrifugal forces which these particles exert.

The ability of the inwardly directed force components to separate small particles from relatively larger particles is recognized as being due to the fact that the relatively larger particles, because of their greater mass, exert a greater outwardly directed centrifugal force. The drag forces depend on the mass size and configuration of the particles; and the relative speed of the particles with respect to the fluid stream within which they are submerged and the physical properties of the fluid stream; whereas the centrifugal forces depend on the mass and the tangential speed of the particles and the radius of curvature of their respective paths at the positions of issue.

In accordance with the present invention I provide a special grinding chamber construction which is designed to utilize these radially inwardly directed force components much more efficiently than has heretofore been accomplished.

An important structural component of my grinding chamber, in one preferred form, is an annular fluid confining member comprising a cylindrical body which is closed by converging top and bottom sections. The cylindrical body thus has its peripheral wall portion constructed of relatively short axial length while the top and bottom sections are spaced apart an axial distance which increases in directions radially inwardly and which reaches its maximum value at points closely adjacent to the central vertical axis of the chamber.

With such a construction I find that by providing a rela-

tively small axial dimension at the peripheral wall portion of the chamber, I am enabled to immediately realize a very substantial reduction in those frictional losses which are normally associated with the contact area of a confined fluid stream of material and which, from a grinding efficiency standpoint, are of considerable magnitude.

Also, in thus providing an annular fluid confining member which has a cylindrical body portion of relatively short axial length, it is further found that two other important objectives may be realized. First, there may be cause to be developed a fluid stream having a force field which varies in intensity in directions axially of the chamber and which occurs with a maximum intensity along a region defined by a plane passing centrally and transversely through the grinding chamber. In conjunction with this force field of varying intensity there is induced at the region of maximum intensity a primary particle flow pattern by which particles of sufficiently small mass will be forced radially inwardly along a more or less direct radial path. There is also induced at portions of the force field of lesser intensity a secondary flow pattern by which particles travel radially inwardly along indirect paths.

The second objective realized from the grinding chamber construction noted above is the formation at the converging top and bottom sections of the chamber of particle trapping spaces into which particles moving radially inwardly, and especially those particles carried by the secondary flow pointed out, are delivered.

In conjunction with the basic grinding chamber design described, and having in mind the principles of operation which are in effect as outlined, I have further devised a novel particle classifier device which cooperates with radially inwardly directed force components in a unique manner and which, together with the grinding chamber features described, produces a greatly improved classifying and separating operation.

Essentially this classifier device is comprised by two tubular bodies, one of which has a closed end portion to constitute, in effect, a plug and the other of which is open to provide a particle discharge outlet. The tubular bodies are axially disposed through the top and bottom sections of the chamber, and are arranged with their inner extremities in spaced-apart relation to define a particle classifying aperture.

I have discovered that this particle classifying aperture may be controlled by suitably adjusting the tubular bodies so that, in a preferred form, the particle classifying aperture coincides with, or at least is substantially enclosed by, a force field of adequate intensity, with the result that particles of a desired small micron size may be more selectively discharged from the force field and in substantially greater quantity.

I have still further discovered that in thus producing a variable particle classifying aperture which is related to a force field of sufficient intensity to provide a desired classifying action, I may provide still another novel instrumentality for guiding particles which are acted upon by forces in all parts of the force field.

This novel instrumentality is comprised by annular particle guide elements mounted on the tubular bodies in a radially disposed position such that they project outwardly to a predetermined radial distance into the force field and thereby the magnitude and location of the particle classifying aperture is materially extended without loss of selectivity. These annular guides also cooperate with the particle trapping spaces and the external surfaces of the guides aid in reversing the flow of trapped particles and guide such particles radially outwardly to desired points. By selecting a proper radial width for these annular guides it is found that some particles which have been ground to a desired state of fineness may be guided to points directly into or above a region of adequate intensity in the force field and more particularly to the part where inwardly directed force components take effect and the selective process is thereby materially improved. At the same time larger particles necessarily are conducted outwardly to a point where, by reason of their mass, they will exert greater centrifugal forces than the drag forces and will be directly returned to the outermost portions of the grinding chamber to undergo an additional grinding process.

Moreover, I have found that the axial adjustability of the selector flanges or guide elements enables these elements to serve as a valve, by means of which the pressure level within the grinding chamber may be uniquely controlled within useful grinding limits without loss of adequate selectivity. The flanges may be positioned independently and may also cooperate with a down stream valve which is used to regulate the pressure level within the grinding chamber. That is, by either of these means the mass flow rate of grinding fluid which passes through the grinding chamber can be regulated to a predetermined pressure level which makes for the most efficient grinding. This feature introduces density control within the grinding chamber as another important control element on the grinding process. It has been found in practice that by using such a method of pressurized grinding a required degree of particle subdivision can be carried out with a much smaller fluid input, resulting in a substantial saving in power.

The selective process which is achieved by means of the classifying device described, and as comprised by the tubular bodies and annular guides, is attended by other unusual and surprising consequences in connection with the over-all efficiency of the grinding machine, as will be explained more fully in connection with the following detailed description of the grinding chamber construction.

In the structure shown in the drawings, and referring in particular to Figs. 1 and 4, numeral **2** denotes a cylindrical or ring-shaped retaining body having a centrally located rib section **4** of relatively short axial length extending around the inner periphery thereof, as is best shown in Fig. 4. Snugly fitted within the ring shaped body **2**, and maintained in spaced-apart relationship by means of the rib **4**, are two converging sections including an upper section **6** and a lower section **8**. These sections are recessed to provide a hollow chamber space, the axial dimension of which increases in magnitude in directions radially inwardly of the chamber. These recessed areas may be of varying contours.

Arranged in concentric relation to the ring **2** is an outer ring **3** which is normally held in fixed spaced relationship to the ring **2** by means of an upper locking plate **5** and a lower locking plate **7**, these members being secured by screws, as **9** and **11**. The sections **6** and **8** are formed with respective annular shouldered portions **10** and **12**, as noted in Fig. 4, and snugly fitted within these shouldered portions are upper and lower bearing members **14** and **16** which are normally secured to the upper sides of the shoulders **10** and **12** by means of screws **18**, **20**, **22** and **24**, for example.

In the grinding chamber construction described is supported my particle classifying device. Centrally located through the bearings **14** and **16** are openings through which are slidably received upper and lower aperture forming elements of the classifier device. These elements include an upper aperture forming element **26** which may conveniently be a tubular body having a closed end portion and a lower aperture forming element **28** which preferably consists of a tubular member open at both its top and bottom portions. The inner ends of the aperture forming elements are normally held in spaced-apart relation to one another, being secured in any desired position of adjustment by means of set screws, as **30** and **32**.

The aperture forming members **26** and **28**, together with the means for adjusting them in a desired spaced-apart relationship to one another, combine with upper and lower casing sections **6** and **8** to form particle trap-

ping regions. Mounted on the tubular bodies **26** and **28** are the annular particle guide members **34** and **36**. These guide members may, for example, be in the form of annular flanges which are mounted at the respective ends of the aperture forming members **26** and **28** and which extend radially outwardly in spaced-apart relation to comprise a restricted particle classifying passageway communicating with a particle discharge passageway **38** in the tubular member **28**.

The annular space defined by the two concentrically arranged rings **2** and **3** has connected thereto, through the ring member **3**, a conduit **40** which is, in turn, connected to a source of a fluid under pressure such, for example, as compressed air. This fluid enters the annular space between the rings **2** and **3**, under pressure, and is forced through a series of air jets **42** which, as has been shown in Figs. 1 and 3, are formed with tapering throats **44** arranged to extend through the inner ring portion **2** in an angular direction so as to cause fluid to be directed somewhat tangentially into the grinding chamber at points around the outer circumference thereof.

The air jet elements **42** are preferably constructed as separate fittings which are pressed into suitable openings **48** formed in the ring member **2**, as shown. By employing a series of these air injection members, a confined stream of gas is developed within the grinding chamber in accordance with the pressure of air delivered through the conduit **40** acting against chamber pressure.

Air or other fluid thus injected, as it travels in a curved path around the grinding chamber, produces a complex force field, a portion of which encloses completely the particle classifying passageway between the particle guide elements when the latter members are in the position shown in Fig. 4. This force field has a central section of relatively short axial extent wherein there is developed an adequate intensity. Above and below this central layer or section of adequate intensity the force field is characterized by regions of lesser intensity and there is, in this way, provided upper and lower force field regions in which a secondary particle flow may take place.

To introduce particles of material to be ground into the chamber, I may employ different types of feeding mechanisms. One desirable form of such mechanism has been shown at the left-hand side of Fig. 1 wherein is shown a bearing portion **50** mounted at one side of the ring member **2**. This bearing portion has formed therein a tapered opening **52**, which communicates with an opening **54** formed through the ring **2**, as shown. Snugly fitted into the outer end of the opening **52** in the bearing **50** is a tubular member **56** which is supported at its intermediate portions in a second bearing member **58** integral with the ring **3**. A packing ring **60** surrounds the tubular member **56** and, together with adjustment clamps **62** and **64** and screw members **66** and **68**, adjustably lock the tubular member in the bearing **58**.

Within the tube **56** is rotatably mounted in a bearing **70** a screw member **72** driven at its outer end by a motor driven sprocket gear **74**. Material is fed into a hopper member **74***a* and passes down through this hopper into the path of the screw member **72** which advances the material forwardly toward the grinding chamber. At the end of the tubular member **56** the material which is fed is firmly packed into the tapered opening and is gradually forced out through the opening **54** into the grinding chamber. If desired a second screw feeding unit may also be symmetrically located at the upper right-hand side of Fig. 1 corresponding, in general, to the screw mechanism just above described. In feeding materials through the conical entry at the inner end of the screw apparatus it may be desired to apply a lubricant to the particles, and in other cases it may be desired to use an injector tip of cylindrical cross-section leading directly to the grinding chamber.

In operation it has been observed that the apparatus described produces a confined stream of fluid material having a force field of varying intensity. There is developed a definite region of fully developed flow at points at which the force field reaches its maximum intensity and there is a relationship between the short axial length of the peripheral wall portions of the chamber and the axial magnitude of the force field.

One explanation of the mode of operation of the force field which is thought to be induced by the specific structural means described is hereinafter set forth as an aid to more fully understanding the invention. It is, however, to be understood that the invention is, in no way, intended to be limited in extent or scope or dependent upon such explanation.

Referring to the structure shown in Fig. 7 it will be observed that a portion of the grinding chamber has been shown on a somewhat larger scale. Indicated in the chamber space are a number of sets of directional arrows which are intended to represent certain paths of particles in the force field believed to be in effect when the machine is operating. The region included within the bracket M and generally corresponding in axial magnitude to the axial height of the cylindrical portion of the chamber periphery defines a force field which, based upon a study of the operating characteristics of the machine, appears to be a region of fully developed flow within which the force field tends to reach its maximum intensity.

Moving in this force field are both large and small particles, of which the large particles are represented by the bold arrows C, which particles develop centrifugal forces directed radially outwardly. Also moving in this force field are relatively smaller particles of a definite micron size and represented by the light arrows P, which particles when at a predetermined radial distance from the central axis of the chamber, start to travel radially inwardly. There is some basis for the further conclusion that these inwardly travelling relatively smaller particles occur in a concentration which is greatest at those portions of the force field included by the bracket M. It is further pointed out that the radial distance from the central vertical axis of the chamber at which the smaller particles start to travel inwardly varies in accordance with a number of variables, such as the physical properties of the guiding fluid and the mass, shape and velocity of the particles in the guiding fluid. Therefore, for a predetermined upper particle size it is possible to approximate a radial distance at which all particles larger than this predetermined particle size will be carried radially outwardly for further grinding. At this same radial distance all particles, large and small, are caused to enter the so-called "fully developed force field," and appreciable quantities of the desired smaller particles will be carried radially inwardly toward the exit and substantially all of the larger particles will be carried radially outward for further grinding. Therefore, the annular guide elements constitute an excellent medium for improving the selectivity and recovery rate of particles of a certain micron size.

Referring further to Fig. 7, it will also be observed that some of the particles as represented by the light arrows P may be directed above and below the particle classifying aperture formed by the guides **34** and **36**. These particles, as has been shown in Fig. 7, may move inwardly until they come into contact with the tubular members. Particles which do contact the tubular members are guided radially outwardly into the main force field at varying radial distances from the vertical axis of the chamber but in all cases at a greater radial distance then the outer flange dimension.

There are two regions above and below the force field included within the bracket M in which the secondary particle flow described above is sought to be carried out. In these regions of secondary flow bold arrows S and S' represent larger particles which move radially inwardly, while light arrows T and T' represent small particles.

which are also caused to move inwardly in these secondary force fields. Such particles travel inwardly into the trapping spaces in the chamber where they ultimately come into contact with the walls of the tubular members and are thereafter guided by the flanges **34** and **36** along a reversely directed path outwardly into the force field for further grinding.

Assuming, therefore, that at certain times in the operation of the grinding chamber some relatively large particles, such as those represented by the arrows S and S' are, in response to some force, displaced inwardly, it is apparent that by the use of the annular guide elements these relatively larger particles must necessarily be carried outwardly to a radial distance such that they will continue to move in this same direction without appreciably disturbing the particles P. Without these guide elements **34** and **36** there is considerable reason to believe that the large particles which move inwardly through the portions of the force field of lesser intensity would tend to move into the path of movement of the inwardly directed particles P and be discharged with the smaller particles.

Whether or not this is the correct explanation for the operation of the forces working in the force field of the grinding chamber, it is definitely established that by control of the spacing of these guide elements, and by varying their radial magnitude, one can exercise greater selectivity in the particular range of particle size which can be obtained from the machine and the output for a given particle size may be substantially increased.

Various modifications may be employed in forming the structural components of the grinding chamber of the invention. For example, it may be desired to change in an important respect the construction of the nozzles through which air is injected into the grinding chamber. Attention is directed to Fig. 8 where I have shown an air injection nozzle which I may conveniently term a "converging-diverging" type of nozzle, denoted by the numeral **80**, and which is formed with a converging throat portion **82** through which air is introduced and from which the air passes to a diverging throat section **84**. It is found that by means of such a construction an increase in the velocity of air which may be driven through the nozzle may be substantially increased. For certain types of grinding operations this increase in air velocity may be very desirable.

Another point at which a change in structure may be desired is in connection with the feeding means for introducing material to be ground into the grinding chamber. Thus, in Fig. 9, for instance, I have shown portions of a grinding chamber including a cylindrical body portion **86** which defines a grinding chamber space **88** closed at the upper side thereof by a conical top section **90**. An outer ring member **92** is rigidly supported in spaced relation to the cylindrical body **86** in the manner already described with respect to the grinding chamber of Figs. 1 and 2. Through the cylindrical body **86** is provided a fitting **94** which communicates with an opening **96** in the wall. Tightly received in the outer end of the fitting **94** is a tubular conduit **96** which is adjustably received by a clamping apparatus generally denoted by the numeral **98** and corresponding to that already described. At its outer end the tubular member **96** is formed with a flanged portion **99** and a threaded extremity **100** around which is secured, in threaded engagement, a feeding head **102** having a feed chamber **104**. Material is delivered into the chamber **104** through a hopper **106**. Communicating with the feed chamber **104** at one side of the member **102** is an opening **108** through which is adjustably received an air nozzle member **110** secured by means of a set screw **112**. This nozzle is connected to a convenient source of compressed air, or other gas, and has not been shown in the drawings as a conventional arrangement of this sort is contemplated.

By means of this arrangement material to be ground is fed from the hopper **106** into the stream of a jet of air which carries the material through the tubular member and ejects it into the grinding chamber under a pressure in excess of the pressure level which is, in effect, within the grinding chamber during the grinding operation. If desired, a plurality of such air injecting feeding means may be employed.

Another form of feeding apparatus which has been found to provide desirable results, and which is characterized by unique features, is comprised by the structure illustrated in Fig. 10. In this apparatus a cylindrical body **114** has supported thereon converging top and bottom sections **116** and **118** which define a grinding chamber **120**. An outer ring member **122** is held in spaced relation to the cylindrical body **114** by means of retaining plates **124** and **126** of the same general class already described. Above and below the top and bottom sections are bearing members **128** and **130** through which extend upper and lower tubular members **132** and **134**, respectively. The tubular member **134** has its inner end extending into the grinding chamber **120** in the manner already described, and is formed with an annular guide element **136**. The upper tubular member **132** has its inner end terminating at the inner face of the bearing member **128** and is open at this inner end. Supported inside of the tubular member **132** by means of a spider arrangement **138**, for example, is a tapered guide element **140** which is formed at its lower end with an annular flange **142** generally coinciding in size and shape with the guide element **136** and normally located in spaced-apart relationship thereto. The guide **140** is constructed with a relatively small spindle portion which tapers outwardly at its bottom portion in the form of a conical cross-sectional shape to provide a conical guide surface **144** which, lying in spaced relation to the inner periphery of the tubular member **132**, constitutes a material feeding passageway through which material to be ground may be delivered. This material may be screw-fed, or air-injection fed, by arrangements such as those described above and which may be conveniently connected to the tubular member **132** in the manner already described. It is pointed out that this construction has several advantages in that it provides a means of delivering material and guiding said material outwardly into a force field without having to be actually forced into the outermost portion of the force field at the outset. It will also be apparent that there are advantages accruing from eliminating the introduction of feed nozzles at the outer periphery of the grinding chamber since this improves axial symmetry and, automatically, the axial length of the cylindrical body portion of the grinding chamber may be made smaller than would otherwise be possible if feed tubes are received therethrough. Various other changes may also be made in the structural components.

Removal of particles passing through the tubular member **28** is conveniently carried out by means of a conical enclosure **28*a*** which is snugly fitted around the tubular member **28**, as shown in Fig. 2, and which has a relatively larger cylindrical bottom portion **28*b***. The latter member is formed with a flange **28*c*** which is adapted to receive a porous receptacle, such as a bag, **28*d***, supported around the flange **28*c***, as shown in Fig. 2. Particles and exhausted fluid are delivered through these outlet members into the bag where the material is collected and exhaust air passed out through the porous side walls of the bag or container.

In some cases still other modified feeding means may be employed. For example, in Fig. 11 I have illustrated a modified form of screw denoted by the numeral **72'** which is supported in a mounting **58'** corresponding to that already described in connection with Fig. 1. The screw **72'** has a helical flight **72''** which increases in width of pitch as it extends forwardly and which also is shaped to fit into a conically shaped tubular tip **56'**. It is found in practice that with certain types of hard packed materials

delivered by the flights of the screw, the particular construction described prevents packing and clogging and allows a small amount of material to be more easily fed into the grinding chamber through a suitable opening therein indicated by the numeral **57'**.

I further find that in dealing with certain types of materials, for example powdered coal and mixtures of powdered coal with other substances, I may combine with the feed screw and hopper mechanism, generally shown in Figs. 1 and 9, means for positively urging the powdered coal, or other material, downwardly through the hopper into the path of movement of the screw member. Thus in Fig. 12, for example, I have illustrated a grinding chamber **160** corresponding in general construction with the grinding chambers earlier described and being supplied by a fluid under pressure through a conduit **162**. Communicating with the grinding chamber **160** is a tubular casing **164** in which is received a screw **166** which terminates at an opening **168** formed in the chamber wall **170**. The screw and tube are supported in suitable bearing means **172** and the tube supports at its outer end a hopper **174** which is closed at its upper side by a sealing cap **176**. Communicating with the upper inner end of the hopper **174** is a pressure line **178** which is adapted to lead fluid coming from the conduit **162** into the top of the hopper and apply or exert a pressure against a body of material in the hopper, causing it to be positively urged against the flights of the screw **166**.

Alternatively, I may provide a screw and hopper arrangement such as that shown in Figs. 13 and 14, in which I have provided a screw **180** in a tubular casing **182**. Constructed as an integral part of the tube, for example, or otherwise communicating therewith, is a pocket feeding mechanism **184** which includes an annular housing having a rotor **186** driven by a sprocket chain **188**, as shown in Fig. 14. The ends of the rotors **186** have their ends adapted to seal with adjacent surfaces of the housing which is open at its upper side to receive material from a hopper **190**, as shown.

Another modification of structure which may be employed has also been shown in Fig. 15 wherein I have shown a tubular member **26'**, which corresponds to the tubular member **26** of Fig. 4. This tubular member supports at its lower end a guide plate **34'** and the tube is adjustable in a bearing **14'**. The novel structure present in this figure resides in the faired or curved portions **14***a* and **26***a*. These portions are provided to sharply accentuate symmetry in the tubular construction, with the object of more uniformly inducing a rotary path of flow of particles coming into the trapping area **25**. A similarly contoured hollow tubular member, corresponding to member **28**, would be used when member **26'** is employed.

From the foregoing description of the invention it will be evident that I have provided an efficient and novel grinding chamber construction in which a number of desirable features have been incorporated in such a manner as to cooperate with one another and to provide for a substantially more efficient grinding operation attended by a more satisfactory degree of selectivity and separation. The force field of an annular fluid energy type grinding unit has been made use of in an improved manner so that a better utilization of the fluid energy available is realized in addition to more effective selectivity.

While I have shown and described preferred embodiments of the invention, it should be understood that various other changes and modifications may be made in keeping with the scope of the invention as defined by the appended claims.

Having thus described my invention, what I desire to claim as new is:

1. An apparatus for grinding material, comprising a casing having an annular chamber formed therein, means for introducing a fluid into said chamber to produce a generally spiralling fluid stream, a feeding mechanism for delivering material into said chamber in the path of this

stream, a particle classifier device located centrally of the chamber, a particle collector communicating with the classifier device, said classifier device including two cylindrical classifier elements disposed axially through respective upper and lower sections of the chamber and arranged in opposed spaced-apart relationship to one another, and one of said cylindrical classifier elements having a closed end portion, the other of said classifier elements being open and a pair of cooperating annular guide elements supported on respective classifier elements and spaced apart a distance substantially corresponding to the axial length of the annular chamber wall.

2. An apparatus for producing finely divided material, comprising a casing having an annular chamber formed therein, means for introducing a fluid into said chamber to produce a generally spiralling fluid stream, a feeding mechanism for delivering material to be ground into said chamber in the path of this stream, a particle classifier device located centrally of the chamber, a particle collecting member communicating with the classifier device, said classifier device including two tubular classifier elements disposed axially through the casing and having their inner ends arranged in opposed spaced-apart relationship to one another, and annular guide rim means mounted on the cylindrical classifier elements and extending radially outward therefrom to define a restricted particle classifying aperture which operates to regulate the size of the particles discharged, and said annular guide means being spaced apart a distance chosen with reference to the axial length of the chamber wall to locate said guide means within that force field of the said spiralling stream which is defined by and included within the said axial length.

3. A grinding machine including a casing having an annular chamber, means for introducing under pressure a fluid material to produce a confined generally spiralling stream of fluid material having a force field of varying intensity, the annular chamber increasing in height in directions radially inward to provide upper and lower force fields of lesser intensity than a maximum force field occurring at the central section of the chamber, means for feeding particles into the stream at outer peripheral portions thereof, a classifier device for selectively separating and discharging ground particles which are acted upon simultaneously by said force field and by radially inwardly directed drag force components, said classifier device including aperture forming members consisting of an open tubular body and a closed tubular body axially supported through the annular chamber, particle guide means mounted on the aperture forming members and spaced apart to enclose therebetween the maximum force field at the central section of the chamber for the purpose of directing the travel of particles acted upon by the radially inwardly directed force components in the fields of lesser intensity, and guiding said particles radially outward into the said maximum force field.

4. A grinding machine including an apparatus for producing a confined stream of fluid material, means for feeding particles into the stream, a classifier device for selectively separating and discharging the particles in a finely ground state from the apparatus, the classifier device comprising a tubular body having a closed end, and a second tubular body having an open end and supported in close proximity to and in axial alignment with the closed end of the said first tubular body; said classifier device further including two annular, radially extending, spaced-apart guide elements occurring in axial alignment, one of said elements having a particle discharge passageway formed therethrough and being secured to the open tubular body and the other of said guide elements being mounted on the closed end of the remaining tubular body of the said classifier device and in substantially parallel relationship to the said first guide element.

(References on following page)

References Cited in the file of this patent

UNITED STATES PATENTS

1,214,249	Williams	Jan. 30, 1917
1,597,656	Morton	Aug. 24, 1926
2,032,827	Andrews	Mar. 3, 1936
2,550,390	Stephanoff	Apr. 24, 1951
2,587,609	Fisher	Mar. 4, 1952
2,588,945	Trost	Mar. 11, 1952
2,616,563	Hebb	Nov. 4, 1952
2,628,786	Piperoux et al.	Feb. 17, 1953
2,685,853	Schlick	Aug. 10, 1954

FOREIGN PATENTS

364,492	Italy	Nov. 8, 1938