April 1, 1941. N. N. STEPHANOFF 2,237,091

PULVERIZING APPARATUS

Filed May 29, 1937 2 Sheets-Sheet 1

Fig. 1

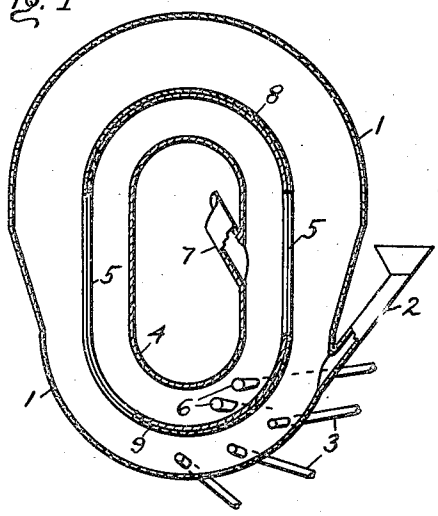


Fig. 3

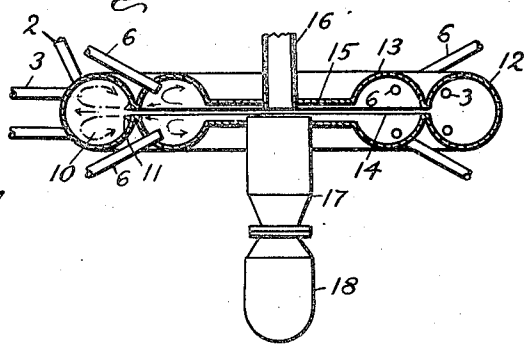


Fig. 4

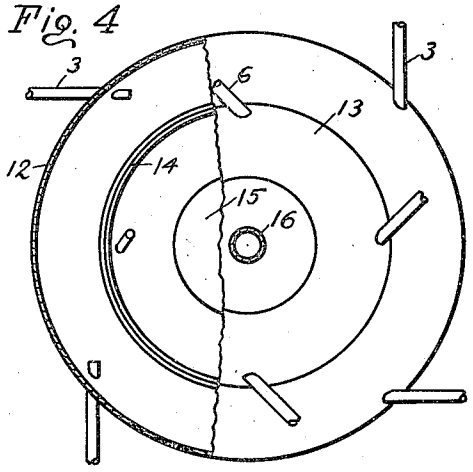


Fig. 2

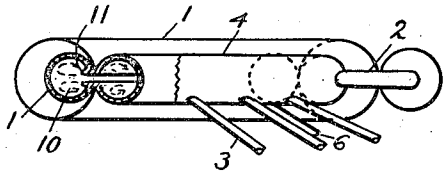


Fig. 5

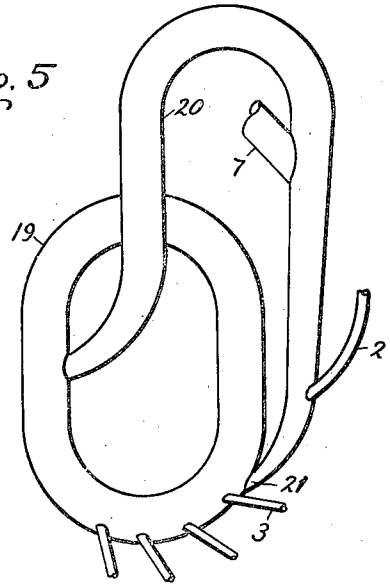
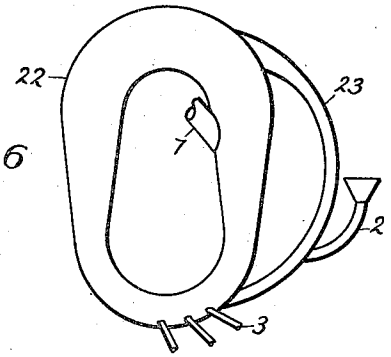


Fig. 6



NICHOLAS N. STEPHANOFF

INVENTOR

BY John P. Nikonow

ATTORNEY

April 1, 1941. N. N. STEPHANOFF 2,237,091

PULVERIZING APPARATUS

Filed May 29, 1937 2 Sheets-Sheet 2

Fig. 7

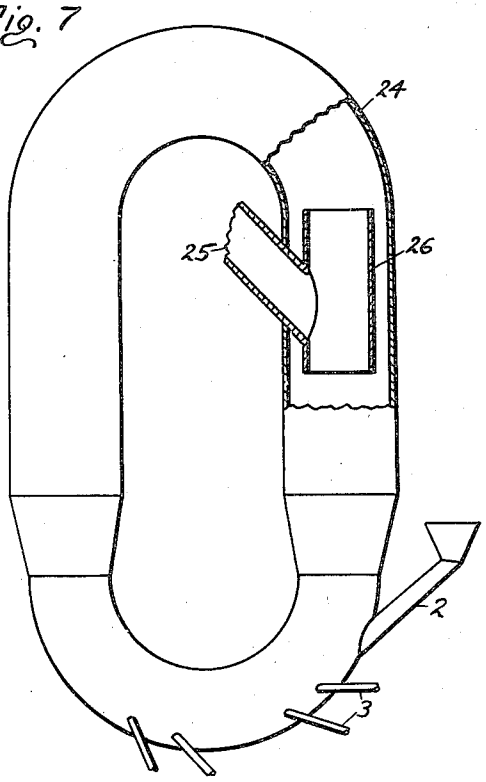


Fig. 8

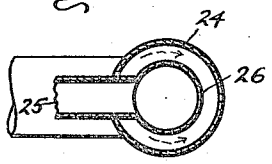


Fig. 9

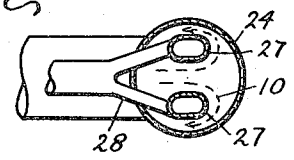


Fig. 10

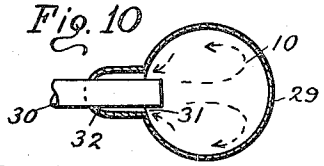


Fig. 11

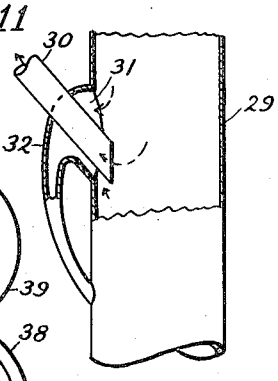


Fig. 12

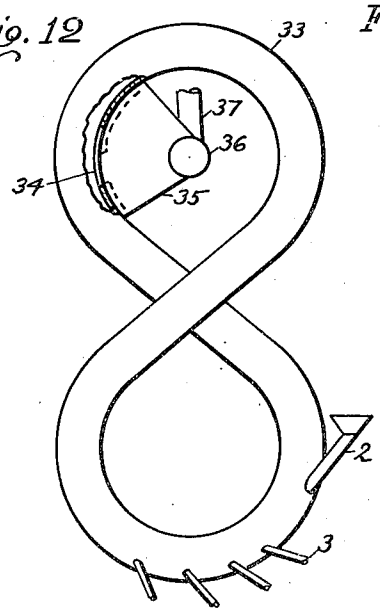
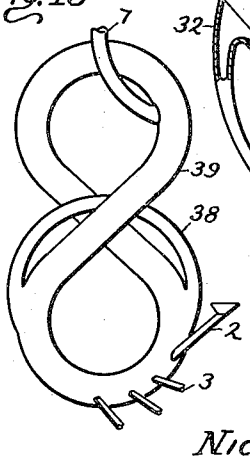


Fig. 13



NICHOLAS N. STEPHANOFF

INVENTOR

BY John P. Nikonow

ATTORNEY

Patented Apr. 1, 1941 2,237,091

UNITED STATES PATENT OFFICE

2,237,091

PULVERIZING APPARATUS

Nicholas N. Stephanoff, Rosselle, N. J., assignor to Thermo-Plastics Corporation, Elizabeth, N. J., a corporation of New Jersey

Application May 29, 1937, Serial No. 145,520

16 Claims. (Cl. 83—46)

My invention relates to pulverizing apparatus and has particular reference to impact pulverizing apparatus in which raw material in a coarsely ground form is finely pulverized by moving it at high velocity in a stream of an elastic fluid.

Impact pulverizers usually have the shape of a tubular chamber closed on itself, the material being circulated through the chamber in a closed continuous circuit. Heavier particles are then thrown by the centrifugal force toward the outer portions of the chamber and continue circulating until ground into a finer powder. An exhaust pipe extends from the inner portion of the chamber where finer particles are present in the fluid. With this arrangement the grinding or pulverizing process is accompanied by separation between the coarser and finer particles.

In actual practice it has been found, however, that despite the action of the centrifugal force, a relatively large proportion of the heavier particles escape into the exhaust from the inner portions of the chamber. The explanation of this fact has been found in a peculiar phenomenon taking place in the chamber, the so-called "double flow" of the fluid which manifests itself in the return flow of the fluid and particles back from the outer wall of the casing toward the inner wall at either side of the central plane. The two streams meet again at the inner portion of the casing and may continue flowing into the exhaust, the heavier particles from the outer wall being thereby entrained with the fine powder in the exhaust.

I have found, however, that it is possible to practically eliminate the larger particles from the exhaust by using an additional chamber for separation only, this chamber forming a second circuit for the fluid in a more or less constant communication with the main circuit.

I arrange the communication between the chambers in such a manner that the second chamber receives practically only finer particles. For this purpose I provide the communication in the form of a narrow slot between the abutting walls of the two chambers so that only the finer particles are drawn through this slot by the escaping fluid, the heavier particles being thrown outward along the middle section of the chamber by the centrifugal force before they reach the slot. This arrangement forms one of the objects of my invention.

Another object of my invention is to provide means to form two or more successive closed circuits of a ground raw material in streams of a rapidly moving elastic fluid, one stream being fed by the material and fluid from the inner portions of the preceding circuit thereby receiving only finer particles. For this purpose I provide concentric annular or elongated casings in a communication with each other by more or less continuous slots along the abutting walls. In order to maintain the material in rapid circulation in the casings, I provide a plurality of nozzles in the casing placed at an angle to the walls of the casings so as to move the fluid in one direction.

Another object of my invention is to provide a plurality of annular more or less elongated chambers disposed in a vertical direction in which the raw material is rapidly circulated by an elastic fluid thereby providing not only successive separation chambers in connection with the primary pulverizing or grinding chamber, but providing for an additional separation due to the inability of the heavier particles to rise in the vertical portions of the casings and to pass into downward portions of the casings, the exhaust connections being made in these downward portions.

Another object of my invention is to provide means for a supplementary or secondary separation in a supplementary separation chamber connected by its intake portion to the inner side of the pulverizing chamber so as to receive the finer particles with the fluid from the pulverizing chamber, the exhaust end of the secondary chamber being connected to the outer portion of the first chamber after the pulverized material has been exhausted from the supplementary chamber through a duct connected to its inner side.

Another object of my invention is to provide means for an increased turbulence and improved separation by forming a tubular closed chamber twisted upon itself into the form of the letter eight, the material and fluid being admitted in one loop of the chamber, the exhaust being connected to the other loop.

Another object of my invention is to provide for an additional separation by means of a tubular member or members disposed in the main chamber and supported at a distance from the chamber walls so that only light particles will flow through the tube, and providing an exhaust duct leading from the inside of the tubular members.

Still another object of my invention is to provide a method of separation of the finer particles from the coarser particles by forming a plurality of separate circuits of a fast moving fluid with the raw material, each succeeding circuit receiving the already separated fine particles from the preceding circuit.

A further object of the invention is the provision of an apparatus in which an upright stack and cooperating parts tend to promote separation of heavier particles. Still further objects relate to the provision of velocity changes promoting grinding, and to various other features which will be understood from the following description, read in conjunction with the accompanying drawings, in which:

Fig. 1 is a sectional elevational view of my pulverizing apparatus consisting of an outer and inner chambers.

Fig. 2 is a bottom view of the same partly in section.

Fig. 3 is a sectional elevational view of a modified apparatus.

Fig. 4 is a top plan view of the same partly in section.

Fig. 5 is an elevational view of another modification.

Fig. 6 is an elevational view of still another modification.

Fig. 7 is an elevational view partly in section of a vertical pulverizing chamber with a separating chamber inside.

Fig. 8 is a sectional view taken on the line 8—8 of Fig. 7.

Fig. 9 is a similar sectional view of a modified device.

Figs. 10 and 11 are two sectional fractional views of a modified exhaust connection.

Fig. 12 is an elevational view partly in section of a modified tubular chamber.

Fig. 13 is a similar view of another modification.

My pulverizing apparatus consists of a tubular chamber 1 of an elongated form closed on itself and supported in a substantially vertical position (supporting brackets etc. are not shown). The lower and upper portions of the casing or chamber are curved as shown and are connected by substantially straight side portions. A raw material in the form of a coarsely ground powder is delivered into the casing through a feed pipe 2 into the curved lower portion at an angle to its radius and in the same direction in which nozzles 3 are fitted into the casing. A second or separation chamber is provided in an inner casing 4 fitted inside the pulverizing chamber 1, the outer side of the inner casing abutting the inner wall of the outer casing. Slots 5 are provided at the sides of the casing forming communication between them. Additional nozzles 6 are fitted into the inner casing and an exhaust duct 7 extends from the inside portion of the inner casing at the vertical side.

The operation of my apparatus is as follows. The nozzles 3 are connected to a source of compressed elastic fluid, preferably steam at a sufficiently high pressure. Steam is expanded in the nozzles so that it acquires high velocity of the order of 1000 feet per second or more. It flows then in a continuous circuit through the chamber 1, entraining the raw material fed through the duct 2. Particles of the material suffer mutual impacts under action of the steam jets from the nozzles and in the general turbulence in the chamber especially if the steam velocity exceeds the sound velocity. As a result, the material is pulverized and is also separated by the action of the centrifugal force into two principal layers, one, consisting of coarser particles and following the outer wall of the casing, the other, consisting of fine particles, remaining closer to the inner wall. These finer particles pass with the steam through the slots 5 into the inner or separation chamber 4. A partition 8 on top prevents the heavy particles from falling into the inner chamber, and a partition 9 at the bottom prevents the particles from being blown into the inner chamber by the steam jets from the nozzles. Steam in the inner chamber continues to rotate forming a separate circuit and it can be accelerated by the supplementary jets from the nozzles 6. The heavier particles in the second circuit are thrown against the outer wall of the chamber and pass through the slots 5 back into the first chamber, while the lighter particles hug the inner wall. They finally escape through the exhaust duct 7. With my double separation it becomes possible to obtain more finely pulverized material than with a single chamber, only the finest particles being collected with the exhaust steam, the so-called "kick-back" particles being returned into the first chamber. The enlargement of the upper portion of the outer chamber 1 causes a reduction in velocity of the circulating fluid rendering it less capable of causing heavy particles to pass over into the down-flow leg of this chamber.

In ordinary pulverizers the kick-back is caused by the particles flowing around the inner wall of the casing in a double motion as shown in Figs. 2 and 3 at 10. The heavier particles under such conditions tend to reach the inner wall and may escape into the exhaust. With my arrangement of the narrow slots 5 these particles are returned to the outer wall through the middle portion of the chamber before they can escape into the slot. The slots may be provided with inwardly extending flanges 11 in order to still further prohibit the particles from passing into the slots. The flanges are absent from the inner casing so that the heavier particles can slide back into the outer casing and there is less tendency therefore to form the double motion eddies. They are also less pronounced in the straight portions of the casing, and for this reason the exhaust duct 7 is connected to the straight leg of the casing in a direction inclined oppositely to the steam flow as shown. Additional separation is effected by the inability of the heavy particles to rise to the top of the casing in its left leg, so that the right leg becomes relatively free from the heavy particles, and for this reason the exhaust duct 7 is connected to the right leg for the clockwise direction of rotation of the elastic fluid.

A modified construction is shown in Figs. 3 and 4. An annular or circular casing 12 is placed horizontally and is provided with a plurality of nozzles 3 for the compressed elastic fluid. An inner separation chamber 13 is disposed inside the outer casing 12 and concentrically therewith, the abutting walls of the casings having a continuous circular slot 14. The inner casing has a narrow central chamber 15 into which extend an exhaust pipe 16 on top in the center, and a dust collector 17 at the bottom, the collector having a removable bag or container 18 for the pulverized product.

Another modification is shown in Fig. 5 representing a pulverizing chamber in a casing 19 with a separation chamber in a casing 20, the latter being connected at one end to the inner side of the casing 19, the other end being connected at 21 to the outer side of the pulverizing chamber back of the nozzles 3. The exhaust pipe 7 is connected to the inner side of the casing 20 in its straight portion below the upper curved portion. The ends of the casing 20 may be of a re-

duced cross-section in order to increase the fluid velocity at these points: at the intake end of the casing 20 the expansion after the reduced portion will have a tendency to retard the upward movement of the heavier particles, and at the exhaust end 21 the reduced section will act as a nozzle for injecting the remaining particles into the pulverizing chamber. This chamber is preferably mounted in a vertical position.

A similar construction is shown in Fig. 6. In this case the inner or pulverizing casing 22 is provided with a by-pass duct 23 for the heavier particles in order to lead them away from the exhaust duct 7. The intake upper end of the by-pass is flattened at the sides and is connected with a corresponding vertical slot in the casing 22. The enlargement of the upper portion of the pulverizing casing 22, as in the case of the modification of Figure 1, prevents to a large extent the carrying over of heavier particles past the top of the casing.

A modified arrangement for the secondary separation is shown in Fig. 7 also representing a vertical elongated casing 24. It is provided with an exhaust duct 25 extending from a tubular separating member 26 disposed in the upper enlarged portion of the casing and at a distance from its walls. The tubular member therefore receives only that portion of the steam flow which carries finer particles, the heavier particles being driven against the walls of the casing by the centrifugal force. The tubular member acts as a supplementary separator for the fine particles, the heavier particles being thereby eliminated from the exhaust. The centrifugal forces produced by flow through the lower bend cause the flow to enter the enlarged upright stack of the apparatus in a direction at an acute angle with the outside portion of its wall. Here, again, the enlargement by reducing the velocity of flow prevents carrying of the heaviest particles into the down-flow portion of the casing.

The separation member may be formed in two portions as shown in Fig. 9, the two tubes 27 being placed at the same elevation and spaced apart so as not to interfere with the double flow streams 10. A forked exhaust duct 28 extends from these tubular members.

Figs. 10 and 11 show a pulverizing casing 29 in a frictional sectional view with an exhaust duct 30 extending inwardly into the casing so as to collect the lighter particles, there being provided a recess 31 with a by-pass duct 32 for the heavier particles flowing along the walls.

A modified construction is shown in Fig. 12 illustrating a pulverizing casing 33 twisted into the figure eight so as to form two loops, the lower loop serving as a pulverizing chamber and the upper loop forming a separation chamber. An exhaust slot 34 opens into an exhaust sector 35 rotatively supported at 36 on the end of an exhaust pipe 37. The sector also has a slot registering with the slot 34, and the opening can be adjusted by turning the sector. The double loop arrangement has an advantage in that the flow of the fluid is reversed in passing from one loop into the other with a corresponding reversal of the double flow streams, which creates an additional turbulence and more intensive grinding with better separation.

The lower loop can be provided with a by-pass loop 38 for the heavier particles as shown on a casing 39 in Fig. 13, thereby keeping the heavy particles from the upper loop.

It is evident, of course, that my principle of supplementary chambers for additional separation can be extended to the use of three or more successive separation chambers for obtaining extreme fineness of the product.

I claim as my invention:

1. A pulverizing apparatus comprising a casing forming an elongated tubular pulverising chamber disposed in a substantially vertical direction by its longer axis, means to admit a raw material into the casing, means to admit an elastic fluid at a high speed into the casing so as to cause the material to circulate through the casing thereby separating heavier particles from the lighter particles by centrifugal force, the upper portion of the casing being of a relatively larger cross-section, a second casing disposed inside the first casing, the outer wall of the inner casing abutting the inner wall of the outer casing, the casings being provided with continuous slots at their intermediate portions, the slots being closed at the top and at the bottom of the casings, the slots being adapted to admit the fluid into the inner casing for continuing its circulation, the heavier particles from the second casing being adapted to be returned by the centrifugal force into the first casing, and an exhaust duct at the inner side of the inner casing.

2. A pulverizing apparatus comprising a casing forming an endless tubular chamber having two curved upper and lower portions connected by substantially straight portions, the upper curved portion of the casing having a relatively large cross-section as compared with the lower curved portion, means to admit a raw material into the casing, means to admit an elastic fluid at high velocity into the lower portion of the casing in a direction to cause the fluid and the material to circulate through the casing, a tubular member disposed in the straight portion of the casing in which downflow is occurring and spaced from the walls of the casing so as to admit such portion of the fluid stream as carries lighter particles of material with it, and an exhaust duct extending from the inside of said tubular member to the outside of the casing.

3. A pulverizing apparatus comprising a casing forming an endless elongated tubular pulverizing chamber having its longer axis disposed substantially vertically, means to admit a raw material into the casing, means to admit an elastic fluid at high velocity into the lower portion of the casing in a direction to cause the fluid and the material to circulate through the casing, thereby separating heavier particles from the lighter particles by centrifugal force, the upper portion of the casing being of relatively larger cross-section than the lower portion, a tubular member disposed in the enlarged portion of the casing, and a pipe extending from the tubular member to the outside for extracting the pulverized product.

4. A pulverizing apparatus comprising a casing forming an endless elongated tubular pulverizing chamber having its longer axis disposed substantially vertically, means to admit a raw material into the casing, means to admit an elastic fluid at high velocity into the lower portion of the casing in a direction to cause the fluid and the material to circulate through the casing, thereby separating heavier particles from the lighter particles by centrifugal force, the upper portion of the casing being of relatively larger cross-section than the lower portion, a shielding member disposed in the enlarged portion of the casing to segregate from each other centrifugally sepa-

rated heavier and lighter particles, and a pipe extending from the shielding member to the outside for extracting the pulverized product.

5. A method of pulverizing raw material comprising mixing the material with a stream of an elastic fluid moving at high speed, causing the mixture to circulate in an endless circuit elongated in the vertical direction, the upper portion of the circuit being curved and of a larger cross-sectional area than the lower portion, separating heavier particles by the centrifugal forces thus created in said curved upper portion of the circuit, returning such heavier particles for further circulation in the circuit, and extracting finer particles at the inner side of the downflow portion of the circuit.

6. A pulverizing apparatus comprising a casing forming an endless elongated tubular pulverizing chamber having its longer axis disposed substantially vertically, means to admit a raw material into the casing, means to admit an elastic fluid at high velocity into the lower portion of the casing in a direction to cause the fluid and the material to circulate through the casing, thereby separating heavier particles from the lighter particles by centrifugal force in curved portions thereof, the upper portion of the casing being of relatively larger cross-section than the lower portion, and an exhaust duct for removing from the casing centrifugally separated particles.

7. A pulverizing apparatus comprising a casing forming an endless tubular pulverizing chamber disposed substantially vertically, means to admit a raw material into the casing, means to admit an elastic fluid in the form of at least one high velocity jet into the casing in a direction to cause the material to circulate through the casing, thereby separating heavier particles from lighter particles by centrifugal force in at least one smoothly curved portion thereof, said casing providing separate passages for centrifugally separated lighter and heavier particles respectively, the passage for the lighter particles having a curved tubular portion to effect further centrifugal separation therein, and an exhaust duct for removing from the passage for the lighter separated particles the lightest particles centrifugally separated therein, the last named passage being arranged to redirect heavier particles into the region of said jet.

8. A method of pulverizing raw material comprising feeding raw material and at least one high velocity jet of elastic fluid into a confined, elongated stream of elastic fluid of defined cross-section, causing said stream to follow a smooth curved path to effect centrifugal separation of lighter and heavier particles therein, dividing said stream beyond said curved region into a plurality of similar confined elongated streams one carrying heavier, and another lighter, particles, causing the stream carrying lighter particles to follow a smooth curved path to effect further centrifugal separation of the lightest and heavier particles therein, withdrawing therefrom elastic fluid carrying said lightest particles in suspension, and then returning both streams carrying heavier particles to the first mentioned stream for further action of said jet upon the heavier particles, substantially all particles remaining in suspension in the elastic fluid throughout all of said streams.

9. A method of pulverizing raw material comprising feeding raw material and at least one high velocity jet of elastic fluid into a confined, elongated stream of elastic fluid of defined cross-section, causing said stream to follow a smooth curved path to effect centrifugal separation of lighter and heavier particles therein, dividing said stream beyond said curved region into a plurality of similar confined elongated streams one carrying heavier, and another lighter, particles, withdrawing from the stream carrying lighter particles elastic fluid carrying in suspension the lightest of the lighter particles therein, and then returning both streams carrying heavier particles to the first mentioned stream for further action of said jet upon the heavier particles, substantially all particles remaining in suspension in the elastic fluid throughout all of said streams.

10. A method of pulverizing raw material comprising mixing the material with a stream of an elastic fluid moving at high speed, causing the mixture to circulate in an endless circuit disposed substantially in a vertical plane, the upper portion of the circuit being curved and of a larger cross-sectional area than the lower portion, separating heavier particles by the centrifugal forces thus created in said curved upper portion of the circuit, returning such heavier particles for further circulation in the circuit, and extracting finer particles at the inner side of the downflow portion of the circuit.

11. A pulverizing apparatus comprising a casing forming an endless tubular pulverizing chamber disposed substantially in a vertical plane, means to admit a raw material into the casing, means to admit an elastic fluid at high velocity into the lower portion of the casing in a direction to cause the fluid and the material to circulate through the casing, thereby separating heavier particles from the lighter particles by centrifugal force in curved portions thereof, the upper portion of the casing being of relatively larger cross-section than the lower portion, and an exhaust duct for removing from the casing centrifugally separated particles.

12. Apparatus for the treatment of material in comminuted form in suspension in elastic fluid to produce a finely divided substantially solid product comprising a tubular passage having a curved axis and adapted to impose centrifugal forces on material flowing therethrough, means for introducing material thereto, a diverging passage arranged to receive material from said curved passage while it is flowing under the influence of said centrifugal forces so as to be directed towards a side of said diverging passage, an enlarged unobstructed elongated substantially straight tubular member into which said diverging passage discharges, means for inducing high velocities of flow through said curved passage comprising at least one nozzle arranged to discharge fluid in the direction of flow therethrough, means for returning elastic fluid from said straight tubular member to the first mentioned tubular passage for recirculation therethrough, and means for removing said product from the last mentioned means.

13. Apparatus for the treatment of material in comminuted form in suspension in elastic fluid to produce a finely divided substantially solid product comprising a tubular passage having a curved axis and adapted to impose centrifugal forces on material flowing therethrough and to discharge said material upwardly, means for introducing material thereto, a diverging passage arranged to receive material from said curved passage while it is flowing under the influence of said centrifugal forces so as to be

directed towards a side of said diverging passage, an enlarged unobstructed elongated substantially straight upright tubular member into which said diverging passage discharges upwardly, which has a cross-sectional area at least as great as that of the diverging passage, and in which gravity separation of heavier particles may occur, means for inducing high velocities of flow through said curved passage comprising at least one nozzle arranged to discharge fluid in the direction of flow therethrough, means for returning elastic fluid from said straight tubular member to the first mentioned tubular passage for recirculation therethrough, and means for removing said product from the last mentioned means.

14. Apparatus for the comminution of material and its treatment in comminuted form in suspension in elastic fluid to produce a finely divided substantially solid product comprising a Venturi-like passage including a throat and a diverging upwardly opening discharge portion, an upright substantially straight elongated stack having a substantially uniform and unobstructed cross-section substantially that of the discharge mouth of said Venturi-like passage, said stack extending upwardly from said discharge mouth and providing a region in which velocities of flow are reduced so that gravity separation of heavier particles may occur, means for introducing material into said Venturi-like passage for flow in suspension therethrough, means comprising at least one nozzle directed into said Venturi-like passage for inducing high velocity turbulent flow of elastic fluid through said Venturi-like passage, means for supplying high pressure elastic fluid to said nozzle to produce a jet having a velocity at least that of sound, means for returning elastic fluid from said stack to said Venturi-like passage for recirculation therethrough, and means for removing said product from the last-mentioned means, the elastic fluid supplied to said nozzle being additional to that returned from said stack to said Venturi-like passage.

15. Apparatus for the comminution of material and its treatment in comminuted form in suspension in elastic fluid to produce a finely divided substantially solid product comprising a casing providing an endless unobstructed passage of tubular form throughout, a portion of said passage being in the form of a Venturi-like passage, means for feeding material to said tubular passage, means providing a plurality of high velocity elastic fluid jets each having a velocity at least that of sound directed into said Venturi-like portion in the direction of flow therethrough, arranged in succession in said direction of flow and inducing a high velocity turbulent flow of elastic fluid through said Venturi-like portion to maintain particles of the material continuously in suspension and recirculating through said tubular passage, means for supplying high pressure elastic fluid to form said jets, and means for diverting fluid carrying suspended material from a part of the tubular passage remote from said Venturi-like portion, the elastic fluid supplied to form said jets being in addition to that recirculated through said tubular passage.

16. The method of grinding substantially solid material in comminuted form comprising subjecting said material successively to the action of a plurality of high velocity jets of elastic fluid, each of which has a velocity at least that of sound to produce a flowing gaseous suspension of minute particles thereof, and subjecting said fluid while it carries said particles to changes of velocity by causing it to recirculate through converging and diverging portions of an endless unobstructed tubular passage forming a Venturi-like region thereof, thereby to effect relative movements and grinding of particles of different sizes while they move through said portions of the tubular passage, at least one of said jets being directed into the Venturi-like region of the passage.

NICHOLAS N. STEPHANOFF.