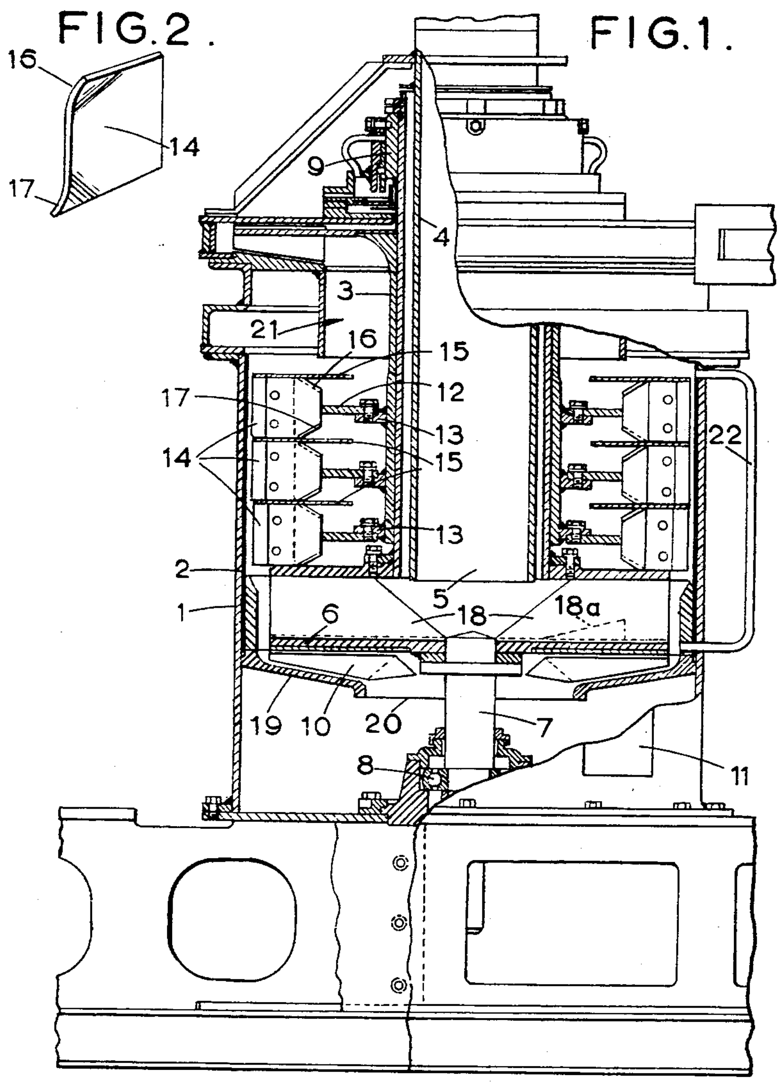
Oct. 10, 1961 J. LECHER 3,003,707

METHOD AND APPARATUS FOR REDUCING THE SIZE OF PARTICLES

Filed Feb. 13, 1956 2 Sheets-Sheet 1



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METHOD AND APPARATUS FOR REDUCING THE SIZE OF PARTICLES

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FIG. 3.

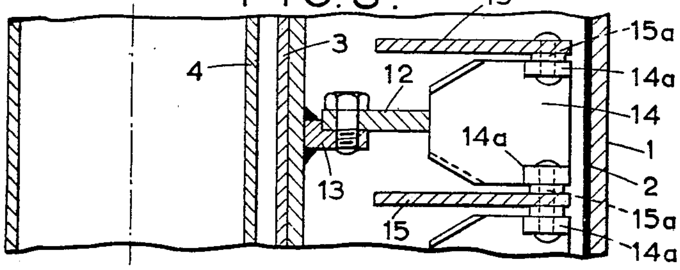


FIG. 4.

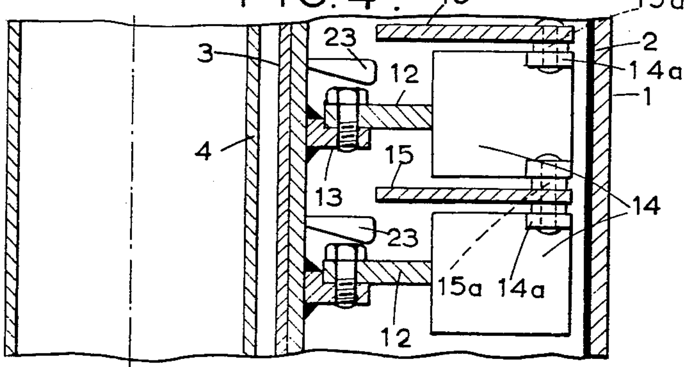
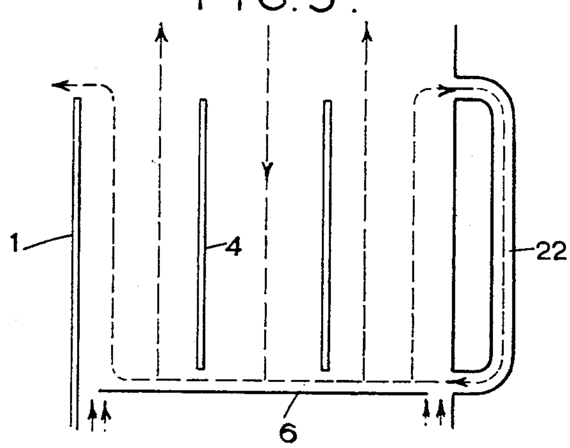


FIG. 5.



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METHOD AND APPARATUS FOR REDUCING THE SIZE OF PARTICLES

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7 Claims. (Cl. 241—1)

This invention relates to a method and apparatus for processing materials and more particularly to the reduction of the particle size of materials while such materials are carried by a flow of fluid. In the reduction of materials utilising methods and apparatus heretofore known, it has been possible to produce particles of a size of 10 microns. With some types of materials and machines it is even possible to produce materials in which a majority of the resultant particles are below 5 microns and wherein the major fraction below 5 microns has an average particle size as low as 3 microns.

However, utilising known methods and apparatus for reducing the particle size of materials, with the exception of the method and apparatus of the specification of my U.S. Patent No. 2,752,097 it has been practically impossible economically to reduce materials to less than 3 micron size on an average. When the material is reduced to, for example, three micron size, the mass of the individual particles is exceedingly small and the behaviour of the particles is different from that of the same material when it has a larger particle size. Thus, most materials when reduced to a fineness size of 3 to 5 microns exhibit at this size range a change in the chemical, magnetic and electrostatic behaviours, and a change in ignition temperature, capillarity, susceptibility of infiltration of moisture and changes in flow as a fluid, as well as changes in surface activity and changes in apparent chemical properties. For practical purposes it has heretofore not been possible (except in the method and apparatus of my aforesaid U.S. Patent No. 2,752,097) reliably to produce on a commercial scale in the same machine pulverised materials of any kind where the particle size is of much less than 10 microns. This, of course, varies somewhat, depending upon the materials, but generally speaking 10 microns has been the usual lower commercial limit, and 5 micron materials are regarded as exceptional. Dry pulverised materials of 3 micron size are exceedingly difficult to produce.

The term "intense sonic energy" as used herein is intended to include a sound energy which, at least at some frequencies, has an energy level in excess of 120 decibels and preferably to excess of 140 decibels (as compared with a datum of 0.0000204 dynes per cm.^{2}), and in which the frequency of such sound energy ranges from the low audible frequencies through and including ultrasonic frequencies. Thus, this term includes a sound energy having an energy level of 120 decibels or greater, as compared with a datum of 0.0000204 dynes per cm.^{2}, at least at some frequencies in the frequency band ranging from the low audible frequencies of several hundred cycles per second through the high audible and well into the range of ultrasonic frequencies such as up to 50 kilocycles or even higher, and in which there may be present subsonic shock waves, both simple, intersecting and reflected, as well as the phenomena of air separation, which produces effects analogous to cavitations. The term "ultra-sonic" as used herein, denotes frequencies of about 18,000 cycles per second or higher, which are not commonly able to be heard by the human ear. The words "sonic" and "sound" as used in this specification refer to vibrations in the fluid medium similar to those which, at very much lower energy levels and appropriate frequencies, can be heard.

It is an object of the present invention to provide an improved method and apparatus for reducing the size of particles which will be capable, for the same size of apparatus, of giving considerably increased throughput and at the same time a greater reduction of the size of the particles as compared with the method and apparatus of the aforesaid U.S. Patent No. 2,752,097. Thus, for example, the throughput may, for some materials, be ten times greater and the average particles size of the product about one quarter of that obtained by an apparatus of the same size according to U.S. Patent No. 2,752,097.

Accordingly, the present invention provides a method of reducing the particle size of particles of solid material in which the solid material is subjected in a disintegrating apparatus to intense sonic energy (as hereinbefore defined) into which apparatus it is, while carried in a fluid, introduced in a first stream which flows substantially vertically downwards and is then separated into a second stream which surrounds the first stream and flows vertically upwards and a third stream which contains solid material of larger particle size than that in the second stream, surrounds the second stream and flows vertically upwards, the fine particles produced in the third stream being continuously passed into the second stream whence they are withdrawn from the apparatus.

Viewed from another aspect the present invention provides a method of reducing the size of particles of solid materials wherein the particles, while carried in a fluid, are caused to collide and simultaneously subjected to the effects of intense sonic energy (as hereinbefore defined) and are then separated into two vertical streams, the inner of which consists of particles whose average size is smaller than the average size of the particles in the outer stream, the particles in at least the outer stream being caused to collide and being simultaneously subjected to intense sonic energy (as hereinbefore defined), fine particles produced in the outer stream continuously passing to the inner stream.

Particles of greater size than desired may be recycled for further processings.

The invention also provides an apparatus for reducing the size of particles of solid material comprising a casing, means for flowing fluid through the casing, means for introducing the particles into the flowing fluid, means within the casing for causing the particles to collide, means within the casing for establishing in the fluid an intense sonic energy (as hereinbefore defined) and means for separating the particles into two vertical streams, the arrangement being such that the inner stream consists of particles whose average size is smaller than the average size of the particles in the outer stream.

According to one embodiment, the apparatus comprises a casing, a horizontally disposed rotatable plate, means for feeding the materials to be treated to the upper surface of said plate, means for introducing an upwardly flowing current of fluid past the periphery of said plate, a rotor inside the casing, the said rotor being provided with at least two axially spaced sets of annular discs carrying vertically disposed blades capable of vibrating circumferentially of the rotor and with a vibratory disc mounted in the space, or each space, between the adjacent sets of blades, the rear part of the top of at least some of the blades being turned backwards with respect to the direction of rotation and the rear part of the bottom of at least some of the blades being turned forward with respect to the direction of rotation, the means for feeding the upwardly flowing current of fluid being such that the fluid flows at a speed such that the blades are caused to vibrate sufficiently to establish an intense sonic energy (as hereinbefore defined) in the fluid and so that the particles are caused to divide into a stream on the inner side of the blades and a stream on the outer side of the blades.

According to another embodiment, the apparatus comprises a casing, a horizontally disposed rotatable plate, means for feeding the material to be treated to the upper surface of said plate, means for introducing an upwardly flowing current of fluid past the periphery of said plate, a rotor inside the casing, the said rotor being provided with at least two axially spaced sets of annular discs carrying vertically disposed blades capable of vibrating circumferentially of the rotor, with a vibratory disc mounted in the space, or each space, between the adjacent sets of blades and with impellers of such aerodynamic shape on the rotor that the fluid is caused to flow upwardly through the casings in two circular streams one within the other and means for feeding the upwardly flowing current of fluid being such that the fluid flows at a speed such that the blades are caused to vibrate sufficiently to establish an intense sonic energy (as hereinbefore defined) in the fluid.

Preferably the material to be treated is introduced down a hollow vertical shaft in a gaseous or liquid fluid or in a liquid fluid with gas entrained in it. It will be understood, however, that the material may be introduced from the side of the casing, as described in U.S. Patent No. 2,752,097.

Preferably also the horizontal plate is provided with vanes to facilitate the conveyance of the material to the periphery of the plate whereby the particles are driven against the casing and are, at this position, disintegrated by shock and friction.

In the accompanying diagrammatic drawings:

FIGURE 1 is a sectional elevation of an apparatus constructed according to the present invention,

FIGURE 2 is a perspective view looking towards the rear end of a radial blade of the apparatus showing one form of oppositely turned corners **16** and **17** to present one aerodynamic shape,

FIGURE 3 is a fragmentary sectional view showing part of the apparatus to an enlarged scale,

FIGURE 4 is a view similar to FIGURE 3, but illustrating a modified apparatus, and

FIGURE 5 is a diagram illustrating the flow of fluid and material through an apparatus constructed according to the invention.

In the arrangement illustrated, an apparatus for reducing the particle size of materials comprises an outer cylindrical casing **1** which has an inner liner **2**. A rotor is mounted in the casing **1** and comprises a sleeve **3** mounted for rotation about a fixed tube **4** which extends axially through the casing and opens at **5** just above a horizontal rotatable distributor plate **6** which is carried on a shaft **7** connected with the sleeve **3**, the whole being rotatable in bearings **8, 9**. Any suitable means can be provided for driving the rotor at high speed, e.g. 25,000 feet per minute peripheral speed or more. For example, the shaft **7** can be provided with a pulley (not shown) which can be driven by V-belts from an electric motor.

Fan blades **10** are mounted on the shaft **7** below the horizontal plate **6** and serve to draw in air through an air inlet or inlets **11** in the lower part of the casing and propel it past the periphery of the plate **6** and upwardly through the casing. If desired, the fan blades can be arranged to draw in a gas other than air, the inlets **11** then being connected to a gas supply.

Annular carrier discs **12** are mounted on lugs **13** on the sleeve and support radially disposed blades **14**. Vibratory annular plates or discs **15** are arranged between the top and bottom of each set of radial blades **14** and are mounted in such a manner that they can vibrate freely. For example, they can, as shown in FIGURE 3, be supported by bolts **15*a*** passing through lugs **14*a*** on the blades. The rear top corner of each blade **14** is turned backwards in the direction of rotation of the sleeve **3** as shown at **16**. The rear bottom corner of each blade **14** is turned forwards in the direction of rotation

of the shaft **3** as shown at **17**. The turned positions have aerodynamic form.

The radial blades **14** and the vibratory discs **15** are made of such a material and are of such a thickness that when fluid is caused by the fan blades **10** to flow past them at high speeds they will vibrate sufficiently to produce intense sonic energy (as hereinbefore defined) inside the casing **1**, especially close to the blades and discs.

Material to be treated, carried in a liquid or gaseous fluid or in a liquid having a gas entrained in it, is introduced into the casing **1** through the hollow tube **4**, the fluid carrying the material discharging from the opening **5** in the tube **4** on to the distributor plate **6**. This plate **6** causes the flow of the carrier fluid to turn outwards. The flow is then turned upwards by the air or gas which flows vertically through the casing under the action of the fan blades **10**. The upper surface of the distributor plate **6** is (as shown in FIGURE 1) provided with a series of deflecting vanes **18** which assist in the outward flow of the solid particles and also connect the rotor sleeve **3** to the plate **6** and therefore to the shaft **7**. Additional vanes **18*a*** can also be provided if desired.

A cover **19** having an axial opening **20** can be fitted beneath the fan blades **10**.

The radial blades **14** and the vibratory discs **15** form passageways through which passes the carrier fluid (now containing air or gas introduced by the fan blades **10**) and the solid material carried by it. The centrifugal forces produced by the rotor will tend to throw the carrier fluid and solids outwardly; however, in contrast to the apparatus described in my aforesaid U.S. Patent No. 2,752,097, the upwardly flowing fluid and solids are (as shown in FIGURE 5 in which broken lines indicate the flow of fluid) divided into two upwardly flowing streams one within the other, the outer stream containing solids of larger average particle size than the inner stream and moving more slowly than the inner stream. The separation into two currents is effected by means of the oppositely turned corners **16, 17** of the radial blades **14**: these oppositely turned corners also assist in propelling fluid through the casing.

As the fluid carrying solids passes upwards through the casing, the solids are reduced by the intense vibrations produced in the radial blades **14** and vibratory discs **15**. The solids are propelled by centrifugal forces through the zones of intense sonic energy produced by the vibrations, through or against shock waves that are set up, and at the same time they collide with each other and are disintegrated.

As hereinbefore mentioned, the inner fluid stream carries solids of smaller particle size than the outer stream. When the particles in the outer stream have been reduced to a sufficiently small size they pass into the inner stream whence they are withdrawn from the top of the casing **1** through an outlet **21**. The solids of larger particle size are, when they arrive near the top of the casing **1**, withdrawn from the casing through a bleed pipe **22** through which they are conveyed towards the lower part of the casing into which they are re-introduced near the periphery of the distributor plate **6**.

FIGURE 4 illustrates a modified apparatus in which the rotor sleeve **3** carries a number of impellers **23** which have such aerodynamic shape that fluid travelling upwards through the casing **1** is divided into two streams flowing one within the other, the outer stream carrying the particles of larger average size. These impellers can be used instead of or in addition to the oppositely turned corners **16, 17** of the blades **14**. When the impellers **23** are used in addition to the oppositely turned corners there results a considerable increase in the throughput of the apparatus.

The solid particles introduced into the mill are believed to be first shattered by simple mechanical impact and/or attrition due to collision with other particles or with the inside of the casing, the radial blades or the vibratory discs and such preliminary impact shatters or wears the material into smaller particles. While the still large particles are weakened and before the cohesive forces have been permitted to recover, the particles are subjected to the intense sonic energy effects hereinbefore mentioned and this further disintegrates the particles.

In general, it may be stated that solid particles may be introduced into the apparatus of this invention in such particle sizes as are conveniently available. It is often most convenient to crush, cut or otherwise comminute the solid material to sieve sizes or even to fairly small size particles (such as 50 microns) which can usually be done easily before feeding into the apparatus.

What I claim is:

1. An apparatus for reducing the particle size of solid material comprising a casing, a horizontally disposed rotatable plate, means for feeding the materials to be treated to the upper surface of said plate, a rotor inside said casing at least two axially spaced sets of annular carrier discs on said rotor, radially disposed blades carried by said discs and capable of vibrating circumferentially of said rotor, the inner part of the top of at least some of which blades is turned backwards with respect to the direction of rotation and the inner part of the bottom of at least some of which blades is turned forward with respect to the direction of rotation, a vibratory disc mounted in the space between adjacent sets of said blades, means for introducing past the periphery of said plate an upwardly flowing current of fluid which at a speed such that said blades are caused to vibrate sufficiently to establish an intense sonic energy in the fluid whereby the particles are caused to divide into a stream on the inner side of the blades and a stream on the outer side of the blades.

2. An apparatus as claimed in claim 1 comprising a hollow, vertical tube through which material to be treated can be fed to the upper surface of said horizontal rotatable plate, and vanes on said upper surface of said plate to facilitate conveyance of said material to the periphery of said plate.

3. An apparatus for reducing the particle size of solid material comprising a casing, a horizontally disposed rotatable plate, means for feeding the material to be treated to the upper surface of said plate, a rotor inside said casing, at least two axially spaced sets of annular carrier discs on said rotor, vertically disposed blades carried by said annular discs so as to be capable of vibrating circumferentially of the rotor, oppositely turned corners on said vertically disposed blades to effect separation of fluid into two streams, a vibratory disc mounted in the space between adjacent sets of said blades, means for feeding an upwardly flowing current of fluid past the periphery of said plate at such a speed that said blades are caused to vibrate sufficiently to establish an intense sonic energy in the fluid, and impellers mounted on said rotor and of such shape on the rotor that the fluid is caused to flow upwardly through the casings in two circular streams one within the other.

4. An apparatus as claimed in claim 3 comprising a hollow, vertical tube through which material to be treated can be fed to the upper surface of said horizontal rotatable plate, and vanes on said upper surface of said plate to facilitate conveyance of said material to the periphery of said plate.

5. An apparatus for reducing the size particles of solid material comprising a casing, means for flowing fluid through said casing, means for introducing the particles into said fluid, a rotor and means carried by said rotor within said casing for causing said particles to collide, said rotor further including a plurality of radially disposed means extending in a direction generally longitudinal to said casing for establishing in said fluid an intense sonic energy and a plurality of shaped and curved blade surfaces disposed in said generally longitudinal direction and interspersed among said plurality of means for separating said particles into two defined vertically ascending and circular streams one within the other and of different velocities, the inner one of which streams consists of particles whose average size is smaller than the average size of the particles in the outer stream.

6. An apparatus for reducing the size particles of solid material comprising a casing, means for flowing fluid through said casing, means for introducing particles into said fluid, a rotor and means carried by said rotor within said casing for causing said particles to collide, said rotor further including a plurality of radially disposed blades capable of vibrating circumferentially of said rotor to establish in said fluid an intense sonic energy, which plurality of blades extend generally longitudinal to said casing, an inner portion of the top of at least some of said blades and an inner portion of the bottom of at least some of said blades being turned in opposite directions with respect to the direction of rotation of said rotor, impellers mounted on said rotor and disposed annularly within and between said plurality of blades, the impellers being shaped to separate, in combination with the blade oppositely directed portions, the upward flow in the casing into two vertically ascending and circular streams one within the other end of different velocities, the inner one of which streams consists of particles whose average size is smaller than the average size of the particles in the outer stream.

7. A method of processing solid material to reduce the size thereof which comprises feeding a controlled supply of the solid material and a gas into a substantially cylindrical grinding area and continuously grinding the solid material at least in part by whirling a fluidal stream of particles of the solid material entrained in the air in an annular upwardly flowing path around the outer periphery of the grinding area while at the same time subjecting the fluidal stream to shock waves ranging from subsonic to supersonic frequencies, and at said same time providing within said outer annular path a defined inner annular path of higher velocity into which fine particles produced in said outer annular path are continuously drawn, and withdrawing said fine particles from said grinding area.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,003,707 October 10, 1961

Joseph Lecher

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, lines 52 and 57, for "0.0000204", each occurrence, read -- 0.000204 --; column 6, line 37, for "end" read -- and --.

Signed and sealed this 20th day of March 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents