June 18, 1929. W. OSTERMANN 1,718,184

COMMINUTING SOLID SUBSTANCES

Original Filed May 6, 1924

Fig. 1.

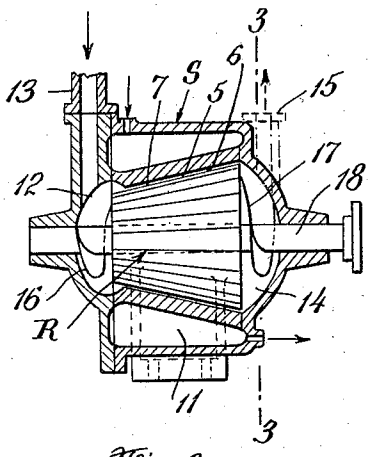


Fig. 2.

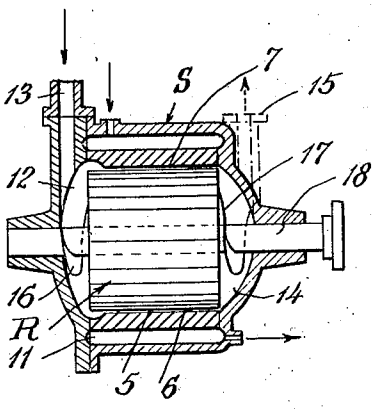


Fig. 3.

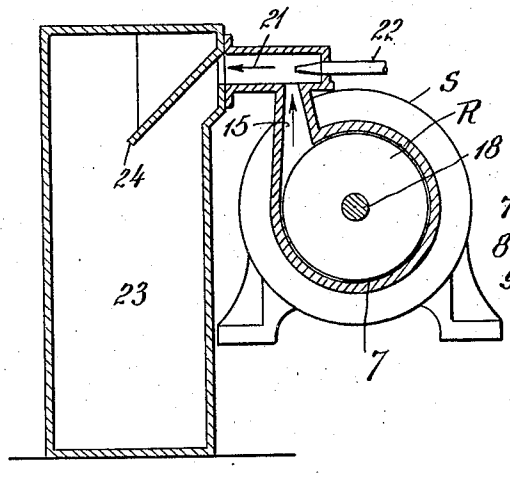
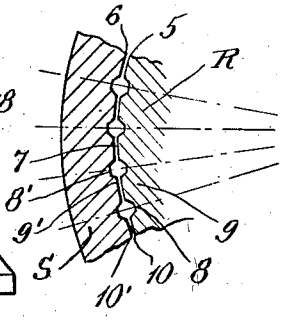


Fig. 4.



INVENTOR
Walter Ostermann
BY
Pennie, Davis, Marvin & Edmonds
ATTORNEY

Patented June 18, 1929. 1,718,184

UNITED STATES PATENT OFFICE.

WALTER OSTERMANN, OF BARMEN-LANGERFELD, GERMANY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO INDUSTRIAL SPRAY DRYING CORPORATION, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

COMMINUTING SOLID SUBSTANCES.

Original application filed May 6, 1924, Serial No. 711,390, and in Germany May 18, 1923. Divided and this application filed July 13, 1928. Serial No. 292,499.

My invention relates to the reduction of the particle size of solid materials by mechanical means, and more particularly to the reduction of such materials to a very fine powder.

Heretofore when it was desired to reduce solid substances to a particularly small particle size, as for example, that represented by the colloidal state, chemical treatment has ordinarily been resorted to. In the last few years, however, mechanical means have been devised which have made possible the reduction of the particle size of solid materials to a fineness at least closely approaching the state of colloidal solution. These "colloid" mills so called, have provided a very notable advance in the art of comminution and have opened up many new fields of industrial application.

Colloid mill operation, however, provides the finely comminuted solid only in the form of a liquid dispersion, for while the embodiments of colloid mill principles of operation have taken different forms, they all essentially involve, in addition to very high operating speed and other features, the use of a substantial quantity of a liquid vehicle, through the medium of which the intense disruptive action is applied. As a consequence of this inherent production of a liquid material, the marked effectiveness of the colloid mill in the way of fine comminution has been practically limited up to the present, to applications where a liquid dispersion of the finely comminuted solid is satisfactory.

It has been attempted heretofore, to render the highly effective comminution of the colloid mill an available medium for the production of finely comminuted solids in the dry state, but the complicated mode of treatment prescribed has served principally to materially nullify the colloid mill action, and has not satisfactorily accomplished the end sought.

In accordance with the prior method of treatment, the solid to be comminuted, carried in a substantial quantity of a liquid vehicle containing certain electrolytes designed to act as despersing agents, and, in some instances, containing protective colloids also, is introduced into a colloid mill of the crossed beater type, which embodies an eccentrically mounted rotor. The batch of liquid material is then subjected to the high-speed mill action for several hours to obtain suitable comminution of the solid. The batch operation of this type of mill is characterized, however, by a very low efficiency, for the time necessary for the comminution is quite protracted and the power consumption involved is greatly out of proportion to the quantity of materials comminuted per unit of time. Moreover, the existence of dead corners and spaces in this type of mill, as well as other objections, does not lend to uniform and thorough comminution, and the percentage of material of colloidal particle size in the liquid dispersion obtained by its action is very small, as a rule not above one percent., most of the dispersed solid being present in a coarser condition.

Thereafter, the liquid dispersion must be subjected to a centrifuging operation to effect a separation of the coarse from the fine suspended particles in the mill-treated liquid. Finally, this centrifuged suspension of the fine particles is then dried as a mass, frequently in vacuo, to eliminate the liquid vehicle.

The quantity of fine powder obtainable by such procedure is very small in proportion to the quantity of solid raw material used, and the practical inefficiency of the operation is pronounced. The caking effect of the mass drying is particularly objectionable in that it serves to greatly nullify the fine comminution secured in the mill. Furthermore, the numerous steps and prolonged period of handling involved, serve to enhance considerably the possibility of undesirably reflocculation of the finely comminuted material which is dispersed in the liquid. The very fine particles in suspension are continually being subjected to bombardment by each other—the socalled Brownian movement, and unless protective colloids or similar means are used, considerable reflocculation will rapidly take place, rendering the comminuting effect of the mill proportionately valueless. In addition, the non-uniform and incomplete comminuting action of the crossed-beater mill, as well as the subsequent centrifugal separation of the coarse particles with the attendant sweeping out of fine particles therewith, also contribute to the inefficiency of the operation and the

generally unsatisfactory nature of the results obtained.

It is an object of my invention to overcome these deficiencies of the prior art and to provide a method and apparatus for producing finely comminuted solid materials wherein the solid can be reduced to very small particle size through the medium of colloid mill action and then be obtained, in the dry state, in the form of very fine powder.

According to my invention, the solid material, while contained in a suitable liquid, is first mechanically comminuted to the desired particle size by a colloid mill action, preferably one which effects such a substantial and sufficiently uniform comminution as to obviate the necessity of using a centrifugal separator. The resulting liquid dispersion of the very finely comminuted solid is then atomized into a fine fog or mist, in sufficiently prompt sequence to the completion of the comminuting and dispersing operation as to reduce to a minimum the possibility of objectionable reflocculation and settling. The liquid dispersion is then dried while in such finely atomized form, whereby the solid material is obtained in finely comminuted dry form.

An illustrative form of apparatus embodying my invention is described in the following specification, taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a longitudinal section of a mill of my invention;

Fig. 2 is a similar section of a slightly modified form of the same;

Fig. 3 is a vertical cross-section of the combined apparatus of my invention taken along the line 3—3, Fig. 1, and

Fig. 4 is a cross-sectional detail on an enlarged scale showing the cooperating surfaces of the mill of Figs. 1 and 2.

Referring to the drawings R designates generally a rotor member and S a stator member surrounding the rotor R, which members may be of slightly frusto-conical form as shown in Fig. 1 or of cylindrical form as shown in Fig. 2. The cooperating surfaces 5 and 6 of the rotor and stator respectively are positioned in closely adjacent, but noncontacting relationship whereby a slight clearance or working gap 7 is provided therebetween, for the fine adjustment of which clearance the slightly conical construction in Fig. 1 is particularly advantageous. These surfaces 5 and 6 are provided respectively, with similar longitudinal grooves 8, 8′ which may be straight or helical and of curved or angular cross-section, and with longitudinal teeth 9, 9′ which terminate in substantially flat faces 10, 10′. Regulation of the temperature in the working gap 7 is provided for by a circumferential jacket 11 through which a suitable heating or cooling medium may be circulated.

The mill per se is the subject of my copending application, Serial No. 711,390, filed May 6th, 1924, of which this application is a division.

As shown in Figs. 1 and 2 a charging chamber 12 is disposed at the feed end of the rotor R, into which chamber the materials to be treated in the working gap 7 are introduced through a tangentially disposed inlet pipe 13, and at the other end of the rotor, a chamber 14 is provided from which the mill-treated materials are discharged through a tangentially disposed discharge pipe 15 (Fig. 3) mounted at the side of the mill opposite the tangential inlet pipe 13.

Helical members 16 and 17, mounted on the rotor shaft 18, are disposed in the chambers 12 and 14 respectively in substantially spaced relationship to the surrounding casing wall, to aid the introduction and discharge of materials into and from the mill, and the feeding may be further facilitated by extending the walls of the chamber 12 in a somewhat funnel-shaped form as shown in Figs. 1 and 2, to a point beyond the terminal face of the feed end of the rotor R.

As best shown in Fig. 3, the tangential discharge pipe 15 communicates directly with an atomizing chamber 21 into which projects a nozzle 22 for injecting into the chamber a current of hot air or other gas under suitable pressure. This atomizing chamber communicates with a drying chamber 23 of any suitable type in which a downwardly inclined baffle plate 24 is disposed in partially obstructing relationship to the communicating passage between the chambers.

The operation of my invention is substantially as follows:

The solid material to be comminuted is prepared in suitably small particle size to permit its ready introduction into the narrow working gap 7 while contained in the liquid vehicle, and is preferably thoroughly mixed with and suspended in the liquid for example water, prior to its introduction into the mill. The liquid material, i. e. the resulting mixture of solid and liquid, is then introduced through the tangential inlet pipe 13 into the chamber 12 whence it is fed into the working gap 7 between the rotor and stator.

As best indicated by Fig. 4, the cooperating surfaces 5 and 6 are of such configuration and relative arrangement that when the rotor R is rotated at the high speed characteristic of my operation, the liquid material confined in the working gap 7 is subjected while in the form of a thin liquid film to an intense film shearing action between the opposed flat faces 10, 10′ of the teeth 9, 9′, to a violent churning by the action of the cooperating grooves 8, 8′, and to an intense film beating action by the sides and edges of passing teeth 9, 9′. The effect of these actions is to produce a remarkably fine comminution and uniform dispersion of the solid material in the liquid.

The rotor R should be maintained at a speed of preferably not less than 3,000 revolutions per minute and at such higher R. P. M. as is necessary to produce the degree of comminution desired. The higher the rotor speed and the narrower the clearance between the rotor and stator the more intense is the comminuting action to which the liquid material in the very narrow working gap is subjected.

With the cylindrical form of rotor, flow of the material through the mill will be mainly induced by the action of the helical members 16 and 17 and the suction effect of the high speed gas current at the outlet of discharge pipe 15. With the conical form these flow-inducing factors will be supplemented by the pumping action induced by the increasing centrifugal force resulting from the gradual widening of the diameter of the rotor, which will tend to draw the material into and through the working gap. The impeller 16 and the expeller 17 find particularly effective application when very viscous material is being treated.

Air or other suitable gas under considerable compression and preferably hot, is injected into the atomizing chamber 21 through the nozzle 22, and the mill-treated liquid material delivered to the chamber 14 after treatment in the working gap, is rapidly discharged into the atomizing chamber through the medium of the helical expeller 17, the tangential disposition of the discharge pipe 15, and the suction created by the gas current. When the mass of liquid material proceeding from the discharge pipe 15 meets this opposing high speed current of gas, it will be violently dispersed into minute particles or droplets, and these particles will be propelled at high velocity in the direction of the drying chamber 23. Upon reaching the drying chamber the particles will be subjected to an intense impact against the baffle plate 24 disposed in their path, as a result of which they will be further shattered into more minute particles or droplets and diverted downwardly as a fine fog or mist into the drying chamber proper. These minute particles of liquid material constituting the fine mist are dried while in gaseous suspension in the drying chamber 23 and the drying gas and heat may be supplied through the medium of the atomizing gas, and or separately in the drying chamber, or otherwise as may be apparent to one skilled in the art. The fine, dry powder of the solid material which results may be separated from the gas and collected in any well known manner.

By the application of my invention a comminution results which is unattainable by prior comminuting practice, and a rapid and continuous operation is provided which presents many advantages over the prolonged and relatively ineffective batch treatment of the prior practice.

The action of the mill is particularly effective and thorough, and results in such a uniform and fine comminution and dispersion of the solid in the liquid, that no practical necessity exists for separating coarse particles by a centrifuging operation, prior to drying the suspension. This elimination of the centrifuging step avoids the loss of fine material as well as undesirable prolongation of the operating period. By subjecting the liquid mill-treated material to the continued dispersive action of the subsequent atomization, in sufficiently rapid sequence to the completion of the milling operation as to reduce to a minimum the possibility of objectionable reflocculation and settling, and drying it while in atomized form, the reflocculation factor is practically eliminated. By this mode of operation the intense comminuting effect obtainable by "colloid" mill principles of operation is thereby made practically available for the production of very finely comminuted solid material, in a dry condition and with a high percentage yield.

Moreover, by conducting the atomization and drying operation in suitably rapid sequence to the comminuting and dispersing operation in the mill, a high yield of fine powder may be obtained without the use of protective colloids or similar means as is the preferred manner of operation, a result impossible of attainment by the prior practice. If it is desired to use protective colloids and the like in the application of my novel operation, a high yield of finely comminuted, uncaked powder may be obtained, which also is impossible of production by the procedure used heretofore.

My invention is capable furthermore of widespread application. Not only is it advantageously applicable for the fine comminution of a single substance, but may be used to particular advantage for securing a homogeneous solid mixture of a plurality of finely comminuted substances, and in such other applications as will be apparent to one skilled in the art.

Obviously the solid materials which may be subjected to treatment according to my invention comprise not only strictly solid materials, but also such semi-solid and liquid materials, for example, melted solids, as are capable of being obtained in non-fluid form. This general category of substances and mixtures thereof are to be considered as coming within the scope of the term "solid" appearing in the claims.

I claim as my invention:

1. The method of producing finely comminuted solid material which comprises subjecting the solid material while carried in a film of liquid to high speed mechanical com-

minution and dispersion, whereby a fine dispersion of the solid in the liquid is obtained, atomizing the resulting liquid material, and drying the resulting dispersed liquid particles to obtain a fine powder.

2. The method of producing finely comminuted solid material which comprises mechanically comminuting and dispersing the solid material at a high speed while carried in a film of liquid, whereby a fine dispersion of the solid in the liquid is obtained, contacting the resulting liquid material with an atomizing current of gas, and drying the resulting dispersed liquid particles while suspended in drying gas.

3. The method of producing finely comminuted solid material which comprises mechanically comminuting and dispersing the solid material at a high speed while carried in a film of liquid, atomizing the resulting liquid material and imparting a high velocity to the particles so obtained, subjecting the moving particles to a further atomizing impact, and drying the particles while suspended in drying gas.

4. The method of producing finely comminuted solid material which comprises subjecting a film of liquid containing the solid material to a high speed film shearing action to obtain a dispersion of said material in finely comminuted form, then atomizing the resulting liquid material, and then drying the atomized material in gaseous suspension to obtain a fine powder.

5. The method of producing finely comminuted solid material which comprises subjecting a film of liquid containing the solid material to a high speed shearing, beating, and churning, whereby said material is finely comminuted and dispersed, then atomizing the resulting liquid material to reduce it to small particles, and then drying said particles to obtain a fine powder.

6. The method of producing finely comminuted solid material which comprises, attenuating a liquid containing the solid to be comminuted to the form of a thin film and subjecting said film while in a confined space to a high speed shearing, beating and churning action whereby a fine dispersion of the solid in the liquid is obtained, then atomizing the liquid dispersion into minute droplets in sufficently rapid sequence to the completion of the aforementioned operation to avoid material reflocculation of the dispersed solid, and drying said droplets while in gaseous suspension to obtain a fine powder of the solid material.

7. The method of producing finely comminuted solid material which comprises, subjecting the solid to be comminuted while carried in a thin film of liquid to the comminuting forces set up in a film of liquid when confined between closely adjacent, non-contacting surfaces relatively moving at very high speed, whereby a fine dispersion of the solid in the liquid is obtained, then atomizing the resulting fine liquid dispersion into minute droplets, and drying the minute droplets while in suspension to obtain a fine powder of the solid material.

8. The method of producing finely comminuted solid material which comprises subjecting a thin film of liquid containing the solid material to be comminuted, to the comminuting forces set up in a film of liquid when confined between closely adjacent, non-contacting concentric surfaces relatively rotating at very high speed, whereby a fine dispersion of the solid in the liquid is obtained, then atomizing the resulting fine liquid dispersion into minute droplets, and drying the droplets to obtain a fine powder of the solid material.

9. The method of producing finely comminuted solid material which comprises, subjecting a thin film of liquid containing the solid material to be comminuted, to the comminuting forces set up in a film of liquid when confined between closely adjacent, non-contacting concentric surfaces, each provided with alternate grooves and flat-faced teeth, and relatively rotating at very high speed, whereby a fine dispersion of the solid in the liquid is obtained, then atomizing the resulting fine liquid dispersion into minute droplets, and drying the droplets to obtain a fine powder of the solid material.

10. The method of producing finely comminuted solid material which comprises, subjecting the solid to be comminuted while contained in a thin film of liquid to the comminuting forces set up in a film of liquid when confined between closely adjacent, non-contacting surfaces relatively moving at high speed, whereby a fine dispersion of the solid in the liquid is obtained, then contacting said fine liquid dispersion with a current of gas moving at high velocity to atomize the dispersion into a fine mist, and then drying said mist with drying gas to obtain a fine powder of the solid material.

11. The method of producing finely comminuted solid material which comprises, mixing the solid to be comminuted with a substantial quantity of liquid, attenuating the liquid mixture into the form of a thin liquid film containing the solid particles and shearing, beating, and agitating said film at high speed, whereby the solid is finely comminuted and dispersed in the liquid, then atomizing said liquid dispersion into minute droplets, and drying said droplets to remove the liquid and obtain a fine powder of the solid material.

12. A method of disintegrating particles suspended in a liquid comprising, subjecting a very thin film of the liquid with the suspended particles therein to the action of closely adjacent surfaces relatively moving one past the other at high velocity, the particles being dis-

integrated by reason of the disruptive forces within the film itself, which increase with the increase of the relative velocity of the surfaces, and decrease with the increase in the thickness of the film, and atomizing the material so treated by a current of gas whereby the pressure on the material leaving the film space is also reduced.

13. A method of disintegrating particles suspended in a liquid comprising, subjecting a very thin film of the liquid with the suspended particles therein to the action of closely adjacent surfaces relatively moving one past the other at high velocity, the particles in their passage through the film being disintegrated by reason of the disruptive forces within the film itself, which increase with the increase of the relative velocity of the surfaces, and decrease with the increase in the thickness of the film, applying pressure to the liquid that is entering the film space, and atomizing the material so treated by a current of gas whereby the pressure on the material leaving the film space is also reduced.

14. A method of disintegrating particles suspended in a liquid comprising, subjecting a very thin film of the liquid with the suspended particles therein to the action of closely adjacent concentric surfaces relatively rotating one past the other at high velocity, the particles being disintegrated by reason of the disruptive forces set up within the film during the relative rotation of the confining surfaces at high velocity and atomizing the material so treated by a current of gas whereby the pressure on the material leaving the film space is also reduced.

15. An apparatus for the comminution of solid material which comprises the combination of a mill having members provided with closely adjacent, non-contacting, co-operating surfaces relatively movable at a high speed between which the solid material is subjected in a film of liquid to an intensive comminuting and dispersing action, and a dryer for receiving the liquid mill-treated material having means for dispersing said liquid material into small particles, and means for drying said particles, whereby finely comminuted solid material is obtained.

16. An apparatus for obtaining solid material in finely comminuted form which comprises the combination of a mill having members provided with closely adjacent, non-contacting, co-operating surfaces relatively movable at a high speed between which the solid material is subjected in the presence of liquid to an intensive comminuting and dispersing action, means for atomizing the mill-treated liquid material whereby continued dispersive action is secured, and a drying chamber associated with said last named means for receiving said atomized liquid material and for drying the same while in atomized form, whereby finely comminuted solid material is obtained.

17. An apparatus for the comminution of solid material which comprises the combination of a mill having members provided with closely adjacent, non-contacting concentric surfaces of revolution relatively movable at a high speed between which the solid material is subjected in a film of liquid to an intensive comminuting and dispersing action, means for discharging the mill-treated liquid material from said mill, means for directing a current of gas moving at high velocity against said discharged material whereby said material is atomized and a high velocity is imparted to the resulting particles in the direction of movement of said gas, and a drying chamber disposed in the path of said gas for receiving and drying said particles while in gaseous suspension.

18. An apparatus for treating solid material which comprises the combination of a mill having members provided with closely adjacent, non-contacting, cooperating surfaces relatively movable at a high speed between which the solid material is subjected in a film of liquid to an intensive comminuting and dispersing action, a discharge pipe for said mill, an atomizing chamber associated with said mill in which said discharge pipe terminates, means for passing a high speed current of gas through said chamber, means for causing the liquid mill-treated material to flow through said discharge pipe and into the path of the gas in said chamber, whereby the mill-treated material is atomized by said gas and propelled co-currently therewith, and a drying chamber associated with said atomizing chamber for receiving the atomized particles and said gas wherein the particles are dried while in gaseous suspension.

19. An apparatus for the production of a finely comminuted, homogeneous mixture of a plurality of solid substances which comprises the combination of a mill having members provided with closely adjacent, non-contacting, cooperating faces adapted to jointly contact with an extensive surface of a film of liquid confined therebetween containing the substances to be treated, said members being adapted to move relatively at very high velocity so that the particles of the liquid material so confined are subjected to intensive comminuting and dispersing action; and a drying chamber associated with said mill, means for supplying a drying gas to said chamber, means for atomizing said mill-treated liquid material to disperse the same into a fine mist, and means for continuously introducing said mist into the drying chamber to subject said mist to the action of said drying gas, whereby the droplets constituting the mist are dried

while in said gaseous suspension and a finely comminuted, homogeneous mixture of the solid substances is obtained.

20. An apparatus for the fine comminution of solid material which comprises, means for subjecting a film of liquid containing the solid material to a high speed film shearing, beating and agitating, whereby a fine dispersion of the solid in the liquid is obtained, means for atomizing said liquid dispersion into minute droplets, and means for drying said droplets to obtain a fine powder of the solid material.

21. An apparatus for the fine comminution of solid material which comprises, means for attenuating to a film a liquid containing the solid to be comminuted and shearing, beating and agitating said film containing the solid at a high speed, whereby a fine dispersion of the solid in the liquid is obtained, means for atomizing said liquid dispersion into minute droplets, and means for drying said droplets while in gaseous suspension to obtain a fine powder of the solid material.

22. An apparatus for the fine comminution of solid material which comprises a generally cylindrical stator surface having alternate grooves and flat-faced teeth extending generally longitudinally thereof, a generally cylindrical rotor surface rotatable at high speed disposed in closely adjacent, non-contacting, concentric relationship with said stator surface and having similar grooves and teeth, means for introducing a liquid containing the solid material to be comminuted into the narrow gap between said surfaces wherein the solid material is finely comminuted and dispersed in the film of liquid by forces set up upon and in the film by the high speed rotation of said rotor, means for atomizing the liquid mill-treated material into minute droplets, means for conveying the mill-treated material to said atomizing means, and means for drying said droplets while in gaseous suspension to obtain a fine powder of the solid material.

23. An apparatus for the fine comminution of solid material which comprises, a mill having a pair of closely adjacent, non-contacting, cooperating surfaces, each provided with alternate teeth and grooves, and relatively movable at high speed, between which surfaces the solid material is subjected in a film of liquid to an intensive comminuting and dispersing action, means for atomizing the liquid mill-treated material into minute droplets, and means for drying said droplets to obtain a fine powder of the solid material.

24. An apparatus for the fine comminution of solid material which comprises, a mill having a frusto-conical stator surface provided with alternating shallow grooves and flat-faced teeth extending longitudinally thereof, a frusto-conical rotor surface rotatable at high speed and provided with similar teeth and grooves, disposed in closely adjacent, non-contacting, concentric relationship with said stator surface, means for conducting a liquid containing the solid to be comminuted into the narrow gap between said surfaces wherein the particles of solid are subjected while in a film of liquid to an intensive comminuting and dispersing action, means for atomizing the liquid dispersion so obtained into minute droplets, means for conducting the dispersion to said atomizing means, and a driving chamber provided with hot drying gas for receiving the atomized dispersion and drying the droplets while suspended in said gas to obtain a fine powder of the solid material.

25. In an apparatus for the fine comminution of solid material, the combination which comprises, a mill having cooperating, comminuting surfaces relatively movable at high velocity, between which the solid material is finely comminuted and dispersed while contained in a film of liquid, an atomizing chamber connected with said mill for the reception of mill-treated liquid dispersion, means for passing a high-speed current of drying gas through said chamber, means for conducting said liquid dispersion into the path of said gas whereby the dispersion is atomized and propelled co-currently with said gas, and a drying chamber for receiving the gas carrying the atomized dispersion and drying the same while in suspension to obtain a fine powder of the solid material.

In testimony whereof I affix my signature.

WALTER OSTERMANN.