United States Patent [19]

Ruzicka

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[45] **March 6, 1973**

[54] **ULTRADISINTEGRATION AND AGGLOMERATION OF MINERALS SUCH AS MICA, PRODUCTS THEREFROM AND APPARATUS THEREFOR**

[76] Inventor: **Josef Ruzicka,** 55-25 98th Place, Rego Park, N.Y. 11368

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[21] Appl. No.: **61,518**

Related U.S. Application Data

[62] Division of Ser. No. 650,543, June 30, 1967, Pat. No. 3,608,835.

[52] **U.S. Cl.** **241/4,** 241/5, 241/47, 241/57

[51] **Int. Cl.**.....**B02c 19/00**

[58] **Field of Search**.....241/4, 5, 18, 19, 23, 47, 48, 241/57

[56] **References Cited**

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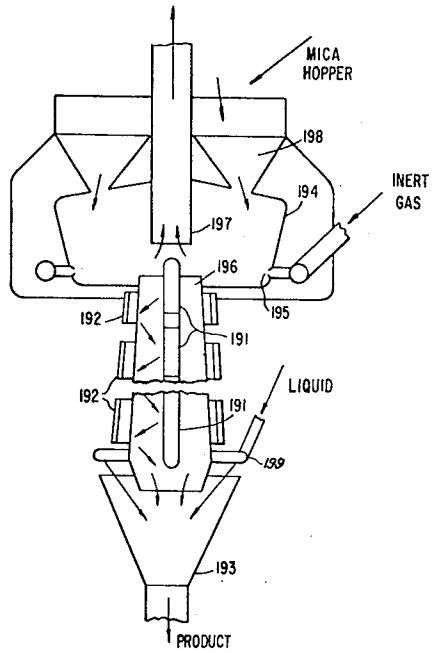
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Primary Examiner—Granville Y. Custer, Jr.
Attorney—Burns, Doane, Swecker & Mathis

[57] **ABSTRACT**

Frangible or cleavable solids, such as mica, are disintegrated in oriented, high-velocity streams of a fluid medium so as to produce thin smooth-surfaced particles or flakes having a high specific surface area and a high ratio of length to thickness. The resulting particles or flakes are useful as agglomerants, fillers or pigments or can be agglomerated to form paper-like webs or solid discs or articles of other predetermined configurations, with or without added binder, either in self-supporting form or adhered to a substrate. Various methods and apparatus for such disintegration are disclosed.

9 Claims, 10 Drawing Figures



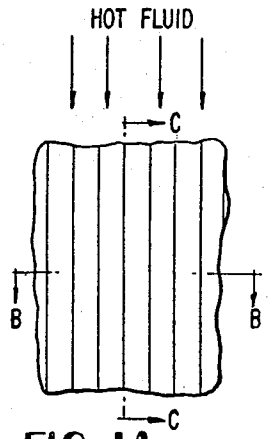


FIG. 1A

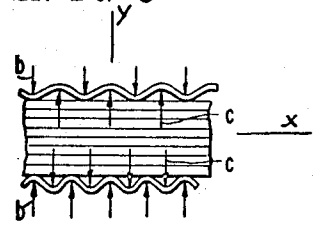


FIG. 1B

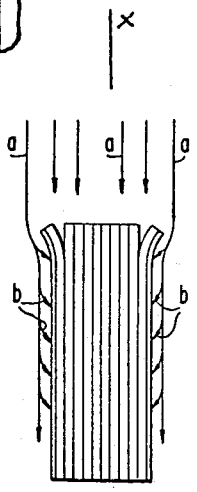


FIG. 1C

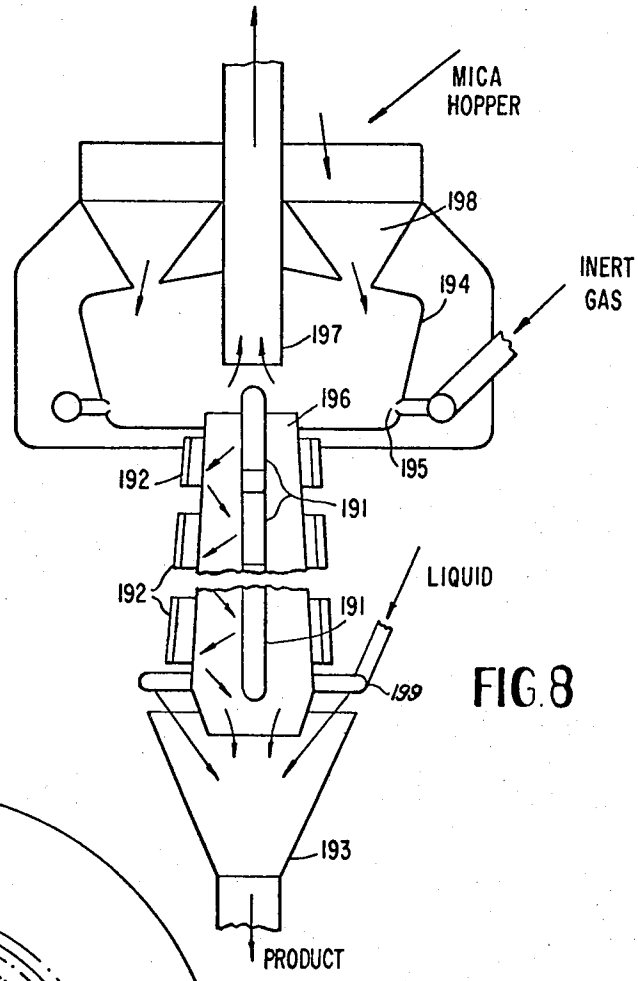


FIG. 8

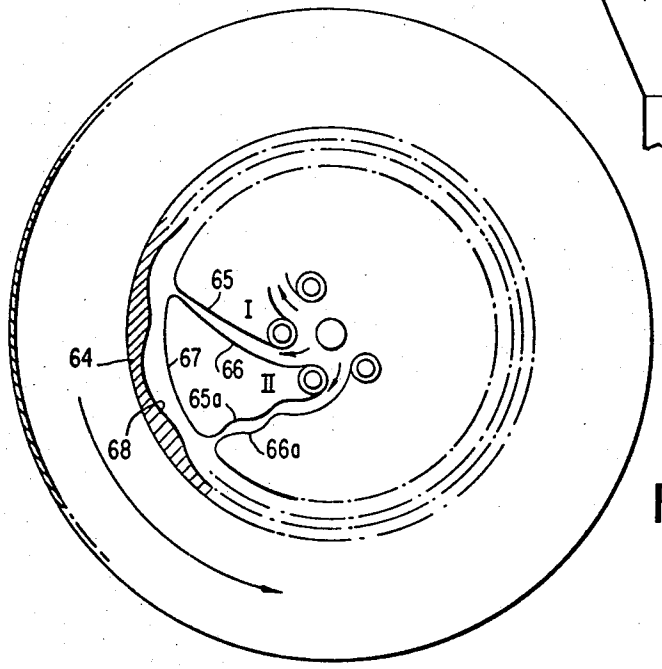


FIG. 3

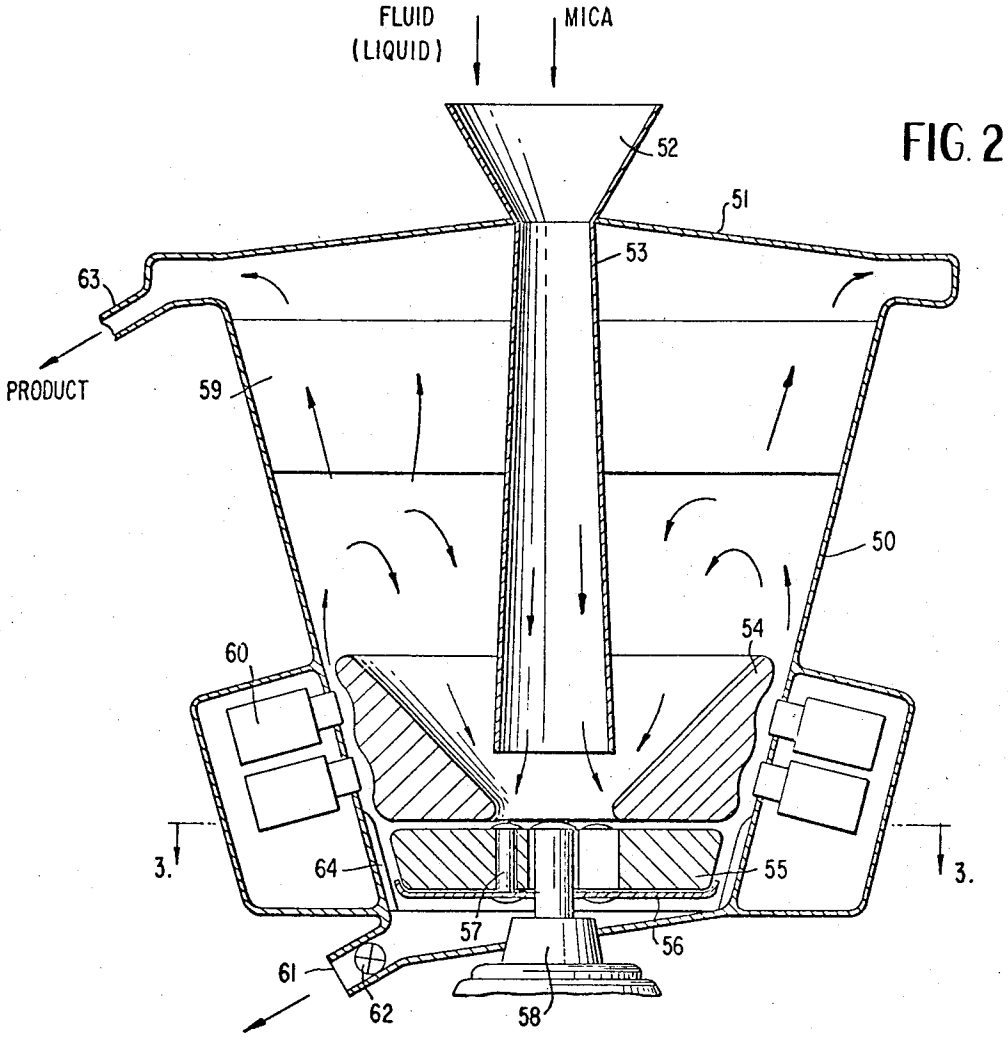

FLUID
(LIQUID)
MICA
52
51
53
63
PRODUCT
59
50
54
60
3.
64
55
3.
57
56
61
62
58

FIG. 2

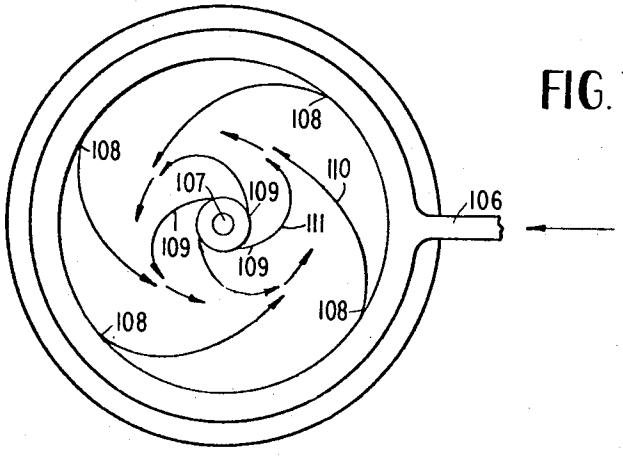
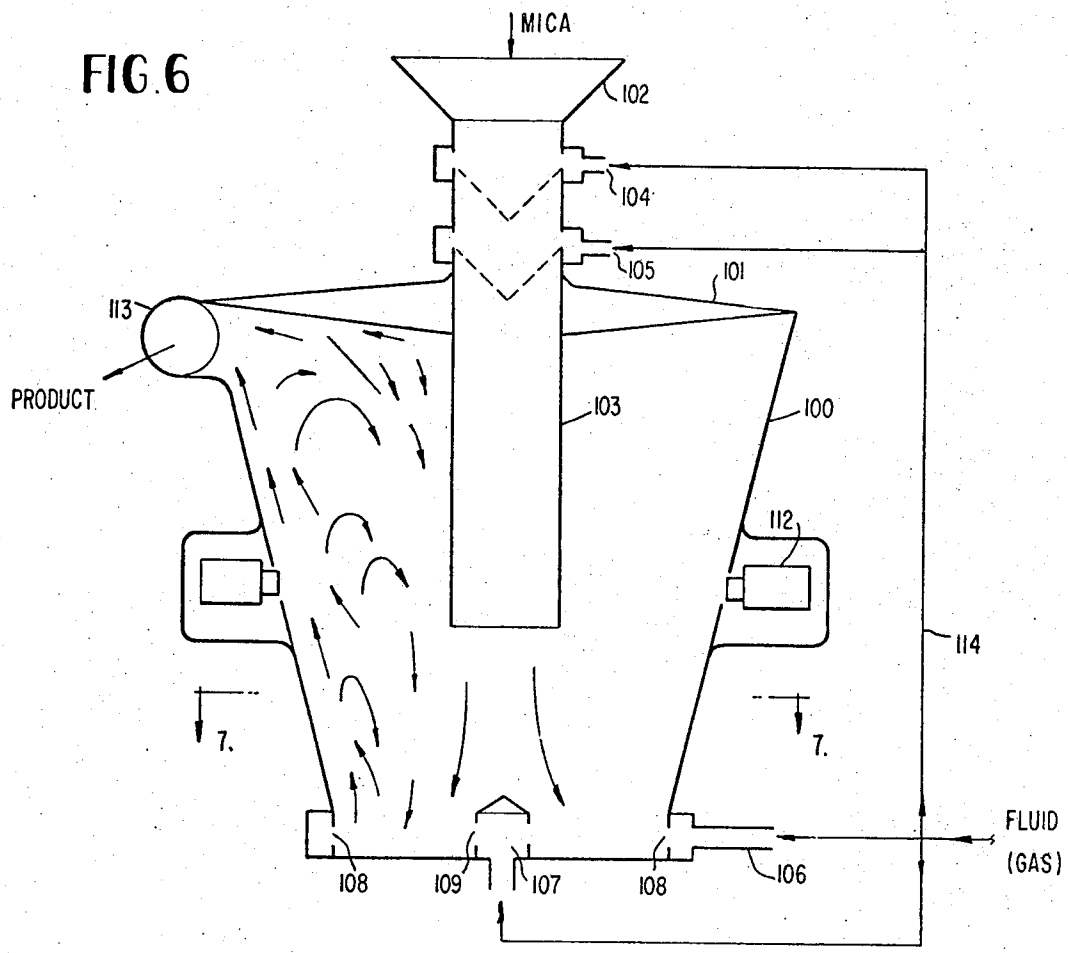

108
108
110
107
109
106
111
109
109
108
108

FIG. 7

FIG. 6



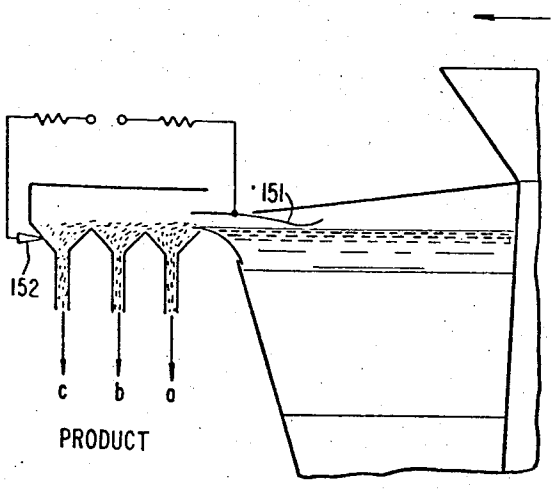


FIG. 4

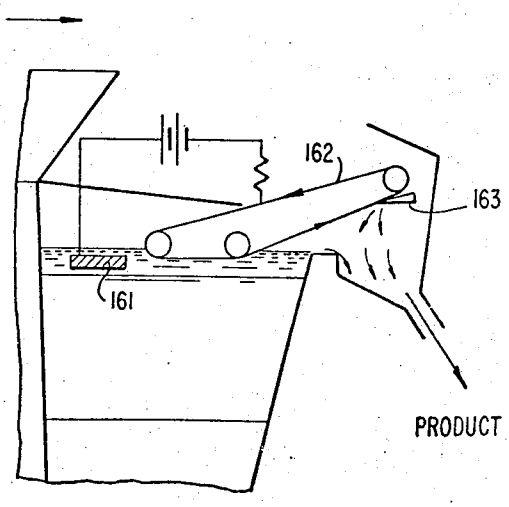


FIG. 5

ULTRADISINTEGRATION AND AGGLOMERATION OF MINERALS SUCH AS MICA, PRODUCTS THEREFROM AND APPARATUS THEREFOR

This is a division of application Ser. No. 650,543, filed June 30, 1967 now U.S. Pat. No. 3,608,835.

This invention relates to the disintegration of frangible solids into ultrafine particles, to apparatus for carrying out such operations, and to various products obtained thereby. More particularly the invention relates to the oriented disintegration of a mineral such as mica into a multiplicity of fluidly suspended ultrathin particles or flakes. Related inventions are disclosed and claimed in U.S. Pat. No. 3,608,835 of which this case is a division and the complete disclosure of which is hereby incorporated in the present specification by reference.

This invention generally is concerned with the splitting of easily splittable or cleavable materials to form fine particles, and especially the cleavage of minerals such as mica into small, thin flakes or scales which have active surfaces and which fall predominately within a relatively narrow size range. The resulting products include mica particles characterized by an unusually high ratio of surface to thickness.

The disintegrating or splitting equipment is intended primarily for the splitting of mica but is also highly effective in splitting other materials, especially minerals, which liberate molecularly bound water or water of crystallization upon heating.

The aforementioned materials can be used in many different ways. For instance, the free particles or unoriented, easily redispersible agglomerates of such particles are useful as pigments and fillers for paints or other coating compositions, for resinous plastics, for elastomeric compositions; or as adsorbents or carriers for other materials, etc. In the form of oriented agglomerates they are useful as insulators or coatings in electrical equipment, as construction materials, etc.

BACKGROUND OF INVENTION

Mica forms a group of silicates, which are minerals characterized by their highly pronounced ability of being cleaved along their basic crystalline plane while being substantially less susceptible to cleavage along the crystalline plane which is substantially perpendicular to the first plane, and being still less susceptible to cleavage along any other plane. Consequently, this type of mineral has crystalographically a plate-like structure which is highly flexible, resilient and strong and can be divided and subdivided into very thin flakes or scales.

Mica as a mineral is found in nature in various crystalline sizes, large sizes being quite rare, and in various chemical compositions such as muscovite, phlogopite, biotite, etc. Because of its excellent dielectric and mechanical properties, chemical stability and resistance to high temperature, mica is used for various industrial purposes, the highest grades of mica being used principally in the electrical industry as an insulating material. Its properties and usefulness however, differ substantially not only depending on its basic type but even in a given type the properties depend on the exact chemical composition. The chemical composition of natural mica differs substantially, sometimes even within a single crystal. Yet the exact chemical composition determines the thermal resistance of individual mica crystals and when the critical dehydration temperature of a given piece of mica is exceeded, usually above 500° C., the mica becomes dehydrated and swells up and disintegrates depending on temperature and duration of heating. Synthetic mica has similar characteristics and properties.

PRIOR ART

Natural and synthetic mica crystals are relatively small while modern industrial requirements point increasingly toward large surfaces. For this reason the efforts in the art have increasingly been toward splitting mica into flakes of ever smaller thickness and reintegrating these thin flakes with the aid of binders into coherent sheets or leaves of large surface area. However, prior methods for making products of large surface area from mica particles having a thickness on the order of a few hundredths of a millimeter, e.g., 0.010 to 0.030 mm, have proved to be very laborious, the utilization of the mica is relatively low and the resulting products are quite non-uniform as well as expensive. Moreover, they lack any adhesive surface forces.

Methods of making sheets of large surface area from mica particles having a thickness on the order of less than 0.01 mm, e.g., about 0.002 to 0.008 mm, have been known for more than 50 years. However, poor physical and especially mechanical properties of the resulting products have prevented them from becoming commercially important. More recent methods such as those described in Heyman in U.S. Pat. No. 2,405,576 or by Bardet in U.S. Pat. No. 2,549,880 have achieved a certain degree of commercial significance particularly because the mechanical properties of the resulting products are better than those of earlier products. However, though these processes are now more than 20 years old they have never achieved wide use. They have only partially succeeded in replacing the older methods which resulted in particles having a thickness greater than 0.01 mm, because their physical and especially their mechanical and dielectric properties still leave much to be desired, their processing is difficult, the utilization of the mica raw material is small, and the operating costs are high.

Even when mica particles are to be used as pigments or fillers the trend in the art to require particles of ever smaller thickness, that is, particles having the greatest possible surface area per unit weight. However, in requiring this there is also often the further requirement that the particles should not exceed a specified maximum dimension and should fall within a rather narrow particle size range. On the other hand, especially in the case of particles having a small diameter, such as 1 micron or less, the art has heretofore been unable to obtain high yields of particles falling within a predetermined narrow size range. The previously known mica particles at best had only very weak adhesive surface forces.

OBJECTS

It is accordingly an object of this invention to prepare fine solid particles such as mica flakes having a high specific surface area and other new or improved properties which make such particles particularly valuable as agglomerants or pigments and also in the production of aggregated products. A still further ob-

ject is to provide new or improved methods and apparatus for oriented cleavage of mica principally along its main plane of crystallization and secondly along one further plane of crystallization while limiting the cleavage or splitting along any other planes, so as to facilitate the production of particles or flakes having a large specific surface area and a geometrically elongated configuration with predominantly submicron thickness, on the order of a few tenths or even thousandths of 1 micron or less, permitting the segregation of flakes having specified geometric dimensions, wherein the invention permits recycling of insufficiently disintegrated mica pieces to be spit further until particles or flakes having the specified dimensions are produced.

A further object is to provide methods and apparatus for preparing and maintaining a fluid suspension of the fine mica flakes, to be subsequently converted either into an agglomerate or into free flowing particles to be used as a pigment or the like.

A still further and particular object is to provide apparatus and methods for producing improved mica paper or other structures either solely from the fine mica flakes or from a mixture of such flakes with other conventionally used auxiliary materials such as binders, fillers and so forth, particularly mica papers less than 20 microns thick.

THE DRAWINGS

In the drawings

FIGS. 1A, 1B and 1C are three views showing a piece of mica being split along its "*x*" and "*y*" axes into thin flakes or plates by the simultaneous action of heat and a high velocity stream of a fluid medium.

FIG. 2 is a view in vertical section of one embodiment of the apparatus for disintegrating materials such as mica using a liquid suspension medium, as more fully disclosed and claimed in U.S. Pat. No. 3,608,835 of which the present case is a division.

FIG. 3 is a plan view of the apparatus shown in FIG. 2, taken along line 3—3.

FIG. 4 is a partial view in vertical section of a variation of the apparatus shown in FIG. 2, as more fully disclosed and claimed in U.S. Pat. No. 3,608,835, of which the present case is a division, wherein product particles are removed from the disintegration chamber via a wide spout by electrostatic means, liquid overflow is absent or very small, and the particles are classified into different fractions according to size.

FIG. 5 is a partial view in vertical section of still another variation of the apparatus shown in FIG. 2, as more fully disclosed and claimed in U.S. Pat. No. 3,608,835, of which the present case is a division, wherein product particles are removed from the disintegration chamber by electrophoresis, employing a moving belt which serves as an electrode to which the product particles adhere and from which they are removed by scraping.

FIG. 6 is a view in vertical section of an embodiment of the apparatus suitable for disintegrating materials such as mica in accordance with the present invention, preferred for use with a hot gaseous suspension medium.

FIG. 7 is a plane view of the apparatus shown in FIG. 6, taken along line 7—7.

FIG. 8 is a view in vertical section of a variation of the apparatus shown in FIG. 6, employing a less complex jet system and downward withdrawal of product with the aid of an electrostatic precipitator.

PIGMENTS, FILLERS AND ACTIVE AGGLOMERANTS

The term "pigment" refers here to finely divided solids intended for addition to paints, other liquid coating compositions, glazes and the like while the term "filler" refers to finely divided solids intended for addition to molding resins, powders, pastes, elastomeric mixtures, graphite compositions, insulating compositions, papers as well as layers of free flowing solids such as layers intended for use as thermal or acoustic insulators. The term "agglomerant" refers here to fine mica particles with active surfaces or adsorptive capacities which make them suitable as carriers for active substances such as insecticides or herbicides, or as components of filtration media, or as carriers for pigments or other colorants or for materials such as silver or titanium dioxide powder or the like to make semi-conductive products therefrom. Depending on requirements, the new flakes have a very much higher specific surface area than similar products made previously, i.e., a surface area in excess of 7 m^2/g, e.g., from above 7 to 700 or even 2,500 m^2/g with certain kinds of mica. The maximum dimension of the new thin mica flakes or particles can be predetermined in accordance with requirements and depending on the desired specific surface area may be of the order of 1 or more millimeters, tenths or hundreds of a millimeter and for special purposes may be of the order of 1 or more microns, tenths, hundredths or even thousandths of microns, especially in pre-selected narrow size ranges falling within the overall range between 30 millimeters down to 2 millimicrons. For instance, the product desirably will consist predominantly of particles having a high ratio of length to thickness, of the order of from 1,000/1 to as much as 5 million/1.

Pigments, fillers and agglomerants made in accordance with this invention make possible new applications and new methods of utilization which were not previously possible, because the characteristics of the new particles are of a fundamentally new kind in the physical sense such that, for instance, the finely divided particles when dispersed in an appropriate fluid behave like colloids, have a surprising ability to adsorb particles of other materials on their surfaces, conform tightly to substrates of various configurations without breaking, etc.

PROCESS OF INVENTION

Step A — Preparation of Raw Material

All available forms of mica, natural or synthetic, may be used in the present invention. The raw mica is cleaned in any conventional manner to remove organic matter, dirt and foreign mineral, preferably to obtain a feed of at least 90 percent purity. One of the important advantages of the present invention is that it permits simultaneous processing of mixtures of mica crystals differing from each other in chemical composition and having a wide particle size range, i.e., mixtures of large and small pieces.

Step B — Cleavage or Delamination

The method of effecting selectively oriented cleavage of mica in accordance with the present invention is illustrated in FIGS. 1A, 1B and 1C. Sudden local temperature effects are indicted by arrows *c* in FIG. 1B while the effects of the high velocity and high frequency fluid stream are indicated by arrows *a* and *b* in FIGS. 1B and 1C, and these bring about perfect cleavage of the mica predominately in two directions. i.e., primarily along the plane of lowest cohesion (the basic plane) and further along the plane having the next lowest cohesion which substantially is perpendicular to the first plane. The effects in other directions are not greatly developed and are suppressed by the elasticity of the mica and are therefore so weak that predominantly they do not reach values necessary for disrupting the mechanical cohesion of the mica in any further, less easily splittable directions.

According to this method the continually fed pieces of mica (FIG. 1A) are exposed to the necessary mechanical, delamination forces, or combination of mechanical and thermal forces, in one or more splitting chambers which are arranged in series or in parallel. The forces, at temperatures between as low as about 100° C. and up to about 1,350° C., act on the large pieces of feed material for periods which depending on individual particle size may range from a fraction of a second to a few minutes within a fluid, and preferably inert, medium. The forces cause splitting of the mica predominately in the direction of two planes, by the pulsating, vibrating and accelerating or decelerating streams of the medium which whirl in a distinctly oriented manner and which cause delamination predominantly progressively from the surface of the mica inward as indicated in FIGS. 1B and 1C until the original pieces are delaminated to the desired extent. For some kinds of mica and some kinds of end use the method may be performed in a single chamber whereas in other cases the splitting may be effected in a plurality of like or different splitters, e.g., first at ambient temperature in a liquid medium and then at elevated temperature in a gaseous medium. This method may of course be modified in that, for instance, the pieces of mica being fed to the splitter may be preheated or thermally pretreated prior to introduction into the slitter chamber, preferably in an inert or protective fluid such as argon or hydrogen.

The resulting flaked or disintegrated products having active surfaces (i.e., an adsorptive surface), which they obtain by virtue of their predetermined geometric dimensions, are immediately and continuously separated and transferred to the next step. In some cases one may add binders or other additives such as organic or inorganic fibers, platelets and the like in order to distribute them uniformly in the eventual product.

In making pigments, fillers and agglomerants rather than predominantly two-dimensional flakes, it is necessary to split the mica as much as possible not only along the first and the second splitting or fissioning planes in order to obtain the greatest possible specific surface area, but also to further split to mica to form an ultrafine particle size.

The ultimate size may be specified in terms of the maximum permissible dimension or diameter or better in terms of the permissible particle size range, e.g., 10 to 30 microns, or 0.1 to 1 micron, etc. Consequently, the splitting method is oriented for splitting according to all planes of fission and for producing the smallest particle size possible it can utilize further effects of the high velocity of the splitting medium, 100 meters per second or more, and high frequency waves (20 kilocycles per second or more) and the acceleration and deceleration of the particles and the consequent cavitations. The method can be still more effective when the splitting medium enters into the reaction chamber intermittently and thus produces pulsations. The apparatus illustrated in FIGS. 6 to 8 are equipped with devices for the production of the aforementioned effects, such that pigments, fillers or agglomerants of various sizes and ratios of length or particle size to thickness may be produced by adjustment of the appropriate variable or variables, e.g., by increasing the velocity of the fluid medium, by increasing the number of operating jets, etc.

Step C — Preparation of Fluid Suspension

The mica particles having active surfaces are kept in or conducted to and maintained in a fluid suspension in the previously present or in a different protective medium. Various combinations of gaseous or fluid media are possible depending principally on the requirements of subsequent utilization. It is possible to make intermediate products in a continuous manner and to concentrate the suspension and only adjust the consistency or concentration of the suspension prior to the next processing step and depending on the requirements of the latter. The maintenance of these particles as a suspension is advantageously effected with the stream of the aforesaid medium, and only by mechanical means, but in some cases it may be useful to employ additionally the effect of an electrical field (FIG. 8).

The suspension of particles of the proper concentration can then be continuously or intermittently added to an appropriate agglomerating step or it can be added directly to some other finishing step as hereafter described.

Referring to FIGS. 6 and 7, this embodiment likewise comprises an axially symmetrical splitting chamber having, preferably, a vertical axis and the shape of an inverted truncated cone **100** wherein mica is circulated and recirculated in a gaseous medium under conditions causing cleavage of the mica raw material into particles or flakes of the desired size. While a gaseous medium is preferred for use in this device a liquid medium can also be used. Operating temperature is preferably above the temperature at which bound water is released from the mica, usually about 800° C. As operating conditions normally are such that the injected fluid medium and the mica feed are not in thermal equilibrium, the gas injected into the process is at a substantially higher temperature than the temperature to which the mica is to be heated. However, the device can also be operated at temperatures below that at which water is released from the mica and may be operated even at ambient temperature or with refrigeration.

The conical vessel **100** is provided with a lid **101** which has a funnel **102** attached in its central portion for supplying the mica raw material to the splitter through tube **103**. In this tube or chimney are fluid dis-

tributors **104** and **105** through which the fluid medium or gas is introduced to provide a protective curtain across tube **103** such that the mica raw material can pass down into the splitter chamber **100** and, if desired, be thus preheated in tube **103** while excluding the ambient atmosphere, as is more fully described further below. In the lower part of the chamber there are arranged fluid distributors or manifolds, manifold **106** being arranged at the circumference while manifold **107** is arranged substantially coincident with the axis of the vessel. Both manifolds have spaced on their respective circumferences jet nozzles **108** and **109**, each having a vertically elongated discharge orifice. These orifices or slits are spaced at regular intervals along the periphery of each distributor in any convenient number, ranging from a single orifice in a small unit to a score or more in large units.

The orifices are arranged so that the fluid medium ejected therefrom forms laminar or planar streams **110** and **111** as shown in FIG. **7**. Fixed to the wall of vessel **100** are devices **112** for the production of sonic or ultrasonic vibrations. In the upper portion of the reaction chamber there is a collector and exit duct **113** for the properly comminuted product. The feeding and distribution of the fluid medium is schematically shown at **114**. Individual portions of this device may of course be formed from a variety of structural materials such as abrasion resistant steel or other metal, or synthetic resins and so forth.

Relatively coarse pieces or fragments of cleaned mica are continuously added to funnel **102**. As long as the pieces are small enough to pass through the feed mechanism, they may be of any size and shape. They pass through fluid distributors **104** and **105** which preferably are formed of the same fluid medium which is used in the main splitting operation. These fluid distributors serve to exclude the ambient atmosphere and can be used simultaneously to preheat the incoming mica and sometimes even to cause some initial swelling of the mica.

The mica thus freed of the ambient atmosphere passes by gravity into the main portion of the reaction chamber, aided by the pressure of the fluid medium issuing from the distributors and by aspirating effect of the fluid medium being jetted from distributors **106** and **107**. Here the mica is split by the action of the high velocity, laminar, preferably flat streams of fluid medium, which for instance, may be jetted from the orifices, e.g., at a velocity of from 5 to 200 m/sec. The cleavage again proceeds primarily from the surface of the mica particles inward as previously described in connection with FIG. **1**.

The split particles of mica are carried upward by the tangential and spiral movement of the fluid medium but particles which have not reached the required degree of comminution return through the central portion of the chamber back into the active splitting zone. Depending on requirements, sonic or ultrasonic vibrators producing vibrations in the range, for instance, from about 20 kc to 10 Mc/sec. may also be brought into action to further increase the effectiveness of the splitting operation by the resulting high vibrations. The particles which have reached the required dimensions rise rapidly toward the collection zone **113** and are rapidly removed from there. Depending on further requirements, the product may be sorted into different size fractions upon removal from the splitting chamber.

For instance, the particles may be classified in the gaseous fluid electrostatically in an electric field. To accomplish this, the individual particles are polarized by induction and the resulting dipoles, which are acted upon by the force of the inhomogeneous electric field, then move in this field in the direction of the greater electrical polar strength, in a manner generally analogous to that illustrated in FIG. **4** of said U.S. Pat. No. 3,608,835.

Briefly stated, the apparatus for such an operation may comprise two mutually opposed electrodes between which an electric field is formed having a high concentration of electromagnetic lines. Between these electrodes it is convenient to arrange a series of chambers or bins to catch particles of progressively smaller size. One of the electrodes then serves to catch the total mica product where it falls from duct **113** (FIG. **6**) but the particles then become attracted by the other, collecting electrode. Because in flying from the first electrode to the collecting electrode the mica particles are exposed to the force of gravity and both electrodes are spaced a substantial distance apart, all particles do not reach the collecting electrode. The heaviest particles collect in the chamber nearest to the first electrode, the next lighter particles collect in the next chamber and the lighest particles collect in the chamber nearest the collecting electrode. To avoid particles from being held on the collecting electrode an insulating wall or shield is preferably placed in front of it to deflect the particles.

EXAMPLES

Example 1

Cleaned pieces of muscovite waste are placed in funnel **102** shown in FIG. **6** from where they are progressively fed into reaction chamber **100**. In this chamber they are split predominantly and progressively from the surface into elementary structural flakes in inert argon gas which is injected into the chamber through orifices **108** and **109** at a velocity of 10 meters per second at a temperature of 1,100° C. In this operation the particles are continually sorted out from the process as soon as they reach a specific surface area of about **10** m^2/g which occurs within a matter of seconds. The recovered particles are then conducted into distilled water, thereby cooled and the particles in aqueous suspension then separated by a device of the kind shown in U.S. Pat. No. 3,608,835 in FIG. **15** into three fractions characterized by different average particle sizes or specific surface area. More specifically, fractions having average specific surface areas about 10 m^2/g, about 15 m^2/g and about 20 m^2/g are thus obtained.

Fraction **1**, comprising mica particles having an average specific surface area of about 20 m^2/g, may then be conducted as a 1 percent aqueous suspension into a work chamber where the particles are deposited by electrophoresis within an electric field at a voltage of from about 200 to 1,000 volts between a pair of spaced electrodes within a few seconds. A sheet having a uniform thickness of about 5 microns can thus be formed. The resulting wet sheet including the support-

ing band is then further pressed and dried and the dried sheet is then removed from the band. The finished product may impregnated with a benzene solution of polystyrene resin in a proportion of 15 parts by weight of resin per 100 parts of mica and pressed between two plates under a pressure of 200 kg/cm² at a temperature of 180° C. The resulting mica plate is then cut by stamping into appropriately shaped products such as small circular plates suitable for use as capacitors.

Fraction 2, which is an aqueous suspension containing 0.5 percent by weight of mica flakes having a specific surface area of 15 m²/g, may be conducted into the front working portion of appropriate sheet making equipment. Here the mica particles in suspension may be coated with a curable epoxy resin binder in a proportion of 5 parts of binder per 100 parts of mica by mixing into the suspension with vigorous agitation an acetone solution of the binder which thus forms an emulsion. When the resulting mixture is filtered to form a raw sheet containing 35 percent by weight of water, it can be formed into an infinite belt 15 microns thick and 2.1 m wide. This wet mica belt is then dried.

Example 2

Cleaned particles of muscovite waste are continuously added to the funnel of the apparatus shown in FIG. 6 from where they are charged to the splitting chamber. Here they are continually split into fine flakes in an inert medium such as argon jetted from the six jets at a velocity of 12 m/sec. at a temperature of 1,030° C.

In this case the particles are continuously sorted out from the process when they reach a specific surface area of 30 m²/g.

Example 3

Mica plates made according to Example 2 and having a specific surface area of 30 m²/g. are loosely charged into the space between two metal walls of an electric furnace spaced 20 mm apart. The resulting layer, though only 20 mm thick, forms excellent thermal and acoustic insulation.

Example 4

Pieces of muscovite are continuously fed into the equipment illustrated in FIG. 8 where they are cleaved into very thin particles which are immediately and continuously sorted out from the process by the circulation of the fluid medium. The medium in this case is argon gas which is jetted from flat oriented jets into the bottom portion of chamber 194 at a velocity of 120 m/sec. This gas is fed into the process at a temperature of 1,150° C. such as to raise the temperature of the mica in the treating chamber to about 890° c.

A very high degree of cleavage is obtained in this case by the simultaneous effects of the high velocity fluid streams and the elevated temperature which causes dehydration and swelling of the mica. The cleavage may be further promoted by the use of ultrasonic devices (not shown) attached to the chamber and vibrating at a frequency of about 800 kc/sec.

Fine particles having a specific surface greater than 30 m²/g. and up to 1,000 m²/g. or more are removed from the process via downpipe 196 with the aid of electrostatic effects resulting from the imposition of an electric field between electrodes 191 and 192. If an aqueous suspension of mica particles is needed, water may be sprayed into the lower portion of downpipe 196. The product particles can be classified into a plurality of different size fractions by otherwise well-known means, or more particularly, by means such as those shown in FIGS. 4 or 5.

The new mica products described herein are substantially better in terms of their mechanical, electrical and other physical properties, than similar mica products heretofore available, generally several times better, such that in effect new classes of mica products having new types of utility are now made available. The advantages are particularly apparent in fabricated products made from the new basic material, i.e., the ultrafine mica flakes. For instance, because of the extremely small thickness of the new mica flakes, it now becomes possible to make self-supporting coherent mica webs, coatings and laminates only a few microns thick.

The key pieces of equipment designed in accordance with this invention have large capacity and relatively small dimensions, such that as much as 10 times more production can be obtained from a given plant area than heretofore. Moreover, the disintegration or cleavage technique of this invention is unusually advantageous in that it permits the simultaneous utilization of different kinds of mica such as muscovite and phlogopite, it also permits the use of a mica feed containing a wide range of particle sizes, and in all of this it makes possible essentially 100 percent conversion of the feed material into desired products.

The methods and apparatus of the invention further make it possible to make combination products from mica and various other materials such as glass fibers or platelets, fibers of asbestos, silica, cellulose or synthetic fiber forming resins, glass cloth, binders, foils of synthetic resins or metals, etc. Because of their high surface area, the novel mica particles themselves offer unusual advantages as pigments, fillers and also as carriers for other pigments and for physiologically active substances and catalytic substances. Because of the extremely small thickness, coatings or compositions made from these new mica particles have far superior barrier effects, novel decorative effects, etc.

As compared with similar products known previously, the ultradelaminated flakes made in accordance with this invention are such that they fall into a quite different and new physical field and are therefore governed by different physical laws than the earlier products. One of the predominant characteristics of the new particles is that they behave like colloids in a suitable liquid medium. Their sedimentation times are extremely long, such that they can be used in processes where the coarser, previously available particles were useless or gave poor results.

In addition to the aforementioned product properties, important advantages are obtained in that certain features of the present invention permit a very high degree of flexibility of the process, permitting the economical use of different types of splitters in parallel or in series depending on types of products required, and high production capacity per unit area. For instance, high rates of continuous production of mica paper can be achieved, several hundred meters per

minute, whereas previously known methods are difficult to operate at rates of more than a few meters per minute and impossible to operate at rates approaching a hundred meters per minute.

It should be understood that the foregoing general description and specific examples have been given primarily for purposes of illustration and that numerous variations and modifications thereof are possible without departing from the scope or spirit of the disclosed invention. It should also be understood that, in the absence of indications to the contrary, all percentages and proportions of materials are expressed in this disclosure on a weight basis.

The scope of the invention is particularly pointed out in the appended claims.

I claim:

1. A process for disintegrating mica into thin particles which comprises:

heating insufficiently fine pieces of mica to a temperature at which its water of hydration is released;

injecting a hot gaseous medium as a multiplicity of swirling, non-radial, converging, flat, high velocity streams from a multiplicity of slit-shaped orifices into a lower portion of an upwardly extending disintegration zone of substantially circular cross section, said multiplicity of orifices being distributed in said disintegration zone in part around its periphery to converge non-radially inward and in part around its central axis to converge non-radially outward, and

exposing said mica pieces to said swirling gas streams in said lower portion at an operating temperature at which the water of hydration of said mica is released until said pieces become split into particles of different sizes and relatively fine particles having the desired fineness escape from said disintegration zone while relatively coarse particles remain therein to be split further.

2. A process according to claim 1 wherein pieces of relatively coarse mica feed are introduced into the lower portion of said disintegration zone in the vicinity of its main vertical axis and wherein product particles of desired fineness are withdrawn from an upper peripheral portion of said disintegration zone.

3. A process according to claim 1 wherein pieces of insufficiently fine mica are introduced into said disintegration zone in a non-central portion thereof and product particles of desired fineness are withdrawn from a central portion in a lower part thereof.

4. An apparatus for disintegrating solids suspended in a fluid medium which comprises:

an upwardly extending shell of generally circular cross section providing a disintegration chamber in the lower portion thereof and an elutriation chamber thereabove;

a first plurality of high velocity nozzle means having substantially vertically elongated orifices disposed within said disintegration chamber around its periphery and oriented for jetting non-radially converging streams of fluid medium in a generally inward direction into said disintegration chamber;

a second plurality of nozzle means having substantially vertically elongated orifices disposed within said disintegration chamber around its main vertical axis and oriented for jetting non-radially converging streams of fluid medium in a generally outward direction into said disintegration chamber;

means for feeding fluid medium to said nozzle means;

means for introducing insufficiently fine pieces of frangible mineral into said disintegration chamber; and

means for removing fine product particles from an upper portion of said elutriation chamber.

5. An apparatus according to claim 4 wherein said mineral introducing means comprises a means for introducing a preselected gas thereinto so as to minimize entry of the surrounding atmosphere thereinto.

6. An apparatus according to claim 5 wherein said shell has the shape of an inverted truncated cone and wherein the means for removing fine product particles therefrom is located in an upper peripheral portion thereof.

7. An apparatus according to claim 4 which further comprises a high frequency vibrating means to create high frequency vibrations within said shell.

8. A process according to claim 1 wherein said gas is an inert gas and said operating temperature is above about 800° C.

9. A process according to claim 8 wherein said gas streams are jetted into said disintegration zone at a velocity of from 5 to 200 m/sec.

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