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Dec. 17, 1946. L. C. FISHER ET AL 2,412,680

METERING MILL

Filed Aug. 3, 1943

Fig. 1.

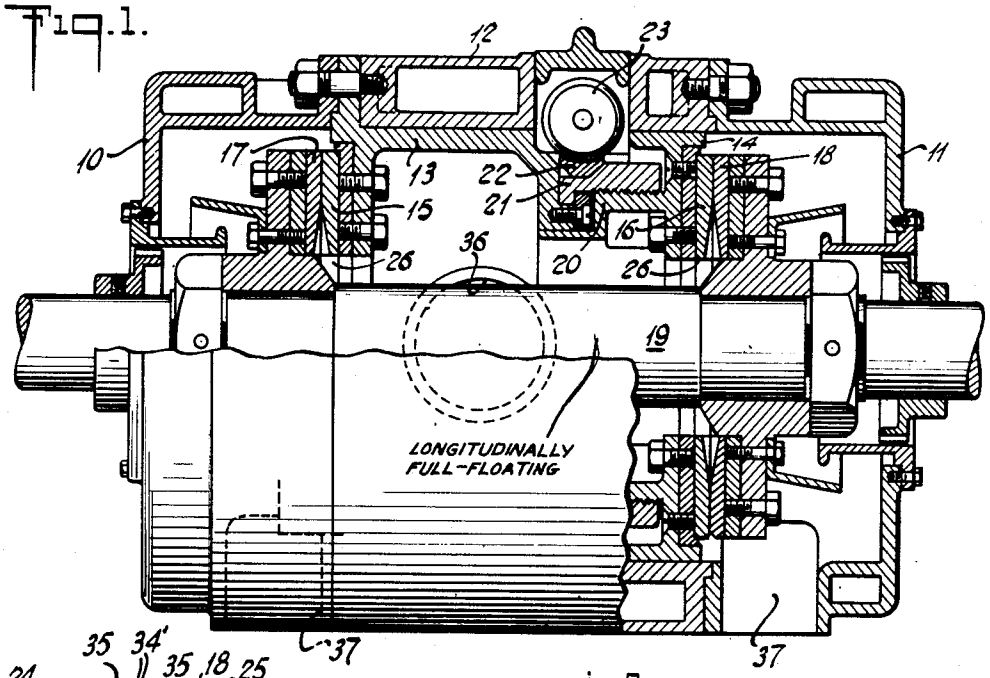


Fig. 3.

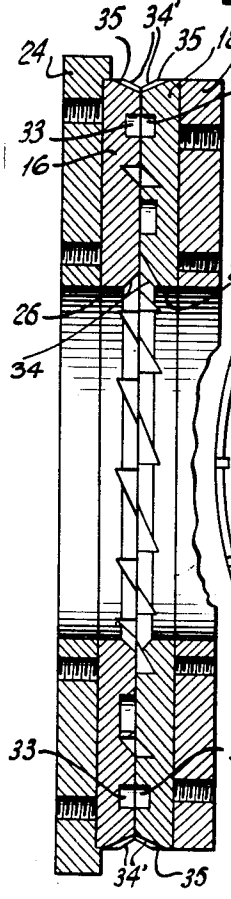
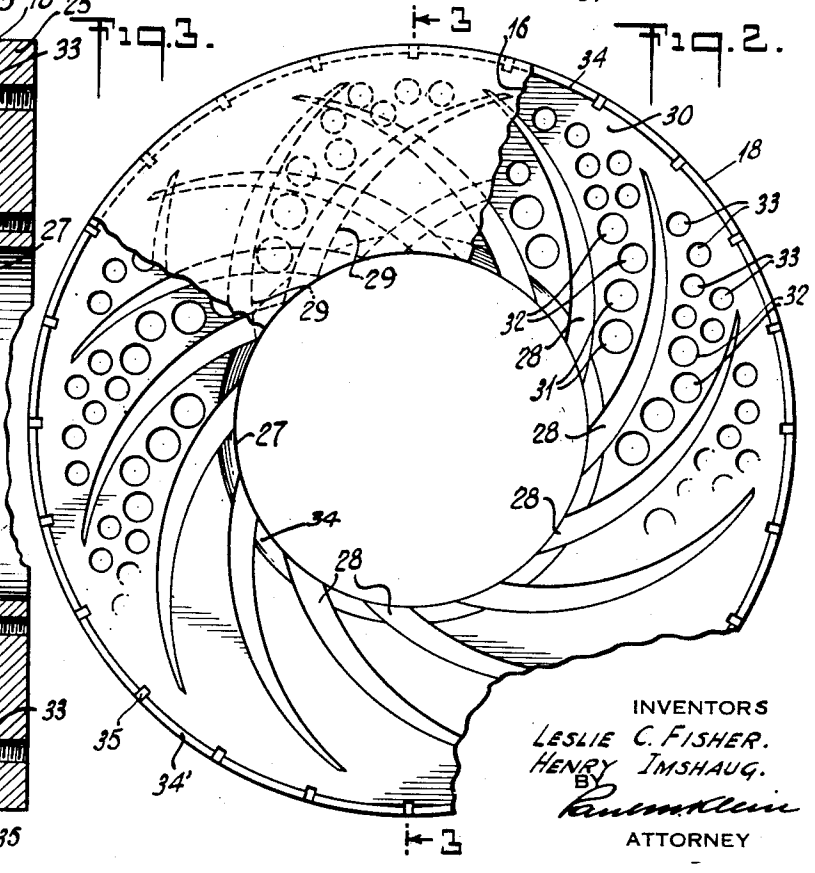


Fig. 2.



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2,412,680

METERING MILL

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Application August 3, 1943, Serial No. 497,268

3 Claims. (Cl. 241—260)

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This invention relates to colloidal mills in general, and particularly to a metering mill for producing colloidal compounds.

Our invention specifically contemplates the provision of means for producing a colloidal compound which is composed of minute solids borne by a liquid carrier, and wherein the ultimately desired size of the solids is accurately metered in the process of production to such a proportion that when the compound is finished, the solids will permanently remain in colloidal suspension within the fluid carrier.

While we are well aware of the existence of numerous devices relating to the present art, we believe that the principle of our device represents an important step forward in the field of producing ready-flowing homogeneous colloidal compounds wherein the solids are maintained in permanent, uniform suspension in their liquid carrier.

In order to establish the vital differences, between heretofore employed devices and our present invention, we shall broadly set forth the underlying principles involved.

When it is contemplated to produce a relatively fluid colloidal compound of a homogeneous structure, one of the essential prerequisites of such structure is a uniform distribution of solids within the fluid carrier in such a way that the solids will always remain in floating suspension within the carrier, irrespective of the volume of the colloidal compound considered. Thus, a large body of such compound, as well as one droplet thereof, must evidence the same uniformity of homogeneousness in its physical structure. In the heretofore known art colloidal mills have been produced, wherein the milling surfaces were made adjustable for reducing the size of solids to approximately the magnitude desired. Other developments in colloidal mills constitute devices wherein the solids are subjected to an interabrasive action between particles of the solid material itself. However, in neither type of such devices stress is laid on exact control, whereby both the size of the solids in suspension, as well as an absolute uniformity of the ultimately desired product may be assured. Such control is of especial importance when the contemplated size of the solids has to be so minute that it will correspond to a 1200 mesh or smaller.

The present invention contemplates the production of colloidal compounds wherein the solid particles suspended in the fluid are of an infinitesimal size, discernible only by microscopic observation. One of the objects of the present

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invention, therefore, is the provision of means for producing relatively free-flowing colloidal compounds which contain solids of uniform, microscopic size, and wherein the solids are permanently and uniformly suspended within their fluid carrier.

The foregoing and numerous important other objects and advantages of the present invention will become more readily apparent from the following explanation and description of the accompanying drawing, which latter illustrates one of the many possible forms of our proposed mill and wherein:

Fig. 1 is a side elevation of a presently preferred form of our device, partially in section, representing a double mill unit in accordance with our invention;

Fig. 2 is an enlarged detail plan view of the milling discs employed in our mill; and

Fig. 3 is a section taken on line 3—3 through Fig. 2.

Referring now specifically to the drawing, Fig. 1 represents our device in its presently preferred arrangement, and is designed to accommodate two sets of mill units. Numerals 10 and 11 denote, respectively, the left and right hand end housings, each of which accommodates one of the mill units. The middle housing section 12, placed between the end housings, is provided with a fixed mill support 13 for the left-hand mill unit and a movable support 14 for the right-hand mill unit. Both mill units comprise, respectively, stator discs 15 and 16, and rotor discs 17 and 18, which latter are mounted upon a free-floating drive shaft 19. The shaft extends from both end housings, and is journaled in bearings exteriorly to the housing, not shown. The mounting of the shaft is such as to permit the latter to shift in longitudinal direction while being driven by motive power, not shown.

Movable disc mounting 14 is provided with a threaded extension 20, the threads of which are engaged by an internally threaded annular member 21, with which latter is fixedly associated a worm gear 22. This worm gear is adapted to be actuated by worm 23, which is journaled within a compartment provided in middle housing section 12.

Mill adjustment

By operating worm gear 23 in either clockwise or anti-clockwise directions, the internally threaded annular member 21 is turned and will cause movable disc mounting 14 to travel in either right-hand or left-hand directions. When

the mounting 14 is caused to travel in right-hand direction, its stationary disc 16 will move against rotary disc 18 and, after engaging the latter, will also cause shaft 19 to shift in right-hand direction, whereby rotary disc 17 of the left mill unit will be brought closer to stationary disc 15.

When the rotation of worm gear 23 is reversed, movable mill support 14 will travel in left-hand direction, and as the two movable discs rotate, the separation of the discs in both mill units takes place. In this manner both mill units become uniformly and simultaneously adjusted.

Taking into consideration the structural details of the adjusting arrangement, it is readily evident that a very minute and virtually a fine metering adjustment of the mill discs is contemplated in our device. The importance of such fine metering adjustment will be better appreciated when the principle of our method becomes fully understood.

Mill disc construction

In Figs. 2 and 3, some of the important details of the mill discs employed in our device are disclosed. These mill discs, of which disc 18 is the movable disc, are made of relatively hard and tough material, and are mounted upon more readily machineable disc supports 24 and 25, respectively, as clearly seen from Fig. 3. Each of the discs actually constitutes a ring with relatively spacious central apertures 26 and 27, for accommodating shaft 19, and for receiving the supply of the mixture of solids and fluids.

The smooth, absolutely parallel milling surfaces of both discs are provided with a plurality of saber-shaped grooves 28 and 29, which grooves diminish in cross section in radially outward direction, their reduced ends terminating a substantial distance from the outer periphery of the discs, so as to provide a relatively broad annular margin 30, the surface of which is unbroken and smooth.

Arranged in the fields between each two adjacent saber grooves is a plurality of substantially cylindrical recesses, which latter progressively diminish in size from within to without so that the larger recesses 31 are closest to the central opening of the discs, the next smaller series of recesses 32 are placed substantially centrally between the large and small groove ends, and the smallest series of recesses 33 are arranged between the reducing tip ends of the grooves.

It will be observed from Fig. 2 that the outer margins of smallest recesses 33 are placed along and within a circle that coincides with that at which the reduced ends or tips of the grooves terminate, whereby the smooth, annular peripheral field 30 of the discs is maintained. The importance of the marginal smooth fields of the discs will be discussed presently.

All recesses are preferably of a cylindrical shape and have flat bottoms. The depths of the recesses may either be uniform or may vary. We prefer the recesses to be gradually diminishing in depth from within to without, in the same manner as the saber-shaped grooves diminish in depth in outward direction. It may however be advantageous to maintain the depth of the recesses uniform, or reverse the progress of their depth so that the larger recesses near the center opening of the discs will be less deep than the smaller recesses near the periphery.

Discs 16 and 17 have internal chamfers 34, forming a feeding groove for the reception of material to be milled, and external chamfers 34' in which latter chamfered surfaces are provided equally spaced, inclined grooves 35, which are designed to facilitate the discharge of the milled compound.

Operation

While the construction of the mill shown in the accompanying drawing provides for one stationary and one movable mill disc for each mill unit, it is quite obvious that both discs may be rotated in opposite directions to one another.

The arrangement of the saber-shaped grooves 28 and 29 of the two oppositely disposed discs is such that the groove tips point towards each other when one disc moves in one direction, while the other either is at rest or moves in the opposite direction. In this manner a veritable sheering operation between the grooves will take place. Such sheering operation becomes progressive as the grooves move against each other from their reduced termini towards their enlarged interior ends. A similar sheering operation takes place between the recesses arranged in the fields between each two adjacent grooves.

As the compound of liquid and solid materials enters the large ends of the grooves, and is forced by centrifugal action from within to without, and thus is being pressed into progressively smaller cross sections of the grooves, the solid particles of the compound are pushed beyond the surfaces of the discs and are thus being subjected to an inter-abrasive action. The "overflow" of the particles from the grooves to the solid and smooth disc faces are trapped within the recesses between the grooves, and as they gradually accumulate within, and finally fill the recesses, they are caused eventually to "overflow" from the recesses to the surfaces of the discs, thus augmenting the abrasive action between the solids, whereby the sizes of the latter are progressively diminished.

Following the transfer of the solids from the grooves to the recesses, there ensues a re-transfer from the recesses back to the grooves, at points progressively nearer to the disc peripheries. Such process of transfer and re-transfer continues until the compound reaches the annular, smooth fields 30 of the discs.

Accompanying this transfer and re-transfer of solids is a progressive abrasing action, which causes the solid particles to gradually, but progressively diminish in their size in the direction from the inner peripheries of the discs towards their outer peripheries.

When the solid particles reach the circle at which the grooves and recesses terminate, their size will have diminished to the required minimum. They now form with the fluid carrier a relatively thin flowing compound, which enters the metered space between the two adjacent smooth, annular zones or fields 30. In consequence of the exact adjustment of the discs, only those solid particles which have acquired the devised minute size can pass through the metered zone space, while larger particles will be left behind to be caught by the grooves and recesses for an additional milling operation, until their size is small enough to pass the metered zone space. Thus a product containing solids of only the required smallness will be propagated to the outer periphery of the mill units.

The centrifugal force to which the compound is subjected will cause the compound to leave the space between the adjacent disc surfaces at a

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considerable force. In the event however the viscosity of the compound should be so great, due to the possible separation of the liquid carrier from the solids, to cause a temporary accumulation of solid or semi-solid matter along the beveled edges **34** of the discs, inclined grooves **35** provided in these beveled edges are designed to break up such accumulation of matter and to cause the latter to separate from the disc peripheries.

Metering adjustment

The provision of the smooth annular peripheral fields or margins **30** arranged at both discs is primarily intended for the purpose of exactly gauging the size of the solid particles permitted to pass through the space between these fields. Depending upon the adjustment of the discs relative to each other, the space between the discs may be either enlarged or reduced, thereby governing the size of the solid particles in the finished product issuing from the peripheries of the mill.

Inasmuch as the present invention contemplates a method for producing a compound wherein all the solid particles are intended to remain permanently in suspension within their carrier, the magnitude of the particles borders on infinitesimality. In order to produce such very small particles, as is required in accordance with our invention, the adjustment of the two discs, or more specifically, the adjustment of the peripheral fields **30**, is of utmost importance. For this reason we have devised the afore-described adjusting arrangement which affords imparting to the discs very minute movements, which movements may be readily indicated on the shaft of worm **23**. The provision of a gauging device being obvious, no specific illustrations thereof are submitted. Suffice it to say, however, that the adjustment must be very accurate and simultaneously uniform for both mill units.

Referring again to Figure 1 it will be observed that middle housing section **12** is provided with an inlet **36**, through which the combined mixture of a fluid carrier and of relatively large solid particles enters the device. When a sufficient quantity of the mixture accumulates within the middle section, it passes through central openings **26** of the stationary mill discs **15** and **16**, from where it is propagated in the manner stated, i. e. from the interior to the exterior peripheries of the discs.

The finished product then issues from the outer peripheries of the discs into the respective end housings of the two mill units and is eventually discharged through outlet ports **37**.

From the above description the different steps of our procedure employed to produce a uniformly homogeneous compound, which will assure permanency in suspension of solid particles within their carrier, are clearly indicated. To repeat, it is contemplated to first introduce a mixture of a liquid carrier and relatively large-sized solid particles into the middle housing section, which latter may be considered a mixing chamber. From this chamber the mixture is drawn in between the discs of the mill units and there it is subjected to a progressive action of first breaking up the larger particles into smaller particles and then subjecting the solids to a reciprocal abrasive action, by successively transferring the solids from holding means for such solids having greater capacities to holding means having progressively smaller capacities, thereby gradually retarding the progress of the solids in outward

direction in order to progressively augment the reciprocal abrasive action between the solids, and alternately shifting them from one type of retention means to another type thereof, until the diminishing of the solid particles reaches a stage when the particles are substantially uniform in size. For the purpose of exactly metering the solids of the ultimate product, the mixture is forced through an exactly metered passage formed between two adjacent surfaces, at least one of which surfaces is in motion. Having thus forcibly gauged the solid particles of the compound before releasing it, the desired uniformity in size of the solids within the compound is effectively assured.

Modifications

While in the submitted drawings the adjacent surfaces of the annular peripheral fields **30** of the discs are shown to form continuations of the disc surfaces disposed in the same planes, it is quite obvious that these peripheral fields may slightly taper against each other, or that they may be both conically off-set in one direction in respect to the interior disc planes. Furthermore, it is also obvious that while these peripheral fields are shown to be of the same material from which the disc bodies are made, it may be advantageous to employ different material for the peripheral disc sections.

Conclusion

While the aforedescribed device for producing colloidal compounds has been dealt with in a more or less specific manner, it is self-evident that changes in the apparatus may have to be made in order to meet different problems arising from the type of products to be manufactured. Thus, for instance, when it is desired to produce a fuel compound, such as an oil and coal mixture, the size of solid coal particles must be such that the latter will remain permanently in uniform suspension within the oil. It has been found that in order to meet such requirement, the solids of the compound must approximate a size corresponding to 1,200 mesh, and that in order to render the compound sufficiently fluid to permit its being sprayed effectively through nozzles, the proportion of coal particles to the fuel oil must approximate 40 percent of the former to 60 percent of the latter.

When compounds are to be produced wherein the difference between the specific gravity of the fluid carrier and that of the solids is either greater or smaller than the difference in specific gravity existing between fuel oil and coal dust, both the proportion between liquid and solids, as well as the size of the solids will have to be altered. Nevertheless, neither the basic principle of the present invention, nor the working principle of the apparatus for practicing it will be effected by the physical changes in or the proportion of the components of the mixture, except that the mechanism of the mill arrangement may have to be correspondingly adjusted.

While, therefore, the above description deals with specific forms of our invention, be it understood that the same shall not be construed in a limiting sense, and that changes and improvements may be incorporated therein without departing from the broad scope of the underlying principle of our invention, as defined in the annexed claims.

We claim:

1. In a metering mill, a pair of cooperating

milling discs, at least one being rotatable relative to the other, both having grinding surfaces provided with spaced, curved grooves diminishing in cross section from within to without and terminating with their reduced ends along a circular curve which is concentric with and is substantially spaced from the outer circumference of the discs, a plurality of flat-bottom, cylindrical recesses provided in the fields between each two adjacent grooves and diminishing in sizes from within to without, the extreme edges of the smallest recesses being also located along the circle at which the groove ends terminate, the portions of the discs between the circle and the outer periphery of the discs providing substantially broad rims having unbroken surfaces, the discs being so arranged in respect to one another that their curved grooves and cylindrical recesses are disposed in opposite positions, and means for providing a metering adjustment of the space between the disc faces.

2. In a metering mill, two cooperative grinding discs having grooved and recessed interior and smooth peripheral outer surface areas at their adjacent planes, the grooves being sabre-curved and equally spaced, their depth and cross sections diminishing in radially outward direction, the recesses being grouped in the spaces between the grooves and having cylindrical shapes with flat bottoms and diminishing in size from within to without, the ends of the grooves and the peripheries of the outermost, smallest recesses of both discs extending to circles parallel with and substantially spaced from the outer peripheries of the discs, whereby relatively broad, annular outer fields are provided having unbroken, smooth surfaces, and annular bevels arranged adjacent to said outer, smooth-surfaced fields, and a plurality of radially disposed, conically inclined peripheral recesses provided in the bevels and extending into the outer, smooth-surfaced fields, the direction of the sabre-grooves and the grouping of the recesses in the two discs being arranged in just opposite relations, so that a progressively increasing shearing action between the cooperating discs is produced when at least one of them moves in respect to the other, said peripheral recesses serving for facilitating the discharge of matter processed between the discs, and means for facilitating a fine, metering adjustment of the space between the smooth-surfaced peripheral fields of the discs.

3. In a metering mill, at least two annular grinding discs having closely adjacent cooperating parallel grinding faces, in both of which are provided exactly like patterns of a combination of grooves and recesses of the same relative shapes and depths, arranged at one disc in exact opposite relations to that of the other disc, the grooves and recesses of both discs diminishing in their retention capacities from within to without and terminating a substantial and uniform distance from the outer peripheries of the discs so as to provide ring-shaped, relatively broad margin areas having unbroken surfaces, the combination of grooves and recesses consisting of a plurality of substantially sabre-curved grooves extending from the interior rims of the discs towards their ring-shaped, unbroken marginal surface areas, and diminishing in cross section in outward direction, and a plurality of straight-bottom, substantially cylindrical recesses arranged between each two adjacent grooves, said recesses diminishing in size in outward direction.

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