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COLLOID MILL

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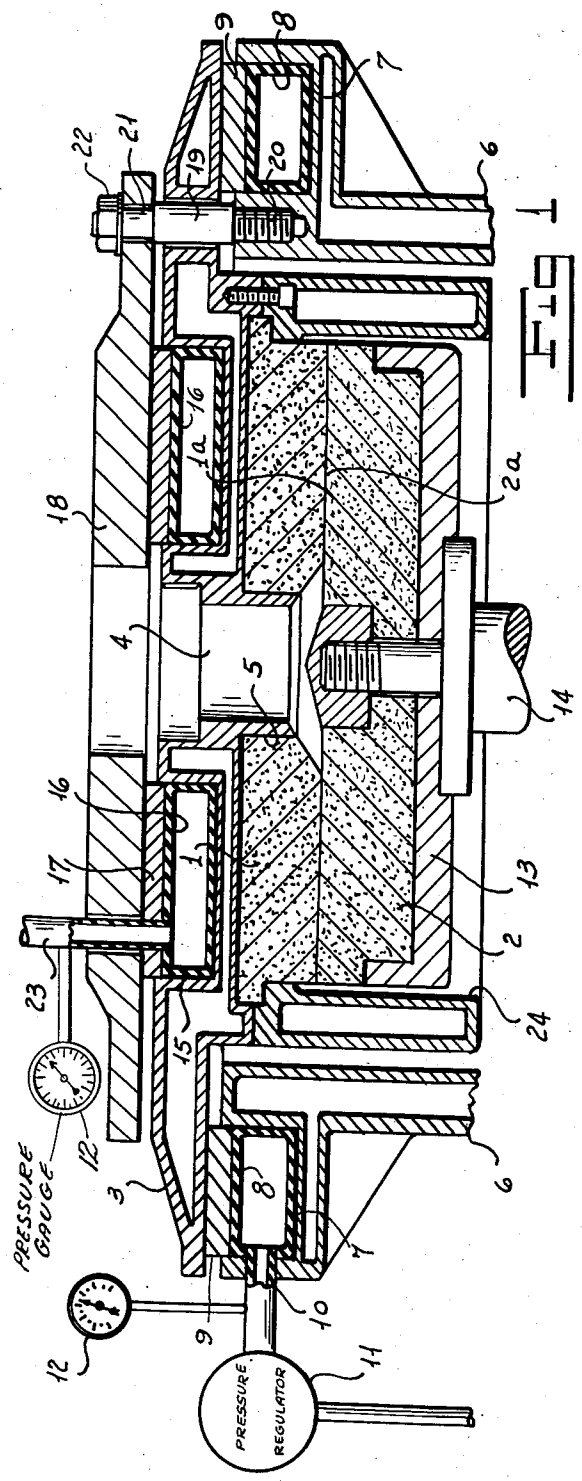


FIG. 1

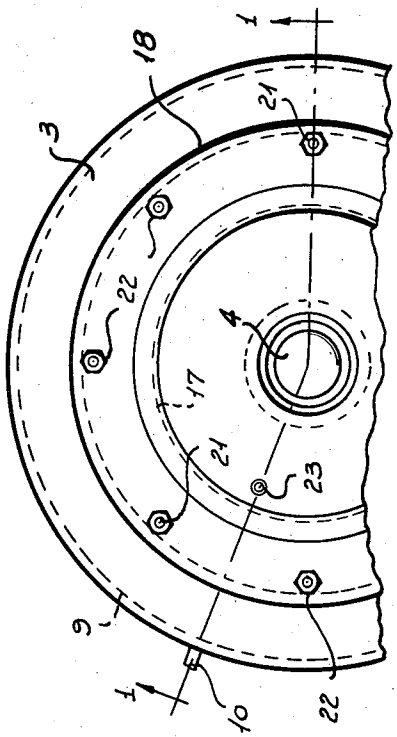


FIG. 2

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COLLOID MILL

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9 Claims. (Cl. 241—37)

This invention is a colloid mill and the primary object of the invention is to provide a mill capable of producing extremely fine dispersions or emulsions through the shearing action of liquid films or films of gel or other non-Newtonian liquids.

Mills capable of producing dispersions or emulsions have long been used, notably among which is the well known Premier Colloid Mill which has been employed commercially throughout the world for upwardly of thirty years. This type of mill produces satisfactory dispersions within ordinary limits, but is generally incapable of producing extremely fine dispersions due to the fact that it has not been able to provide a film thickness sufficiently fine, e. g., a fraction of one thousandths of an inch, and to maintain that thickness during the life of the so-called working faces of the stator element, hereinafter called the "stator," and the relatively rotatable or gyratory element, hereinafter called the "rotor."

This inability to maintain a very thin and uniform film thickness between the stator and the rotor is due to inaccuracies, tolerances and wear which must inevitably be present in these machines. For example, the shaft on which the rotor revolves is only true to the extent that the bushings or bearings in which it is mounted run true. Every anti-friction bearing will have certain tolerances in play under the best conditions and these conditions will result in lost motion by at least .001" during the life of the machine. Moreover, it is practically impossible to insure true parallelism between the two working surfaces of the stator and rotor and if clearance or thickness of film is measured by means of a suitable gauge, one will invariably obtain readings at different points of the working surfaces which clearly indicate a lack of parallelism. When such a condition exists, it is impossible to obtain uniformly fine colloidal dispersions. There has long existed a very definite requirement for a mill which will produce dispersions of the order of one micron or less and which at the same time will be a good production mill and capable of producing such a product throughout the life of the mill and regardless of wear and lost motion in the movable parts associated with the rotor.

The mill of the present invention is such a mill. It will function with high efficiency when operating on films of .001" or less thickness and will maintain a predetermined film thickness within these limits, so long as the material fed to the working surfaces of the rotor and stator is of the same general consistency. Nevertheless it is so constituted that, in the event any foreign matter is inadvertently introduced into the mill, such foreign matter will be efficiently and expeditiously discharged from between the working surfaces without damage thereto or to any other part of the mill.

The mill of the present invention has been conceived and developed as a result of many years experimentation and research and tests, as a result of which I have evolved certain definite factors respecting the mechanical

and functional features of the structure, among which are the following.

The stator must be mounted on an appropriate carrier supported from below against the force of gravity by a hollow elastic lower annulus which encircles the stator and is adapted to be supplied with air or gas under pressure, hereinafter referred to as pneumatic pressure. In addition, an upper coaxial hollow elastic annulus, also supplied with pneumatic pressure, must act against said carrier in a counter direction. The pneumatic pressures within these two annuli must be controlled so that the stator and rotor will be in stable equilibrium while they are in operation upon an interposed film of material of the required film thickness to produce the desired dispersion. I have found that this requires different pressures in the respective annuli. The stator is preferably positioned above the rotor, in which case the lifting action of the lower annulus plus the resistance offered by the film under treatment will equal the downward pressure exerted upon the carrier by the upper annulus plus the weight of the parts which are imposed upon the stator, whereby there will result the static condition which will maintain a uniform working clearance occupied by the film of material under treatment between the working faces of the rotor and stator. If the stator were positioned below the rotor the lifting action of the lower annulus would be equal to the downward pressure exerted by the upper annulus, plus the resistance of the material plus the weight of the parts which are imposed on the stator.

In order that the static equilibrium of the system may be maintained and the spacing of the working faces kept constant, the relative pressures in the respective annuli are controlled by appropriate pressure regulating means which function to hold these annuli under the predetermined and requisite differential pressures irrespective of temperature changes which occur as the mill warms up and during its normal operation. The difference in pressures in the respective annuli will vary according to the material under treatment. E. g., when dealing with a relatively thin material in a mill wherein the weight of the stator is of the order of 30 pounds and the lower annulus has a cross section of 50 inches, the pneumatic pressure in the lower annulus may be of the order of approximately 1 pound and the pressure in an upper annulus of like area need only exceed the pressure in the lower annulus by a pound or so. These pressures are low and the stability of the system will be correspondingly low, but said system will be stable although very flexible. This flexibility permits the stator to autogeneously adjust itsef to any inaccuracies in the rotor or loss motion or excessive clearances in its mounting, while maintaining the working gap uniform throughout. When treating materials of higher viscosity, higher pressures than those referred to are required to maintain the fine film gap which may be but a fraction of .001" and in some cases pressures up to 50 to 100 pounds may be required. However, I have found that a difference in pressure exerted by the two annuli will be required in all cases to maintain the desired film thickness and keep the system stable.

An important feature of this invention is that the use of the twin annuli provides uniform application of pressures at all parts of the working gap, thus avoiding distortion of the working elements due to the application of pressure thereto. Such distortion would be very undesirable in a mill with a working gap of .001" or less.

Another important feature of this invention is that the stator is so mounted that it may, in effect, float on the film of material under treatment. To this end the carrier of the stator is supported for edgewise movement in all

directions within reasonable limits. Consequently, if there be any inaccuracy or loss motion in the mounting of the rotor, either in a new machine or due to wear, this does not matter in any way for the stator is free to flexibility follow the operations of the rotor and automatically compensate for such inaccuracies in its operation. This fact makes it possible to operate this mill at extremely low film thicknesses without recourse to a high degree of mechanical accuracy. Ordinary manufacturing procedure may be employed in the manufacture and yet a satisfactory and highly efficient and effective operating mechanism will result, well capable of operating within the film limits to which I have referred.

The relative peripheral speed between the rotor and stator of the mill of this invention is, in practice, from 1,000 feet per minute to 10,000 feet per minute or more depending upon the nature of the material to be treated. For example, in a mill wherein the rotor and stator have a diameter of eight inches and a rotor speed of 3,000 R. P. M., the peripheral speed of the rotor will be approximately 6,000 feet per minute. This relative peripheral speed may be obtained by rotating the dispersing elements in opposite directions but there is no advantage in doing this.

In the mill of this invention, the rotor and stator must have working faces which are substantially planetary. This fact allows them to have floating coaction while maintaining uniformity of film gap and also facilitates the discharge of treated material from the gap by centrifugal force which would be impeded if the faces were otherwise.

Heat is generated during the operation of the mill and it is therefore necessary to water jacket the parts contiguous to the rotor and stator for cooling purposes.

It is also desirable in practice to surround the zone of the working faces with a skirt functioning as a baffle positioned sufficiently close to the periphery of the rotor and stator to obviate undue aerating of the treated material after it is discharged from between the rotor and stator and this skirt should also be cooled.

The manner in which the differential pressures are utilized as described constitutes a novel method forming part of this invention.

Features of the invention, other than those adverted to, will be apparent from the hereinafter detailed description and appended claims, when read in conjunction with the accompanying drawing.

In the accompanying drawing I have shown the preferred form of apparatus of this invention which may be employed in the carrying out of the method of this invention, but the structure therein shown is to be understood as illustrative, only, and not as defining the limits of the invention, nor is the method to be understood for use with this particular machine, only.

Fig. 1 is a transverse diametric section taken on the line 1—1 of Fig. 2 through an essential portion of a mill embodying this invention.

Fig. 2 is a fragmental plan view of the structure shown in Fig. 1 on reduced scale.

Referring to the drawings, **1** designates a stator which is provided with a working face **1***a* and **2** a rotor having a working face **2***a*. The stator is rigidly secured to a carrier **3** provided centrally with a passage **4** leading into the eye **5** of the stator. **6** indicates the upper portion of the frame of the mill, the lower portion thereof being conventional and of any suitable construction.

In the top surface of the frame **6** is formed an annular chanel **7** coaxial with the eye of the stator **1** and in this channel is positioned a pneumatic cushion in the form of a hollow lower annulus **8** of elastic material, preferably rubber. This annulus is of less depth than the depth of the channel **7** and fitted into the upper portion of the channel which is not occupied by the annulus is a ring **9** which is preferably of rubber or some other flexible material. It need not be resilient. This ring simply functions after the nature of a piston within the channel **7** which has the relation thereto of a cylinder, so that, when pressure is introduced into the lower annulus **8**, the upper portion of the cylinder is sealed so as not to permit of a blow-out of the annulus, the walls of which may be quite thin.

At one point in the periphery of the lower annulus, it is provided with an inlet **10** which leads to an automatic pressure regulator **11** which is in turn connected to an appropriate source of pneumatic pressure. Any suitable means for supplying such pneumaitc pressure may be employed and any appropriate form of pressure regulator may be employed. The function of the regulator is to pass pneumatic pressure to the lower annulus **8** and to so control that pressure that it may be maintained constant at a predetermined value at all temperatures. Inasmuch as such pressure regulators are common and well known, it is not considered necessary to detail the same. A pressure indicator **12** may be associated with the inlet so that the operator may be apprised of such pressure.

The rotor **2** is mounted in a suiatble housing **13** and both the rotor and its housing are fixedly secured to a coaxial shaft **14** mounted in suitable bearngs (not shown) and adapted to be rotatably driven from any appropriate source of power. The bearings are preferably ball or roller bearings of conventional type as close tolerances are not required. The shaft may be connected for direct drive with an electric motor or may be geared from any appropriate source of power, the only criteria being that the rotor may be revolved or gyrated, as the case may be, on a vertical shaft held within reasonable limits to its desired sphere of operation and having appropriate thrust bearings to maintain the working face of the rotor in substantially a predetermined horizontal plane for cooperative relation with the similarly located working face **1***a* of the stator **1**.

The stator **1** is, as stated, supported on the carrier **3** with the peripheral margin of the carrier resting upon the upper surface of the ring **9**. The top surface of the carrier **3** is provided with an annular channel **15** which is coaxial with the eye of the stator and in this channel is positioned a pneumatic cushion in the form of a hollow flexible upper annulus **16**. This annulus like the lower annulus is of less depth than the channel **15** which functions after the manner of a cylinder to contain the upper annulus also the lower portion of a ring **17** which corresponds in structure and function to the ring **9** of the lower annulus. A bridge **18** extends across and bears upon the upper surface of the ring **17** and is provided adjacent its periphery with a series of annularly disposed and arcuately spaced apart holes for cooperation with a like number of studs **19**. The lower end of each stud **19** is tapped, as at **20**, into the frame **6**, while its upper end is reduced and threaded as shown at **21**, thus providing a shoulder against which the bridge may be clamped by a nut **22** screwed upon the stud.

The nuts **22** are preferably screwed upon the studs **19** sufficiently tight to rigidify the bridge in a direction axially of the studs but to permit of limited sliding movement of the bridge in a direction normal to the axis of the studs. To permit of this sliding movement, the holes in the bridge through which the studs pass are made of slightly greater diameter than the reduced diameter **21** of the studs as clearly shown in Fig. 1.

The upper annulus **16** is provided with an inlet **23** through which pneumatic pressure may be introduced. This inlet is equipped with a separate pressure regulator and pressure gauge like unto **11** and **12** associated with the inlet **10** of the lower annulus, but adapted in practice to maintain and indicate a somewhat higher pressure in the upper annulus than in the lower annulus for the reasons stated.

The carrier **3**, as well as the upper portion of the frame, are cored to provide water jackets adapted to be connected with an appropriate supply of coolant. The same is true

of an annular skirt 24 arranged coaxially of the rotor and stator and supported on the carrier in such manner as to be fairly closely spaced from the periphery of the rotor. The purpose of this skirt is to eliminate undue aeration of the dispersed end product material as it is discharged from the working space.

In the practical operation of the mill, the optimum conditions of pressure in the two annuli can only be found by experience or brief test runs on the particular materials to be treated, but having found the correct differential pressures of the two annuli they will be kept constant, irrespective of temperature changes, through the operation of the pressure regulators associated with the respective annuli and this in an entirely automatic manner to maintain a constant film thickness when the pressures have been properly adjusted.

In practice I find it highly desirable to feed material by gravity or by a relatively low hydrostatic head for experience has shown that, when working with minute film thicknesses, there is no advantage in feeding the material under pressure, as will be apparent when we consider that the thickness of the film is of the order of only .001" or less. Centrifugal force is adequate to pass a properly treated material to the periphery of the rotor and to discharge it therefrom as it leaves the rotor and impinges upon the baffle 24.

It is characteristic of the machine of this invention that, as the material is being treated with the rotor operating at the high speeds which are employed, the stator will actually float in lateral directions upon the surface of the film. The movement is not great but is sufficient for the essential purpose of compensating for inaccuracies in the operation of the rotor. The clearance permitted between the reduced portion of the studs and the bridge allows of this floating operation which is also permitted by the fact that neither the bridge 18 nor the carrier 3 is attached to the respective underlying rings 17 and 9. In fact I may, in practice, lubricate the upper surfaces of these rings to facilitate the floating movement to which I have referred.

When the parts of this machine are operated as described, the film thickness remains constant for particular differential pressures. There is no tendency of either the stator or rotor to tilt, although if the faces of either be out of true relative to the axis of the shaft, these faces will maintain uniform spacing throughout for the parts are made relatively light and the mobile character of the pressure medium which maintains the gap permits the parts to adjust themselves in such manner as to maintain parallel relation between these working faces.

I perferably employ working faces 1*a* and 2*a* of Carborundum, diamond faced Carborundum, Alundum, or the like, chiefly because, in the event of accidental contact with one another at high speeds, they will not be seriously damaged. When working with the close spacing described, the actual working faces will at all times be spaced apart and free from contact with one another at all points, so that the dispersion operation is carried out by a shearing action within the body of the film. In other words, the surface strata of the film which are in contact with the respective working surfaces have sufficient skin friction therewith to tear apart or shear the intermediate stratum of the film and inasmuch as all portions of the film are in constant agitation with the surface strata constantly changing, excellent dispersions throughout the entire thickness of the film result. Moreover, faces of Carborundum or the like present somewhat rough surfaces to the material under treatment and will, apart from the film shear, produce a turbulence in said film which augments the disintegration forces at work in the film. While this invention is thus primarily employed in the carrying out of a shearing operation, it may with some materials exercise an additional abrasive action thereon.

It is to be noted that since the working surfaces are pneumatically held to a predetermined spacing under relatively low pressures, these surfaces are capable of separating to permit the passage of a piece or particle of foreign matter which may inadvertently be included in the mix. In other words, foreign matter may pass from the eye of the stator to the periphery thereof without damage to either of the working surfaces.

While the invention is adapted to treat a wide variety of materials and for use in many industries, it has been found particularly effective in the dispersion of many pigments and dyestuffs in the presence of a liquid. In acting upon such materials, the solids may be effectually reduced to dimensions of the order of one micron in a regular production mill of the character described, the resulting product being of superior quality over that produced by prior known methods.

In the operation of this mill, I utilize, when desirable, suitable wetting, dispersing and emulsifying agents, protective colloids and the like, all of which, in one form or another, are commonly employed in the production of dispersions and emulsions.

The underlying concept of this invention is based upon a fundamental method of dispersing materials. According to this method, the material to be treated is acted upon by and between two relatively rotatable parallel plane surfaces in superimposed horizontal spaced apart planes, one of which is fixed in an axial direction and the other of which is axially movable. The latter surface is acted upon in opposite directions normal to its said surface by pneumatic pressures of different magnitude for the purpose of overcoming the resistance of the interposed film to such extent as to maintain the proper film thickness of such material between said surfaces and thus insure the desired fineness of the dispersion. This distinctly novel method constitutes a part of the present invention.

The foregoing detailed description sets forth the invention in its preferred practical form, but the invention is to be understood as fully commensurate with the appended claims.

Having thus fully described the invention, what I claim as new and desire to secure by Letters Patent is:

1. A colloid mill comprising: a rotor and a stator both having plane working faces normal to the axis of rotation of the rotor and arranged one above the other, an annular flexible walled pneumatic cushion completely coaxially surrounding the axis of the stator and operable to exert pressure against the stator independently of the rotor and in a direction away from the rotor, another annular flexible pneumatic cushion also completely coaxially surrounding the axis of the stator and operable to exert pressure on the stator in the direction of the rotor, and means for supplying gaseous fluid under different pressures to both cushions.

2. A colloid mill according to claim 1, wherein the pneumatic cushion which exerts pressure on the stator in the direction of the rotor exerts a greater pressure than the other pneumatic cushion.

3. A colloid mill according to claim 1, wherein the stator is mounted for floating movement to permit it to deviate slightly from the horizontal position so as to maintain a parallel relation between its face and the face of the cooperating rotor.

4. A colloid mill according to claim 1, comprising: a compressed air supply conduit leading to each of the pneumatic cushions, and a pressure regulator in each of said conduits to automatically individually maintain the predetermined pressure in such cushion.

5. A colloid mill comprising: a horizontally positioned stator and a rotor arranged in superimposed relation and having opposed plane working faces, means for supporting the rotor below the stator for rotation and against axial movement, a carrier for the stator, said carrier and stator having a central passage or eye through which material may be fed between said working faces, a lower

flexible annular tubular pneumatic cushion positioned beneath the carrier and entirely surrounding the axes of both the stator and rotor, a bridge arranged above the carrier, an upper flexible annular tubular pneumatic cushion interposed between the bridge and the carrier and also surrounding the axes of both the rotor and stator, and means for maintaining a sufficiently greater pressure of the upper pneumatic cushion than of the lower pneumatic cushion to maintain uniform spacing of the material gap between the working faces of the rotor and stator during the operation of the mill.

6. A colloid mill according to claim 5, comprising: a compressed air supply conduit leading to each cushion, and a pressure regulator in each of said conduits to individually automatically maintain the pneumatic pressure in said cushion uniform irrespective of changes in temperature.

7. A colloid mill according to claim 5, wherein the stator and its carrier are supported for floating movement to permit it to deviate slightly from the horizontal position so as to maintain a parallel relation between its face and the face of the cooperating rotor.

8. A colloid mill comprising: a supporting frame, a rotor supported for rotation within the frame and having a plane cross axial upper working face, said frame being provided coaxially of the rotor with an annular channel having an open top, a lower flexible pneumatic cushion in said channel, a ring entering the open top of said channel

and seated on the pneumatic cushion therein, a carrier bearing on said ring and having an annular channel provided with an open top and coaxial with the axis of the rotor, an upper pneumatic cushion in the latter channel, a ring entering into the open top of said channel and seated on the pneumatic cushion therein, a stator supported on said carrier above the rotor and having a lower plane working face for cooperation with the upper working face of the rotor, a bridge overlying the carrier anchored to the supporting frame and bearing upon the ring of the upper pneumatic cushion, and means for introducing pneumatic pressure into each of said cushions.

9. A colloid mill according to claim 8, comprising means for automatically regulating the pneumatic pressure in each cushion.

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