Aug. 13, 1963 R. W. NORRIS, JR 3,100,628

DISPERSING APPARATUS

Filed March 5, 1962

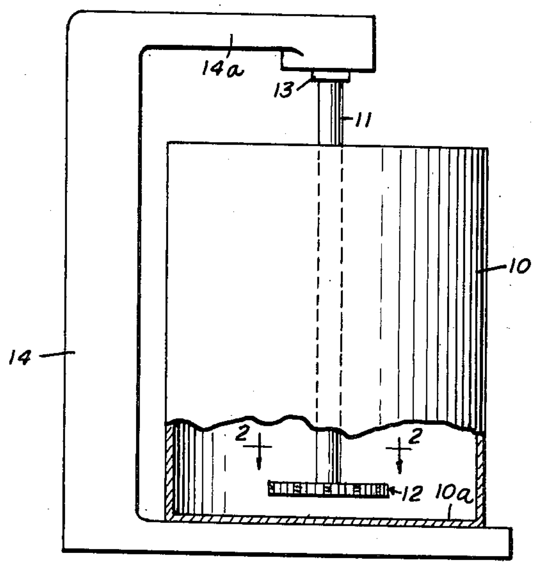


FIG. 1

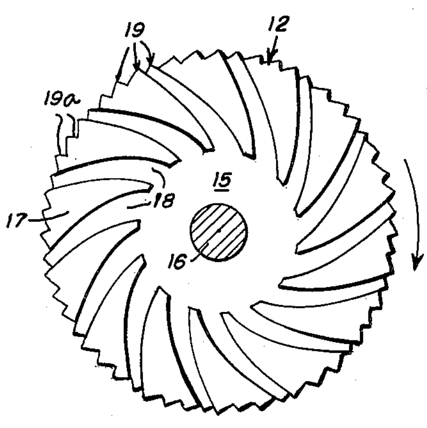


FIG. 2

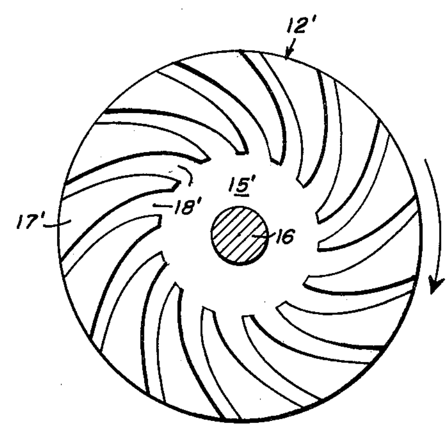
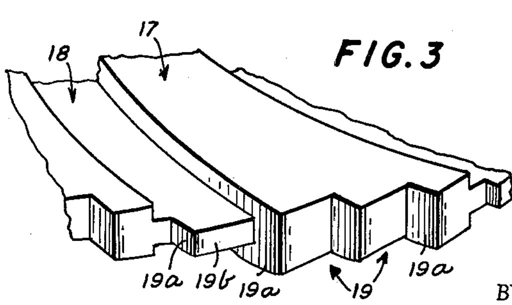


FIG. 4

FIG. 3



INVENTOR

ROBERT W. NORRIS, JR.

BY Beale and Jones

ATTORNEY

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3,100,628
DISPERSING APPARATUS

Robert W. Norris, Jr., Salem, Oreg.

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This invention relates in general to an apparatus for disseminating solids in liquids as, for example, disintegrating and dispersing agglomerates of an insoluble material and dissolving a soluble material in a liquid vehicle. More particularly, this invention relates to rotary impellers which are useful for forming uniform dispersions of a finely divided solid in a liquid medium.

Several types of apparatus for effecting the dispersion of finely divided solids in liquids are known in the art. For example, paints have been formulated in the past by dispersing a pigment in a vehicle by means of pebble mills, high speed stone mills or roller mills. However, when using apparatus of this type it is usually necessary to pre-mix pigment and a portion of the liquid vehicle in one vessel, run the mixture through the mill and subsequently add the remaining vehicle in still another vessel. This is not only very time-consuming, but also a large amount of space is required for all the necessary equipment.

It has also been suggested to use impellers which rotate on a vertical shaft in a container of a liquid-solid mixture to effect dispersion of the solid in the liquid. Impellers of a great many different shapes and configurations have been used for this purpose such as multibladed propellers and paddle wheels. However, the impellers heretofore known have not been completely satisfactory. Some of them result in the entire body of liquid and solids being circulated, thus causing a vortexing effect which results in a considerable amount of solids in the bottom of the container remaining undispersed. Other types do not achieve complete dispersion because only the liquid and solids in the immediate region of the impeller are acted upon and they fail to achieve effective circulation of the entire contents of the mixture within the container.

It is an object of this invention to provide an apparatus for quickly and completely dispersing a finely divided solid in a liquid. It is another object of this invention to provide such an apparatus which will break up agglomerates and which will crush particles of an easily friable material. It is a further object of this invention to provide an apparatus for speeding up chemical reactions which are conducted in a liquid medium such as, for example, solution or emulsion polymerization.

These and other objects are accomplished by this invention which, briefly, comprises providing an impeller formed of a circular plate-like member and a rotary shaft to which the impeller is attached. The impeller is secured to the shaft at the end thereof and rotates about its center on an axis that coincides with the axis of rotation of the shaft. The impeller has, on both its upper and lower surfaces, a centrally located smooth area which surrounds the center of the impeller. A plurality of alternate ridges and grooves originate at the peripheral edge of the smooth area and extend outwardly toward the peripheral edge of the impeller. Each of the grooves lie in the same plane as—i.e., level with—the plane of the centrally located smooth area which surrounds the center of the impeller. The grooves each become progressively narrower as each groove approaches the peripheral edge of the impeller. Each of the ridges between the grooves becomes progressively wider as it approaches the peripheral edge of the impeller. Obviously, the ridges are not in the same plane as the smooth area which surrounds the center of the impeller but are spaced above this plane on the top side of the impeller and spaced below the corresponding plane of the smooth area on the bottom side of the impeller.

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The means for causing the impeller to rotate about an axis is preferably an elongated shaft which is secured to the impeller at or near its center. The shaft is connected to a suitable source of power such as an electric motor to cause it to rotate, thereby driving the impeller in a rotating motion about its center.

The smooth area which surrounds the center of the impeller on both the top and bottom faces is preferably circular although it need not necessarily be so. The smooth areas are preferably parallel but these areas may be convergent or divergent to one another. The ridges which are widest at the periphery of the impeller each narrow or converge at the peripheral edge of the smooth area which surrounds the center of the impeller. The surfaces of these ridges, which are preferably parallel with the plane of the adjacent smooth area which surrounds the center of the impeller and with the plane of the grooves, preferably all lie in the same plane. The number of sets of alternate ridges and grooves may vary depending upon their dimensions and the dimensions of the impeller and the nature of the material to be treated. These factors may also vary depending upon the speed at which the impeller is to be rotated. Thus, when the material to be treated is viscous, the impeller is generally rotated at a slower speed than if the material is of low viscosity. If a large impeller is used containing a large number of alternate ridges and grooves, it will not be necessary to rotate the impeller at as high a rate of revolutions per minute to achieve the same dispersive effects as when a smaller impeller containing fewer alternate ridges and grooves is used. Generally, the number of alternate ridges and grooves will vary between about 10 and 20 pairs of ridges and grooves. In a preferred embodiment of this invention, there are about 14 equally spaced ridges, all of the same size, on each side of the impeller.

The invention will be more particularly described with reference to the attached drawings wherein:

FIGURE 1 is a side elevational view partly in section, of the apparatus of this invention showing the impeller in a container.

FIGURE 2 is a top plan view of an impeller constructed according to this invention.

FIGURE 3 is an enlarged fragmentary perspective view taken of FIGURE 2.

FIGURE 4 is a top plan view of an alternative form of impeller.

Referring to the drawings in detail wherein each individual numeral has the same significance in the different figures:

FIGURE 1 shows a container 10 which may be of any suitable size. Extending into the container is a vertically disposed shaft 11. An annular member or impeller 12 is mounted on the lower end of the shaft 11 perpendicular to the longitudinal axis thereof so that the shaft 11 serves as a vertical axis upon which the impeller 12 may rotate. The impeller 12 is spaced from the bottom 10*a* of the chamber 10 a sufficient distance to allow free circulation below the impeller. The spacing distance is not particularly critical so long as free circulation of the material to be treated is possible. Generally, the impeller will be spaced at least an inch from the bottom 10*a* of the chamber 10. The upper end of the shaft 11 is connected by means of a coupling 13 to a conventional drive assembly which is not shown but is located within the horizontal arm 14*a* of the stand 14. The drive assembly may be connected through a system of gears or pulleys which are not shown to a source of power such as an electric motor that is not shown. The drive assembly and power source which are not illustrated are entirely conventional and form no part of this invention. The drive assembly merely supplies power which causes rotation of the impeller 12 on the axis of the vertical shaft 11.

As seen in FIGURE 2, the impeller 12 is an annular member having a circular centrally located smooth area 15 which surrounds the center 16 of the impeller 12. The center 16 is the point at which the vertical shaft 11 is joined to the impeller 12. Extending outwardly from the smooth area 15 are a plurality of spaced ridges 17 each of which becomes progressively wider as it approaches the circumferential edge of the impeller 12. Each of the ridges 17 terminates at the circumferential edge of the impeller 12. The spaced ridges 17 form a plurality of grooves 18 which lie in the same plane as that extending through the smooth area 16. Thus, there is provided one groove 18 between each pair of spaced ridges 17. The ridges 17 are of such dimensions that the grooves 18 become progressively narrower as they approach the peripheral edge of the impeller 12. Each of the grooves 18 terminates at the outer edge of the impeller 12. Equally spaced around the peripheral edge of the impeller 12 are a plurality of serrations 19. As more clearly shown in FIGURE 3, each serration 19 has a face 19*a* and a side portion 19*b*. The face 19*a* of each serration is approximately perpendicular to the side portion 19*b*. The serrations 19 are particularly valuable when the apparatus is to be used to break up agglomerates or to crush an easily friable material as well as to disperse finely divided solids in a liquid.

A modified form of this invention is shown in FIGURE 4 wherein an impeller 12 is provided with central smooth area 15' and a plurality of ridges 17' and grooves 18', of precisely the same construction and arrangement as those shown in FIGURE 2. Unlike the impeller shown in FIGURE 2, however, the peripheral edge of the impeller 12' is smooth. This impeller may be used when a primary objective does not require the impeller to break up agglomerates or to crush material.

In operation, the solid and liquid materials to be treated are introduced into the container 10 and the impeller 12 is rotated in a clockwise direction at a high speed; such as, for example, a speed of about 1,800 revolutions per minute. While the impeller 12 is being rotated, particles of solid material impinge upon the smooth area 15. A centrifugal motion is thereby continuously imparted to the solid particles and they flow over the smooth area 15 and are thrown into one of the grooves 18. Since the grooves 18 become progressively more constricted as they approach the peripheral edge of the impeller 12, a jet-like action is imparted to the particles as they travel through the grooves 18 between adjacent ridges 17 and are dispersed outwardly into the liquid medium. This results in quick, complete and uniform dispersion of all of the solid material in the liquid vehicle. When the solid material is made up of agglomerates or of large particles of friable, easily disintegratable material, the ridges 17, grooves 18 and serrations 20 coact to impart a high shear to the solid material, thereby breaking up the agglomerates or large particles into finely divided particles and dispersing them in the liquid medium.

After all of the particles of solid material have been dispersed in the liquid medium, the impeller may be quickly cleaned by immersing it in a solvent medium and rotating it at a high speed in such a solvent.

The novel apparatus of this invention may be used to accelerate chemical reactions which are conducted in a liquid medium as well as to disperse solid particles and break up agglomerates in liquid mediums. For example, the polymerization of a vinylidene monomer, such as styrene or vinyl chloride in an aqueous suspension may be expedited by subjecting an aqueous dispersion of the polymerizable monomer to the shearing action of the impeller of this invention.

EXAMPLE 1

This example illustrates the preparation of a white gloss interior enamel. Into a 350 gallon tank, there were placed 400 pounds of a 60% solution of a soya alkyd resin in an organic solvent vehicle, and 30 pounds of mineral spirits. The impeller shown in FIGURE 2 was immersed in the tank and was rotated at medium speed during the addition over a 15 minute period of 1000 pounds of rutile titanium dioxide pigment. After all the pigment had been added, the impeller was rotated at high speed for 30 minutes. The impeller was then rotated for 15 minutes at a low speed during which time 1164 pounds of alkyd vehicle and 150 pounds of mineral spirits were added. There were thereby obtained 300 gallons of a uniform white gloss interior enamel. The total time required to formulate the paint was 1 hour.

By way of comparison, an equivalent amount of the same enamel was formulated by a conventional dispersion technique by means of a pebble mill. The pigment, 500 pounds of alkyd vehicle and 50 pounds of mineral spirit were charged into a Patterson Pebble Mill and the mill was run for about 8 hours. The resultant paste was then charged into a tank and the mill was flushed with the remainder of the alkyd vehicle and mineral spirits into the tank. A conventional paint mixer was then used to complete the mixing operation. The total time required to formulate 300 gallons of enamel using the pebble mill was 9½ hours.

Equivalent sized batches of the enamel were also prepared using a Morehouse High Speed Stone Mill and a Day High Speed Roller Mill. Each apparatus required about 6 hours to formulate the enamel.

EXAMPLES 2–8

These examples show how the impeller of this invention may be used to break up agglomerates of pigments while effecting dispersion of the pigment particles in the vehicle. The apparatus used was the same as described in Example 1. To 150 pounds of a 60% solution of a soya alkyd resin vehicle, 20 pounds of mineral spirits and 2 pounds of lecithin there were added 650 pounds of pigment agglomerates. The impeller was then run at high speed for a time sufficient to break up the pigment agglomerates and to make a uniform dispersion of the pigment particles in the vehicle. Table I sets forth the type of pigment agglomerates used in each example, the largest micron size of the particles contained in the agglomerates, the Hegman Fineness of pigment attained with the impeller and the time required to complete the batch.

Table I

Ex.	Type pigment agglomerates	Largest micron size particle	Hegman fineness attained with impeller	Time in minutes to complete batch
2	Coarse talc	20% greater than 44 microns.	2–3	15–30
3	Medium to fine talc.	3% greater than 30 microns.	5–5½	15–30
4	Coarse $CaCO_3$	20% greater than 44 microns.	1–2	15
5	Fine $CaCO_3$	20% greater than 12 microns.	6–6½	15–30
6	Coarse clay	20% greater than 35 microns.	4	15
7	Fine clay	5% greater than 5 microns.	6½	30
8	Rutile TiO_2	Average about 0.3 microns.	7	15

I claim:

1. An apparatus for disseminating solid material in a liquid comprising a chamber, a rotatable impeller in said chamber having a pair of annular planar surfaces located on opposite sides of the impeller in the center thereof and a plurality of alternating ridges and open grooves in each of the opposing sides of the impeller,

each of said open grooves having an inlet end located at the outer edge of the adjacent annular planar surface and an outlet end located at the outer edge of the impeller, said grooves becoming progressively narrower as they approach the peripheral edge of the impeller, the total area of the surfaces of said ridges being greater than the total area of the surfaces of said grooves.

2. An apparatus as set forth in claim 1 wherein the ridges on said impeller are flat ridges, each of said grooves being of uniform depth and having a planar bottom surface lying in the plane of the adjacent annular planar surface.

3. An apparatus as set forth in claim 1 wherein the peripheral edge surface of said impeller contains a plurality of saw tooth members, each of said members having a surface generally tangential to said impeller and a reentrant surface extending from said latter surface inward toward the center of the impeller.

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