

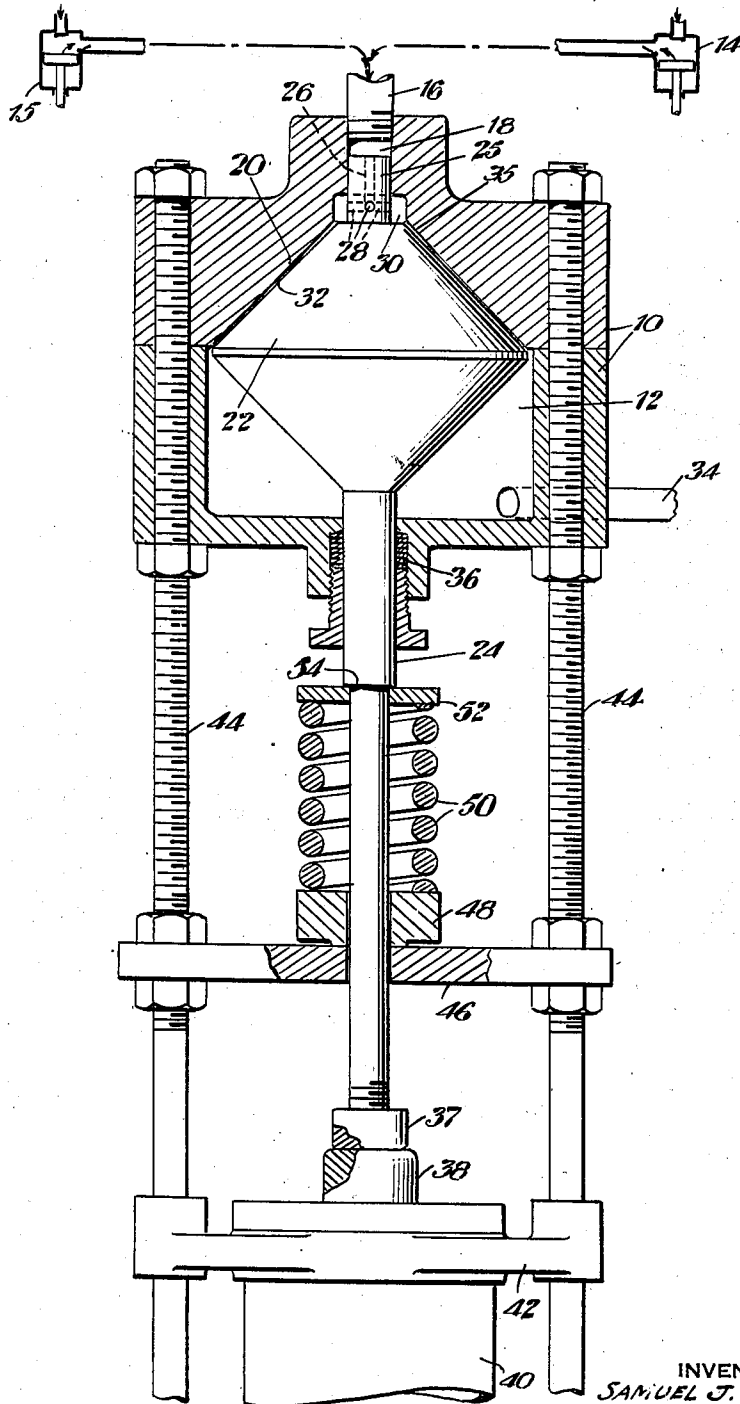
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METHOD AND APPARATUS FOR PREPARING DISPERSIONS

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METHOD AND APPARATUS FOR PREPARING DISPERSIONS

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This invention is directed to improvements in method and apparatus for preparing fine dispersions of a liquid or a finely divided solid in a liquid dispersion medium.

A primary object of the present invention is to provide method and apparatus whereby to prepare fine dispersion economically with continuous throughput of dispersion constituents.

For continuous formation of fine dispersions or suspensions of solid in liquid, apparatus of the colloid mill has been heretofore generally used. In the colloid mill disintegration and dispersion takes place as a result of high centrifugal and hydraulic shear forces developed in a dispersion forming zone of small area between two oppositely rotating disks, or between a rotating disk and a stationary casing. The disks rotate at a relative speed of at least 100 ft. per second and high centrifugal stresses are developed.

Fine dispersions or emulsions of immiscible liquids are quite generally prepared by the use of homogenizers which operate to produce dispersions by forcing a coarse dispersion at high linear velocity in a flowing stream through an orifice type flow restriction.

A more particular object of the present invention is to provide method and apparatus adapted for preparing finely dispersed suspensions and emulsions without the necessity of developing either high linear flow velocities or high centrifugal and shear forces.

According to the present invention a coarse dispersion mixture of the constituents is forced to flow as a thin fluid film at moderate linear velocity through a flow restriction path of substantial area and length. Such mixing as is thus developed in the flowing fluid film by release of the pressure developing flow is greatly augmented by subjecting the mixture to high frequency vibration forces which are developed by flowing the film through a rapidly changing clearance space between two opposed uniformly contoured faces of working parts one or both of which are reciprocated at high frequency, as, for example, between the opposed faces of a reciprocating hammer and a stationary anvil. The rapidly repeated successive impact and withdrawal strokes of the hammer face are in a direction normal to the opposed face of the anvil and normal to the direction of flow of the film, so that the restriction to flow and film thickness are continuously varied between maximum and minimum limits measured by the hammer strokes, at a rate corresponding to the hammer frequency. The opposed faces of the hammer

and anvil which form the flow restriction path should be uniformly contoured throughout a substantial area to provide a film flow path of uniform thickness and of substantial width and length.

The direction of film flow may be linear across the hammer face from one side to the other of the flow restriction path, but according to a preferred adaptation of the invention the hammer and anvil faces are respectively of convex and concave conical contour and the film flow is radial from the apex toward the periphery of the conical clearance zone and in a direction generally counter-current to the forward impact strokes of the hammer, whereby additional surge turbulence is developed within the flowing stream.

With the above and other objects and features in view, the invention consists in the improved dispersion forming method and apparatus which is hereinafter described and more particularly defined in the claims.

In the following description reference will be had to the accompanying drawing, the single figure of which illustrates diagrammatically, partly in longitudinal section, apparatus representing a preferred embodiment of the invention.

As illustrated in the drawing, the preferred apparatus incorporates a two-sectioned housing 10 enclosing a chamber 12 into which a preformed and suitably proportioned coarse dispersion mixture of liquid dispersing medium and of finely divided solid or liquid material to be dispersed is fed under pressure by pumps 14 and 15 through a feed pipe 16. The delivery end of pipe 16 is threaded to engage threads in a central aperture 18 in the top section of the housing. A conical depression in the top section of the housing forms a smooth stationary anvil face 20 which is shaped and dimensioned to conform with the conical striking face of a hammer 22. Hammer 22 is mounted on a stem or rod 24 for reciprocation within chamber 12. A forward extension 25 of rod 24 is slidably journaled in aperture 18 as a guide to hold the hammer in central alignment with anvil 20. Rod extension 25 is provided with an axial bore 26 and communicating radial apertures 28 by which coarse dispersion entering aperture 18 may flow into an annular feed chamber 30 at the head of chamber 12.

The fine dispersion which is produced by radial expansion flow of the coarse dispersion in a thin film through a flow restriction clearance

zone 32 between the faces of the hammer and anvil is collected at the bottom of chamber 12 and may be withdrawn through a draw-off pipe 34. Before entering zone 32 the coarse dispersion flows from chamber 30 through a disintegration zone 35 of somewhat greater clearance than zone 32 wherein the substance to be dispersed is reduced to fine particle size. It will be understood that the working faces of the hammer and anvil may have matched convex and concave curvatures, or may have pyramidal or other suitable shapes, and that the longitudinal axes of the hammer and anvil may lie in inclined or horizontal planes.

A packing gland 36 is shown as disposed centrally in the bottom section of housing 10 at the point where the housing is apertured to journal the rod 24. The lower end of rod 24 is shown as enlarged to provide a target 37 for receiving successive upwardly delivered impacts of a reciprocating electro-magnetic plunger 38. Plunger 38 may be reciprocated with a short stroke and at high frequency (for example 60 per second or higher) by means of a solenoid 40 or equivalent source of vibration energy which is only illustrated partially and diagrammatically. Solenoid 40 is shown as disposed in properly spaced central alignment with rod 24 and as clamped in position by a collar 42 and by extensions of tie bolts 44 which couple the sections of housing 10 together.

The strokes of energizing plunger 38 and of hammer 22 may be very short, for example .001-.002 inch. Also the treating zone clearance between the working face of hammer 22 and the opposed working face of the anvil 20 at the upward extremity of the hammer stroke may be very small, for example, .001-.002 inch. Consequently it may be necessary to maintain a considerable pressure differential between feed chamber 30 and outlet pipe 34 to insure continuous flow of dispersion constituents in a thin film into and through the conical treating zone 32 between the hammer and anvil. In order to maintain hammer 22 in suitable low clearance relation to anvil 20 under the high feed pressure obtaining in chamber 30, a centrally apertured bracket 46 straddles rod 24 in adjustably spaced position below housing 10. Bracket 46 in turn carries a supporting base 48 for a compression coil spring 50. The top of spring 50 supports a collar 52 in tight engagement with a shoulder 54 of rod 24. By adjusting the position of bracket 46 the tension of spring 52 may be varied to counterbalance the pressure differential between feed chamber 30 and outlet 34 and to regulate within narrow limits the amount of clearance between the hammer and anvil, and the rate of flow of coarse dispersion through the treating zone. Suitable stops (not shown) may be used to positively limit the stroke of the hammer to maintain the clearance between the hammer and anvil within predetermined maximum and minimum limits.

In practicing the process of the invention a continuously flowing stream of preformed coarse dispersion may be forced in a thin film through a treating zone 32 of small cross-section and extensive area, and simultaneously subjected to the disintegration effect of rapidly repeated successive impact compression and withdrawal expansion forces applied at substantially right angles to the direction of flow. These forces are applied by a reciprocating hammer operating opposite a stationary anvil plate with a very short

stroke and at a high frequency. The intense beating and surge turbulence which is developed within and propagated by the liquid dispersing medium throughout the entire area of film between the hammer and plate surfaces operates in conjunction with the radial release of pressure by which the flow is developed through the treating zone, to effect rapid disintegration and fine dispersion with a relatively low power consumption and without substantial power dissipation by friction between the liquid and the hammer and anvil.

The apparatus has been designed so that its treating capacity can be easily regulated in accordance with the degree of dispersion which is sought and with the characteristics of the dispersion constituents. Adjustment of the rate of dispersion constituent throughput may be effected primarily by varying the pressure at which the coarse dispersion is supplied to the treating zone, by varying the thickness of film flow through the treating zone, and by varying the vibration frequency of the hammer. However, in addition to the above adjustments provided by the apparatus design as illustrated, it will be recognized that to meet a particular problem the area of the treating zone, and consequently the area of the film, can be changed to allow for treating a larger or smaller volume of dispersion constituents at one time within a film of predetermined thickness. Also the apparatus design may be changed to provide a longer or shorter film flow path, whereby to vary the number of hammer blows which can be imparted to a unit volume of dispersion mixture flowing through the treating zone to thereby regulate the degree of dispersion effected during the period of sojourn of the dispersion mixture in the treating zone.

According to the preferred apparatus design illustrated, the direction of flow of dispersion constituents through the treating zone is generally countercurrent to the direction of movement of the hammer on its forward or compression stroke. Under any design including the preferred design illustrated, the forward stroke of the hammer operates to squeeze the film and effect a temporary reversal of flow of the dispersion constituents in the treating zone, and to develop an inertia to forward flow during and immediately following each forward hammer stroke. Consequently the rate of flow of coarse dispersion into and through the treating zone bears an inverse proportional relation to the vibrational frequency of the hammer. With the pumps 14 and 15 developing a high pressure sufficient to force the coarse dispersion as a flowing film through the restricted treating zone, and with the hammer operating alternately in a direction with the forward flow to speed up such forward flow and to widen the flow path (during the withdrawal stroke), and to reduce the flow path and force reversal of the direction of fluid flow during the forward stroke, it will be appreciated that intense alternate compression squeezing and expansion cavitation forces are developed in the flowing film between the hammer and anvil, and that intense "wire drawing" forces are also developed in directions generally parallel to the direction of fluid flow. All of these forces cooperate to produce extreme turbulence and rapid effective disintegration and dispersion of the constituents throughout the area of the treating zone.

The term "substance" has been used in the 75 claims to define a solid, or a liquid which is im-

miscible with, the other liquid in which it is to be dispersed.

The invention having been thus described, what is claimed as new is:

1. A method of preparing fine dispersions of a substance of the class consisting of a solid and a liquid immiscible with the liquid with which it is to be admixed which comprises, forcing a coarse dispersion stream of the substance and liquid to flow in a confined stream as a thin film through a flow restriction clearance zone of substantial area and length, and subjecting said film to rapidly repeated alternate squeezing and expansion forces by alternately increasing and decreasing said clearance within narrow limits at a frequency sufficiently high to develop intense surge turbulence within the film to thereby effect fine dispersion formation.

2. A method of preparing fine dispersions of a substance of the class consisting of a solid and a liquid immiscible with the liquid with which it is to be admixed which comprises, forcing a coarse dispersion stream of the substance and liquid to flow in a confined stream as a thin film through a flow restriction zone of substantial area and length, and subjecting said film to rapidly repeated alternate compression and expansion forces at a frequency sufficiently high to develop intense surge turbulence within the film to thereby effect fine dispersion formation.

3. A method of preparing fine dispersions which comprises, forming a coarse dispersion mixture of a substance of the class consisting of solids and liquids and a liquid which is immiscible with the other liquid of the said dispersions and maintaining flow of a confined stream thereof in a thin film through a flow restriction treating zone of substantial area and length, and continuously varying the thickness of said film between maximum and minimum limits and subjecting the mixture therein to rapidly repeated alternate compression and expansion forces acting countercurrent to the direction of flow of the stream at a frequency sufficiently high to develop intense surge turbulence within the film to thereby effect disintegration and fine dispersion formation.

4. In dispersion forming apparatus, two relatively reciprocable members having oppositely disposed uniformly contoured working faces forming therebetween a fluid flow restriction clearance zone of substantial area and length, means for varying said clearance between restricted maximum and minimum limits by reciprocation of at least one of said members at high frequency, and a pump and connections arranged to force a preformed coarse dispersion to flow as a fluid stream in a thin film through the flow restriction clearance zone.

5. In dispersion forming apparatus, a hammer, means for reciprocating the hammer, a closed pressure tight chamber surrounding the hammer and having as one wall a stationary anvil face shaped to conform to the striking face of the hammer and disposed in close clearance relation thereto to cause a dispersion mixture to pass between the faces as a thin film, together with means for forcing a coarse dispersion of material to be dispersed and a liquid dispersing medium under pressure into the chamber and through the clearance space between the hammer and anvil.

6. In dispersion forming apparatus, a chamber having an anvil as one wall, a hammer mounted for reciprocation within said chamber, means for imparting short stroke blows at high frequency to said hammer, said anvil and hammer having oppositely disposed uniformly contoured and dimensioned working faces, and means for forcing a preformed coarse dispersion as a fluid stream in a thin film through the clearance space between said working faces.

7. In apparatus for forming dispersions, a chamber, a hammer mounted on a stem for reciprocation within said chamber, an anvil plate inner wall for said chamber disposed in parallel close clearance relation to the working face of the hammer, the oppositely disposed faces of said plate and hammer being shaped to form therebetween a dispersion forming zone of substantial area and uniform clearance, means outside the chamber for imparting successive impacts at high frequency to the hammer stem, means for forcing a preformed coarse dispersion to flow in a confined stream as a thin film into and through the clearance space between said plate and hammer, and means for adjusting said clearance.

8. In dispersion-forming apparatus, a closed pressure tight treating chamber, a hammer mounted for reciprocation within said chamber, means to reciprocate the hammer with a short stroke at high frequency, a wall for said chamber having a lining shaped to form an anvil face which conforms in contour with the striking face of the hammer and which is disposed in close clearance relation thereto to cause a dispersion mixture to pass between the faces as a thin film, and means for forcing a coarse dispersion mixture to flow through the clearance space between the faces of the hammer and anvil in a direction generally countercurrent and at right angles to the direction of impact blows of the hammer.

9. In dispersion forming apparatus, a closed pressure tight treating chamber, a hammer mounted within said chamber, means to reciprocate the hammer with a short stroke at high frequency, a wall for said chamber having a lining shaped to form an anvil face which conforms in contour with the striking face of the hammer and which is disposed in close clearance relation thereto to cause a dispersion mixture to pass between the faces as a thin film, a pump and connections for forcing a coarse dispersion mixture to flow as a stream through the clearance space between the hammer and anvil, and means for adjusting the clearance between the hammer and the anvil.

10. In dispersion forming apparatus, a treating chamber, a hammer mounted for reciprocation within said chamber through a short stroke at high frequency, a wall for said chamber having a lining shaped to form an anvil face which conforms in contour with the striking face of the hammer and which is disposed in close clearance relation thereto, a pump and connections for forcing a coarse dispersion mixture to flow in a confined stream as a thin film through the clearance space between the hammer and anvil, and a counter balancing spring operatively connected to said hammer whereby to hold said hammer in adjustably spaced clearance relation to the anvil against the pressure developing film flow.

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