METHOD AND DEVICE FOR PRODUCING UNIFORM DISPERSIONS

Filed Dec. 22, 1965 3 Sheets-Sheet 1

FIG. 1

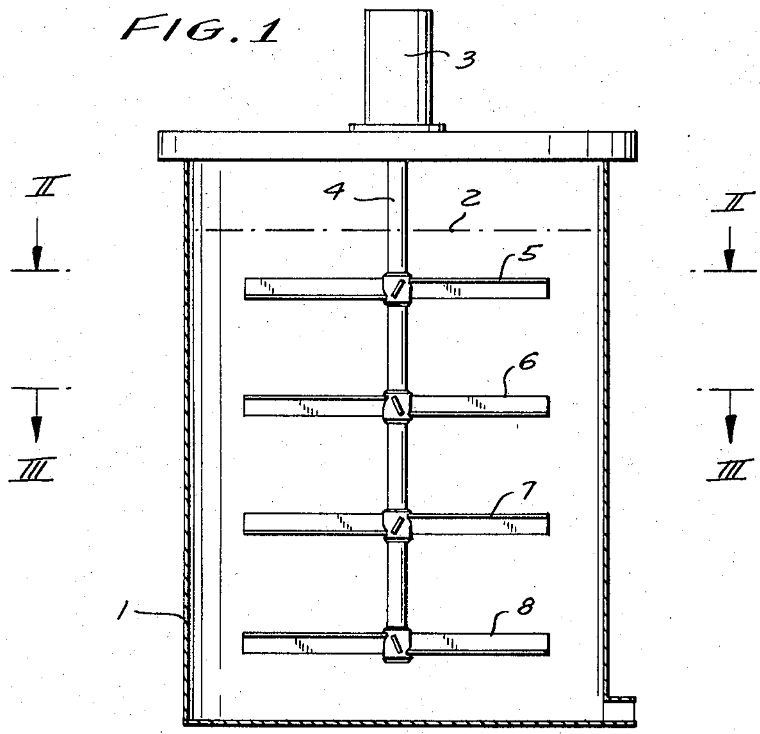

FIG. 2

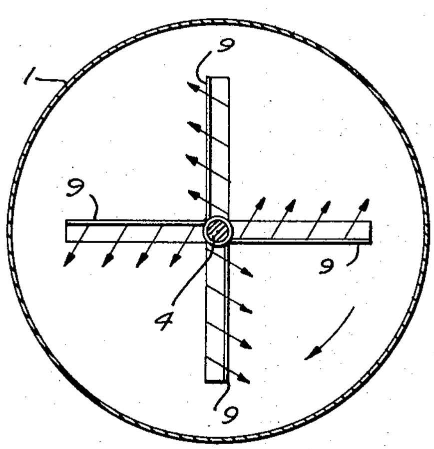

FIG. 3

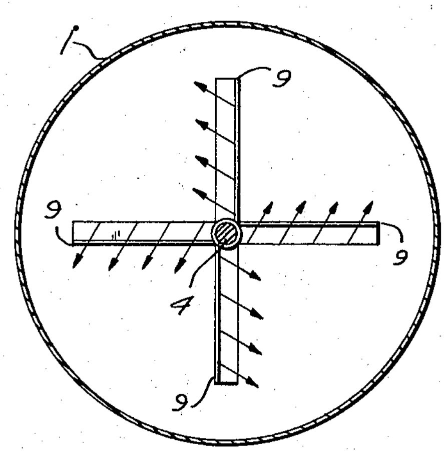

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FIG. 4

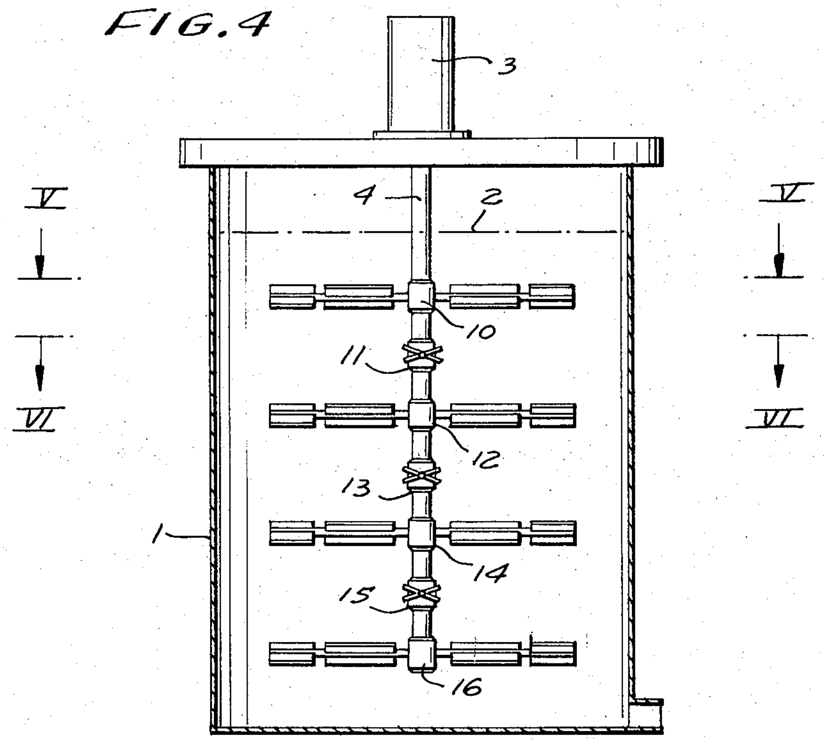


FIG. 5

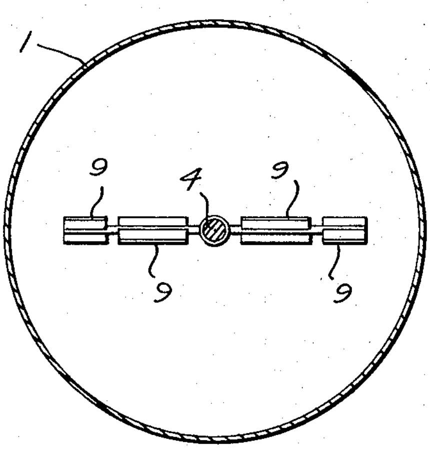
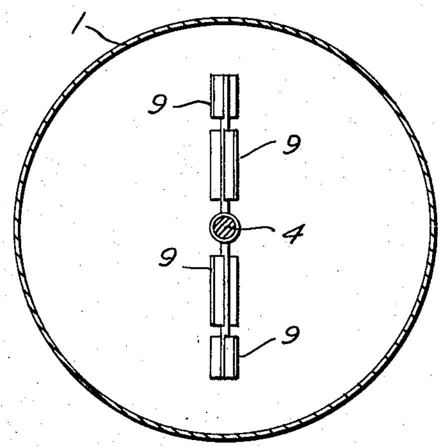


FIG. 6



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METHOD AND DEVICE FOR PRODUCING UNIFORM DISPERSIONS

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FIG. 7

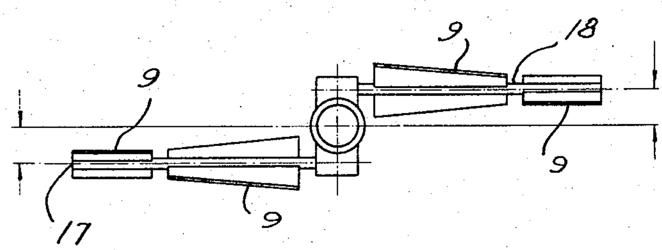
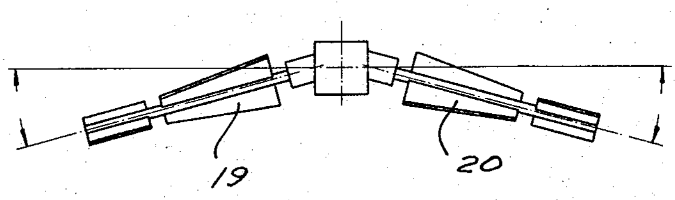


FIG. 8



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METHOD AND DEVICE FOR PRODUCING UNIFORM DISPERSIONS

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5 Claims. (Cl. 259—107)

ABSTRACT OF THE DISCLOSURE

A uniform dispersion of subdivided material in a liquid is produced by confining a body of liquid which contains such subdivided material in an upright chamber of uniform unobstructed cross section throughout substantially the entire length thereof, and imparting to the subdivided material-containing body of liquid in the chamber in a plurality of superposed zones in radial and tangential direction a turbulent flow having in the axial direction of the chamber a component of movement of such strength as to cause intrusion of liquid from the respective zones into adjacent zones so as to create in the liquid of such adjacent zones eddy currents resulting in intimate mixing of the liquid and the subdivided material and information of a uniform dispersion; and a stirring device for carrying out the above process which comprises a single unobstructed upright chamber for the subdivided solids-containing liquid, with a shaft at least partially located and coaxial with the chamber, and a plurality of sets of stirring blades carried by the shaft within the chamber and located in the respective zones, whereby each of the sets of stirring blades comprises a plurality of blades respectively extending transversely of the shaft from the region thereof towards the periphery of the chamber and whereby consecutive blades in each set of blades are oppositely inclined with respect to an axial plane of the chamber, and each of the blades has a portion located in a common plane with a portion of a blade in an axially adjacent set and these portions of blades in adjacent sets are inclined to the common plane in mutually opposite directions.

The present invention relates to a method and device for producing uniform dispersions of gases and/or liquids and/or solid materials in a continuous liquid phase.

Several devices are known for more or less evenly distributing gases or liquid or solid materials in liquids. These devices include rotating or oscillating stirring members, and—under particularly advantageous conditions—may occasionally produce dispersions. Many attempts were made with stirring members or arrangements of various kinds to produce dispersions of subdivided gases or liquids or solid material in a continuous liquid phase in a reliable manner, however, generally, the results obtained thereby were unsatisfactory since the methods and devices proposed up to now do not lead to an even distributon of the dispersed phase in the continuous phase throughout the entire contents of the dispersion vessel or container holding the liquid phase and the subdivided material which is to be distributed therethrough. Even in cases of relatively small differences in the densities of the dispersed and continuous phases, these methods and devices do not operate satisfactorily.

Frequently, leaf stirrers of large surface area are used, however, primarily a horizontal rotation of the entire content of the container is achieved thereby without a substantialy vertical flow component within the mass which is to be dispersed.

Stirring as it may be accomplished, for instance, with propeller or disk stirrers, or by pumping with turbines or centrifugal pumps, even if several stirring devices are arranged on one and the same drive shaft, and even if flow deflecting obstructions in the suspension vessel tend to form several separate mixing zones, also do not assure the desired result. Anchor and finger stirrers with high ratio of stirrer diameter relative to the inner diameter of the suspension vessel and with relatively small radial width of the stirring members, will cause rotation of the contents of the suspension vessel, however, will not cause a sufficient vertical flow which, as has been found in accordance with the present invention, is a decisive prerequisite for producing uniform dispersions by means of properly shaped and operated stirring devices. Furthermore, the results obtained with the devices generally used up to now were greatly dependent, with respect to dispersion of the material, on the frequently varying height of the liquid mass in the dispersion container, and this dependency creates further difficulties with respect to arriving at an orderly procedure for producing suspensions so as to obtain reproducible results.

It is therefore an object of the present invention to overcome the above difficulties and disadvantages.

It is a further object of the present invention to provide a method and apparatus for forming uniform dispersions of gaseous, liquid or solid material in a continuous liquid phase, which method may be carried out in a simple and economical manner and which apparatus or device is of relatively simple and economical construction.

It is yet another object of the present invention to provide a method and device for producing uniform dispersions which requires relatively little power.

Other objects and advantages of the present invention will become apparent from a further reading of the description and of the appended claims.

With the above and other objects in view, the present invention contemplates a method of producing in a liquid a uniform dispersion of subdivided material, comprising the step of forming in a body of the liquid containing the subdivided material a plurality of superposed zones of turbulent flow in axial, radial and tangential direction, the axial flow being sufficient to cause intermingling of liquid of at least one of the zones with liquid of adjacent ones of the zones, thereby forming at least of marginal portions of the adjacent zones marginal zones of turbulent countercurrents and causing intimate mixing of the liquid and the subdivided material so as to form a uniform dispersion thereof.

The present invention in also concerned with a stirring device for producing in a liquid a uniform dispersion of subdivided material, comprising, in combination, container means for holding a liquid therein, a shaft at least partially located in the container means; and a plurality of sets of stirring blades located within the container means and each set of blades fixed to the shaft and extending outwardly from the region of the shaft in planes, respectively, superposed and spaced from adjacent sets of blades, the blades in each set of blades extending outwardly from the shaft, and consecutive blades in each set of blades being oppositely inclined with respect to each other.

According to various preferred embodiments of the stirring device of the present invention, the blades of the various sets of blades may extend in a direction parallel to the radii extending from the shaft, or in such directions as to form angles with the radii extending from the shaft. Preferably, the shaft extends in upward or vertical direction, the blades of each set of blades are directly fixed to the shaft and extend outwardly from the shaft in a direction substantially perpendicular to the same, such as a horizontal direction if the shaft extends vertically.

Suitable drive means are provided for rotating the shaft and the sets of blades fixed thereto. These drive means, per se, may be conventional.

The blades of the superposed sets of blades may be equally arranged but with corresponding blades of adjacent sets being oppositely inclined.

It is also within the scope of the present invention to provide individual blades which include an outer portion, and an inner portion interposed between the shaft and the outer portion, whereby the inner and outer portions of each blade are oppositely inclined with respect to each other.

According to one embodiment of the present invention, two, three, four or more blades may be advantageously arranged in each set of blades, and, if the number of blades in one set of blades is four, then the blades are preferably so arrnaged as to define between themselves angles of about 90°.

Each blade, as it extends from the shaft, may be subdivided in longitudinal direction of the blade into several portions which are oppositely inclined relative to each other whereby, if two blades define between themselves an angle of about 180°, blade portions equidistant from the shaft preferably are similarly inclined (of FIGS. 5 and 6).

It has been found, according to the present invention, that a very uniform distribution of the dispersed phase can be obtained and thus very uniform dispersion of gas and/or liquid and/or solid materials in a liquid continuous phase can be achieved, if the materials which are introduced into the continuous liquid phase and which are to form the dispersed phase, as well as the continuous liquid phase, are subjected to intermittent axial, radial and tangential or peripheral acceleration.

This is accomplished with the device of the present invention by arranging several superposed sets of stirring blades with adjacent blades within one set being oppositely inclined so that within the dispersion vessel several superposed preferably horizontal zones of turbulence are formed in which the turbulent flow includes a sufficiently strong flow in axial direction, i.e., in a direction substantially parallel to the drive shaft, so that in adjacent marginal portions of superposed turbulent zones countercurrents are formed which are induced by impulses and which may simultaneously cause a reversal of the rotational direction of the turbulences.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

FIG. 1 is a schematic elevational view of a stirring device according to the present invention;

FIG. 2 is a schematic horizontal cross sectional view, taken along the line II—II of FIG. 1;

FIG. 3 is a horizontal schematic cross sectional view of the stirring device as shown in FIG. 1 taken along the line III—III;

FIG. 4 is a schematic elevational view of another embodiment of a stirring device according to the present invention;

FIG. 5 is a schematic cross sectional view taken along line V—V of FIG. 4; and

FIG. 6 is a schematic cross sectional view taken along line VI—VI of FIG. 4.

FIG. 7 is a schematic horizontal cross sectional view of a third embodiment example of a stirring device according to the present invention whereby one set of blades comprises two subdivided stirring blades.

FIG. 8 is a schematic elevational view of a fourth embodiment example of a stirring device according to the present invention.

Referring now to the drawing and particularly to FIGS. 1–3, it will be seen in FIG. 1, that the stirring device comprises four sets of blades identified, respectively, by reference numerals **5**, **6**, **7** and **8**, which blades are so arranged that adjacent blades within each set are oppositely inclined and thus, upon rotation of the set, will cause the formation of countercurrents. The four sets of blades are fixed to a drive shaft **4** which in turn is rotated by motor **3**. The upper level **2** of the liquid mass in the dispersion container is located above uppermost set of blades **5**.

FIG. 2 illustrates one of the sets of stirring blades, namely set **5**, with the upward side edge of the individual blades indicated by reference numeral **9**. By rotating shaft **4** in the direction of the arrow in FIG. 2, the mixture of the liquid continuous phase and of the material which is to be dispersed therein will be pushed by four blades of set **5** alternatingly in upward and downward direction.

FIG. 3 illustrates in a manner similar to that of FIG. 2 the set of blades **6**, and it will be seen that the direction of movement imparted by the blades in FIG. 3, wherein again the upper edge of the respective blades is indicated by reference numeral **9**, will be opposite to that of the corresponding blades of FIG. 2.

In other words, if the individual blades of sets **5** and **6** are directly superposed upon each other, then one of two directly superposed blades will impart downward movement and the other upward movement to the liquid mass contacted by the blades upon rotation of shaft **4**.

Referring now to the embodiment of the present invention illustrated in FIGS. 4–6, it will be seen that according to this embodiment the material, which is to be dispersed in the liquid filling the container up to level **2** will be put in motion by rotating blades which within each set of blades located in substantially one plane will comprise inclined blades which alternatingly will impart a movement in the direction of rotation and in opposite direction to the liquid with which the blades come in contact, thereby causing a mixing of the liquid mass so that even portions thereof which are of a greater specific weight will be pushed up to the surface **2** of the liquid mass and even portions of lesser specific weight will be pushed downwardly towards the bottom of container **1** by a series of continuously changing impulses. Thereby, upon rotation of shaft **4**, an intimate and even mixing of the dispersed material and of the continuous liquid phase will be accomplished.

Within each set of blades, the individual blades are arranged substantially within one horizontal plane and, according to the illustrated example, the two blades of each set of blades are respectively subdivided in radial direction into an outer and an inner portion which are oppositely inclined and which will have the effect of causing turbulence extending into the turbulent zone formed by the adjacent higher or lower set of blades.

The stirring device of FIGS. 4–6 comprises seven sets of blades indicated by reference numerals **10**, **11**, **12**, **13**, **14**, **15**, and **16**, each set of blades comprising two subdivided blades forming between themselves an angle of 180°, and adjacent sets of blades form with each other angles of 90°.

Similar to FIG. 1, the container **1** carries a motor **3** for rotating shaft **4**, and shaft **4** carries the seven sets of blades **10–16**. The level of liquid within the container is above the uppermost set of blades **10**. FIG. 5 illustrates the set of blades **10**, and here again the upwardly directed edge portions of the blades are indicated by reference numeral **9**. It will be seen that these upwardly extending edge portions alternate, or that the individual blade portions are successively inclined in opposite directions. The upper edges of the blades are also shown in double lines.

FIG. 6 illustrates the next lower set of blades **11** which forms with set of blades **10** an angle of 90°. Here again, the upper edges of the blade portions are indicated by reference numeral 9 and are arranged in a manner similar to that described in connection with FIG. 5.

Due to the different inclination of the blade portions of each blade, the liquid mass in the vicinity of shaft 4 will be moved in an axial direction opposite to the axial direction in which the liquid mass affected by the outer portions of blade 9 is moved.

Referring now to FIG. 7 of the drawing it will be seen indeed, that the two subdivided stirring blades 17 and 18 lie in the same horizontal plane, but they extend in a direction parallel to the radii extending from the shaft and to one another.

FIG. 8 illustrates in a schematic elevational view a set of two blades in a vertical plane containing the axis of a stirring device according to the present invention. Each blade as it extends from the shaft is subdivided in longitudinal direction of the blades into two portions which are oppositely inclined relative to each other. Moreover the two blades define between themselves in a horizontal plane an angle of 180°. The axis of the shaft is the bisector of the angle between the two blade axes. The surface of revolution described by the blades is a cone-shaped shell.

It may be said that in accordance with the present invention the dispersion is formed by impulses which occur upon violent contact or collision between liquid streams flowing in opposite direction, and thus the present method may also be identified as an impulse-counter-current method for producing uniform dispersions.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of stirring devices, differing from the types described above.

While the invention has been illustrated and described as embodied in a stirring device including a plurality of superposed sets of stirring blades of opposite inclination relative to each other, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge readily adapt it for various applications without omitting features, that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

I claim:

1. A stirring device, particularly for producing in a liquid a uniform dispersion of subdivided material, comprising, in combination, container means defining a single unobstructed upright chamber arranged to accommodate a liquid therein; a shaft at least partially located in and coaxial with said chamber; and a plurality of sets of stirring blades carried by said shaft within said chamber and located in respective axially spaced parallel planes, each of said sets comprising at least two blades respectively extending transversely from opposite sides of said shaft towards the periphery of said chamber, each of said blades having radially consecutive oppositely inclined portions and in each set of blades the consecutive portions of one of the two blades being inclined oppositely to the corresponding blade portions of the other of said blades.

2. A stirring device for producing in a liquid a uniform dispersion of subdivided material as defined in claim 1, wherein the blades of each set of blades extend in substantially horizontal direction.

3. A stirring device for producing in a liquid a uniform dispersion of subdivided material as defined in claim 1, wherein axially adjacent blades are arranged so as to define between themselves angles of about 90° and wherein the blade portions of each set are inclined oppositely to the corresponding blade portions of the axially adjacent set.

4. A stirring device for producing in a liquid a uniform dispersion of subdivided material as defined in claim 1, wherein said blades, respectively, of said sets of blades extend in directions parallel to the radii extending from said shaft.

5. A stirring device for producing in a liquid a uniform dispersion of subdivided material as defined in claim 1, wherein said blades, respectively, of said sets of blades define angles with radii extending from said shaft.

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