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[54] **DEVICE FOR CONTINUOUSLY MIXING OR REACTING LIQUIDS**

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[51] **Int. Cl.** **B01f 7/26,** B01f 3/08

[58] **Field of Search** 259/6, 104, 21, 41, 259/64, 22, 23, 24

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[57] **ABSTRACT**

A device for continuously mixing or reacting liquids has a cylinder with a plurality of spaced radial liquid inlets intermediate its ends for sequentially adding liquid and an outlet. An agitator having two or more shafts disposed parallel with the axis of said cylinder also has a plurality of blades fixed on the respective shafts for extremely restricting the mixture and agitation of the liquids on the axial direction but mainly drives the added liquids radially.

4 Claims, 4 Drawing Figures

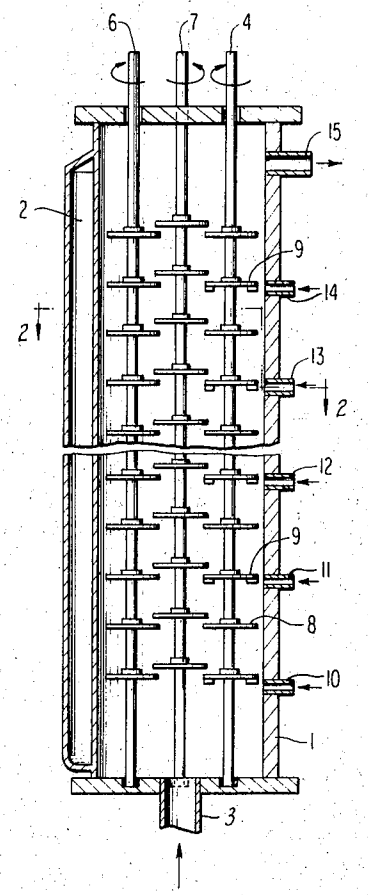


FIG.1

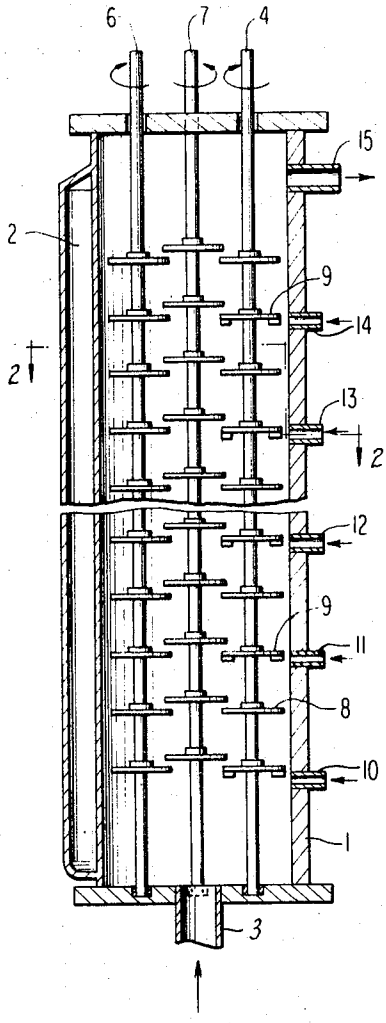


FIG.2

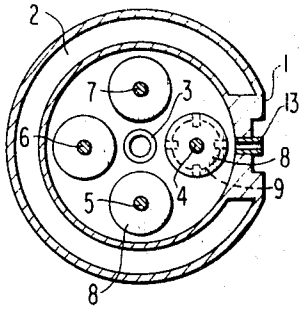
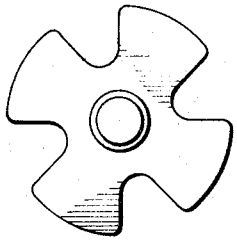


FIG.3



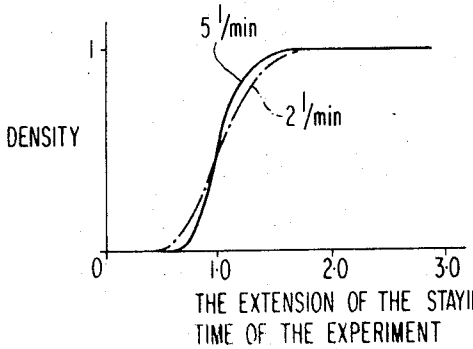


FIG.4

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DEVICE FOR CONTINUOUSLY MIXING OR REACTING LIQUIDS

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

This invention relates to a device for continuously mixing or reacting two or more types of liquids, and more particularly to a device for continuously fabricating silver halide emulsion for photographic photosensitive material.

2. DESCRIPTION OF THE PRIOR ART

Generally, in order to continuously mix or react liquids so as to obtain uniform and superior quality of material, the following points are considered:

1. Immediately after different types of liquids to be mixed or reacted to each other are mixed, the mixture of the liquids must be made uniform. If there exists partial irregularity of the mixture of the liquids, difference of reacting speeds of the liquids occurs with the result that it becomes difficult to obtain uniform quality of product.
2. The mixture of the liquids must be completely uniform in composition until the next added solution is applied. This is because the subsequent mixture and reaction of the liquids become irregular with the result that the effect of the solution is reduced or detrimental product extremely deteriorates the quality of the mixture.
3. The staying time of the liquid in the device must not be extended. The extension of the staying time of the liquids in the device produces the extension of the performance distribution of the composition of the liquids passing through the device.

The necessity of stable time and the loss of the products due to the existence of the transient state at the start-up and before stopping are frequent troubles in a continuous process of mixing the liquids and exist mostly from the extension of the staying time in the device resulting in difficulty of exchange of type of product in the continuous fabricating device.

Heretofore, if the aforementioned mixture and reaction were continuously conducted, there have been used, for example, a continuous tank type in which several mixers and reactors consisting of agitators and tanks are disposed serially wherein the tanks are connected in turn; a type in which several pipe line mixers are serially disposed; a cylindrical agitator having upper and lower partitions of the agitating blades for preventing the liquids from mixing reversely by the agitating blades; or an orifice tower type having a porous plate as a shelf in the cylinder.

The former three types may provide uniform density quickly from the mixed liquids and may also mix the solution according to a predetermined order, but are difficult due to the increase in the staying time of the liquids in the mixer and reactor and the parts are also difficult to partially clean.

The last one of orifice tower type may prevent relatively the extension of the staying time, but is difficult to uniformly mix and to clean it.

Thus, these conventional types of the mixers and reactors are not adapted to a continuous process in which uniformity of the quality of product and of mixture are important with the result that such mixture and reaction must be conducted by fabricating processes divided into sections.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a device for continuously mixing or reacting liquids which does not lose the merits of the conventional process for extremely restricting the extension of the staying time of the liquids in the device without difficulty of cleaning and fabrication of mixture.

It is another object of the present invention to provide a device for continuously mixing or reacting liquids which has a short time from the start-up to stable state of the process.

According to one aspect of the present invention, there is provided a device for continuously mixing or reacting liquids which comprises a cylinder having a plurality of liquid inlets and an outlet for mixing or reacting liquids, an agitator having two or more shafts disposed parallel with the axis of said cylinder and also having a plurality of blades fixed on the respective shafts for extremely restricting the mixture and agitation of the liquids in the axial direction but freely flowing the liquids radially.

BRIEF DESCRIPTION OF THE DRAWINGS

The other objects, features and advantages of the present invention will become apparant from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a longitudinal sectional view of one embodiment of the device constructed in accordance with the present invention;

FIG. 2 is a sectional view of the device taken along the line 2—2 in FIG. 1;

FIG. 3 is a view of an agitating blade used in the device formed according to the present invention; and

FIG. 4 is a graph showing the extension of the staying time of one experiment using the device of this invention.

Reference is now made to the drawings, particularly to FIG. 1, which shows one embodiment of the device constructed according to the present invention.

Reference numeral 1 illustrates a cylindrical body for mixing or reacting liquids, 2 a jacket for holding liquid in the body at a predetermined temperature, 3 an axial inlet for a first liquid to be mixed or reacted liquid, shafts 4, 6 and 7 for agitating blades 8 and 9 connected to drive means (not shown) such as an electric motor through mechanical seals or bearings fixed to the upper and lower walls of the cylinder. The agitating blades 8 and 9 are thin planar disc shape for flowing the liquids radially. 10 to 14 show radially disposed adding inlets provided at the side wall of the cylinder for introducing respectively, other liquids to be mixed with or reacted to the first liquid in order into the cylinder, 15 is an outlet for discharging mixed or reacted liquid out of the cylinder.

In operation of thus constructed device of this invention, the first liquid is introduced into the cylinder 1 through the inlet 3 by liquid feeding means such as a pump (not shown) and is obliged to flow rotatably in the rotating direction of the agitating blades 8 and 9 in the cylinder 1 by the rotary force of the agitating blades 8 and 9. Thus, the first liquid moves rotatably in the direction perpendicular to the axis of the cylinder with sufficiently stirring, at the same time, the first liquid is carried to the outlet 15 along the axis of the cylinder as a whole. While other liquids introduced into the cyl-

inder 1 through respective inlets 10 to 14 are also obliged to flow in the rotating direction of the agitating blades 8 and 9 as a rotary flow in the cylinder by the action of agitating blades provided near respective inlets 10 to 14 and mix with the first liquid in turn. And, since respective liquids introduced into the cylinder 1 through the inlets 10 to 14 do not flow down in the axial direction of the cylinder 1 by the action of agitating blades 8 and 9, respective liquids are never mixed in the reverse order and the staying time of the liquid in the cylinder 1 is not so extended. Thus, all liquids are mixed uniformly and speedily in predetermined order. In an additional effect of the device of the present invention, a plurality of agitating blades provided perpendicularly to the axis of the cylinder function to lessen a stationary rotating portion of liquid around the shafts, so that the liquids are further uniformly and effectively mixed.

The device of the invention will now be further described in detail with respect to its specifications.

The inner diameter of the cylinder may be selected depending upon the type of reaction, reacting time, treating capacity, etc., and also depending upon the number of agitating shafts and the size of the agitating blades. The number of shafts of the agitator must be at least two or more, and may preferably be four. The shape of the agitating blades must be, for example, of circular disc shape as shown in FIGS. 1 and 2 such that the axial mixing and agitating of the liquids is extremely restricted but the liquids to be sequentially mixed are mainly flowing during mixing in the direction perpendicular to the axis of the cylinder, and the thickness of the blades may preferably be of 1 to 5mm, the diameter of the blades may preferably be one-fourth to one-half the inner diameter of the cylinder. The distance between the agitating blades on the same shaft may preferably be 20 to 60 mm. The number of revolutions of the agitating blades may preferably be 400 to 500 rpm, and if it is excessively low, the mixing becomes worse, while if it is excessively high, the staying time of the liquids is extended due to the reverse mixing. The rotating direction of the blades may be in the same direction, or may partially be in the reverse direction. The distance and number of the radial inlets mounted at the wall of the cylinder may be determined depending upon the number of the solution or liquids and adding capacity and mixing time. There exist some upward and downward flows near the inlets for the liquids but there exist mainly radial flows, and if turbine blades superior in spattering force are provided, the mixing of the liquid, restriction of the liquid of the upward and downward flows and prevention of extension of staying time are improved effectively.

In order to further clarify the features and advantages of the device of this invention, the distribution of the staying time and mixture will now be described with respect to the following examples.

EXAMPLE 1

Conditions of Device:
- Diameter of cylinder: 80 mm
- Length of cylinder: 2000 mm
- Number of agitating shafts: 4
- Direction of agitating shafts: the same direction
- Number of revolution: 700 rpm
- Diameter of agitating blades: 30 mm
- Shape of agitating blades: Circular disc
- Distance between agitating blades: 40 mm

Conditions of Liquids:
- High polymer solution for photographic photosensitive material
- Viscosity: 40 CP
- Specific weight: 1.1
- Flow rate: 2000 cc/min. and 5000 cc/min.
- Tracer: non-spattering, water-soluble coloring matter.

As a result of examination of staying time distribution and degree of mixture with the above conditions, the non-dimensional staying time expressing the extension of the staying time was 0.6 to 1.4. In comparision of this result with the result of the conventional similar experiment, the result of the device of this invention is seen greatly improved. And, the liquid at the axial distance of 30 mm from the inlets became completely uniform in density.

As seen fom the above description, one feature of the device of this invention is such that the device comprises a plurality of rotary shafts in a reactor and agitating blades provided on the shafts so that the mixture and agitation of the liquid in the axial direction are extremely restricted but the radial flow of the liquid is freely provided in design so as to prevent the upward and downward mixture of the liquids but to improve the radial mixture.

Another example of the device of this invention to the fabrication of silver halide emulsion for photographic photosensitive material will now be described in the following Example.

EXAMPLE 2

Conditions of Device:
- Inner diameter of reactor: 100 mm
- Length of reactor: 1500 mm
- Number of agitating shafts: 4
- Rotating directions of the shafts: 2: clockwise 2: counterclockwise
- Number of revolutions: 500 rpm
- Diameter of agitating blades: 35 mm
- Shape of agitating blades: Planar circular disc
- Distance between the blades: 40 mm

Conditions of Liquids:
- Silver halide emulsion for photographic photosensitive material
- Viscosity: 30 CP
- Specific weight: 1.2
- Flow rate: 3000 cc/min.
- Adding organic compounds: three types of methanol solutions
- Flow rate 50 cc/min – 300 cc/min.
- Inorganic compounds: four types of water solutions
- Flow rate: 50 cc/min. – 500 cc/min.

As a result of this experiment, the silver halide emulsion for photographic photosensitive material which does not produce foreign materials due to the reaction of the liquids and which is of high quality is fabricated stably at 30 seconds after starting.

Thus, the present invention provides the effects such that: '1. Uniform mixture of liquids is quickly obtained.
2. Extension of staying time is lessened so as to provide uniform quality of mixture.
3. Transient losses of the liquid at the starting and stopping are eliminated.
4. Cleaning is easy.

As indicated in FIG. 4, the concentration of the secondary liquids within the first liquid is plotted in terms of the residence time of the liquids within the cylinder for flows in terms of five feet per minute and two feet per minute, respectively. Where the density reaches or approaches one, indicative of complete and uniform concentration, which is the desired end result, there is relatively little extension in the staying time by the apparatus of the present invention for, particularly, increased flow rates.

What is claimed is:

1. A device for continuously mixing or reacting a plurality of liquids comprising:

a cylinder having an inlet for receiving a first liquid at one end, and an outlet for discharging the same at the opposite end,

a plurality of axially spaced, radially directed second liquid inlets on the wall of said cylinder, and being disposed intermediate of said first liquid inlet and said outlet, and

an agitator comprising at least two rotatable shafts disposed within said cylinder, said shafts extending parallel to the longitudinal axis of said cylinder, each shaft including a plurality of axially spaced disc-shaped blades at respective positions in planes substantially common to the axes of said second liquid inlets,

and said disc-shaped blades mounted on said shaft nearest said second liquid inlets and lying in the same plane therewith carrying means for impelling said second liquids entering the cylinder from said second liquid inlets in a radial direction relative to said cylinder to mix said second liquids sequentially with said first liquid; whereby, rotation of said shafts cause mixture and agitation of the liquids in directions radial to the longitudinal axis of the cylinder but restricts mixture and agitation of the liquids in an axial direction to effect sequential, complete and uniform mixing of the second liquids with the first liquid in the direction of said liquid outlet.

2. The device as claimed in claim 1, wherein said means for impelling said second liquids in a radial direction comprises circumferentially spaced, radial projections adjacent the peripheries thereof, in the path of the incoming respective second liquids.

3. The device as claimed in claim 2, wherein said shaft nearest said second liquid inlets further carries a plurality of axially spaced, disc-shaped blades at positions intermediate said blades carrying said impelling means to further restrict mixing and agitation of the liquids in an axial direction.

4. The device as claimed in claim 1, wherein said shaft nearest said second liquid inlets further carries a plurality of axially spaced, disc-shaped blades at positions intermediate said blades carrying said impelling means to further restrict mixing and agitation of the liquids in an axial direction.

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