

Sept. 10, 1968

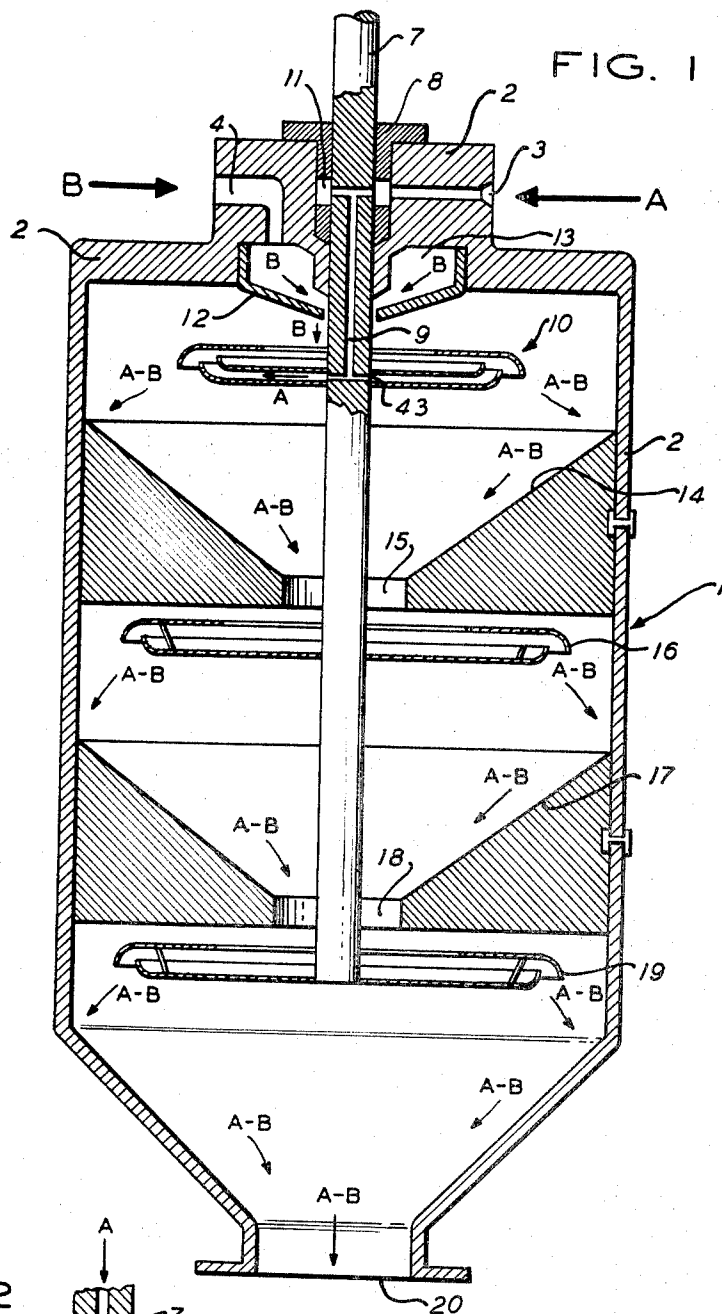
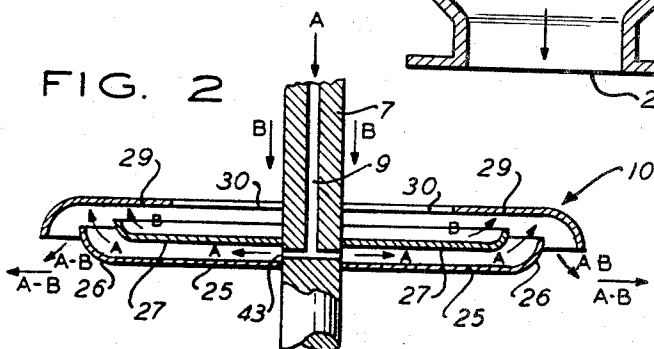
TSUNEO ONISHI ET AL

3,400,915

RAPID MIXING APPARATUS

Original Filed April 29, 1964

2 Sheets-Sheet 1



INVENTORS
TSUNEO ONISHI
YOSHIRO HIGASHIYAMA
KATSUO AKAO

John A. Casper
AGENT

Sept. 10, 1968

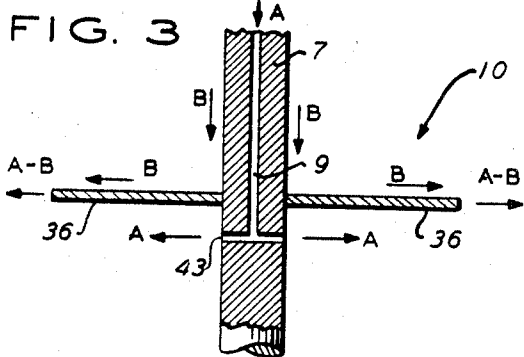
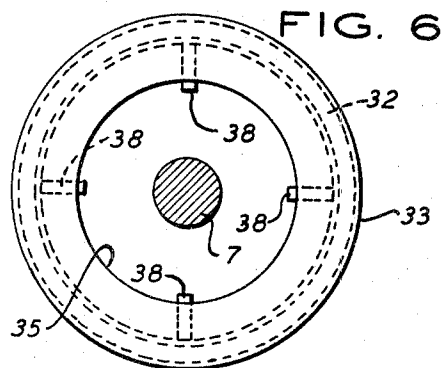
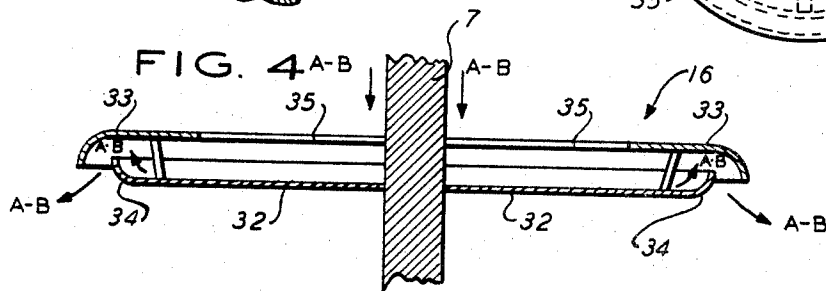
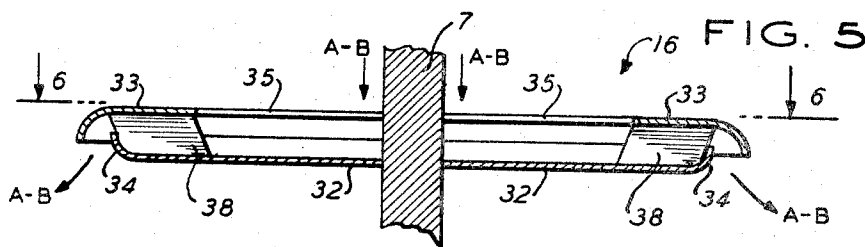
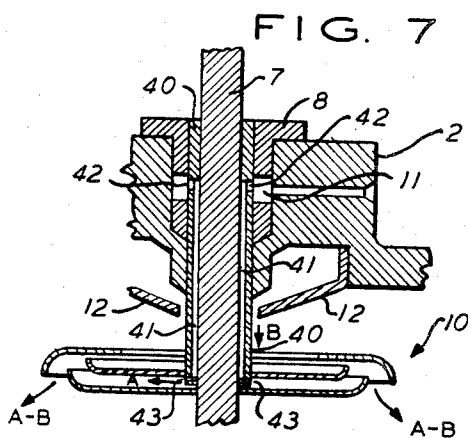
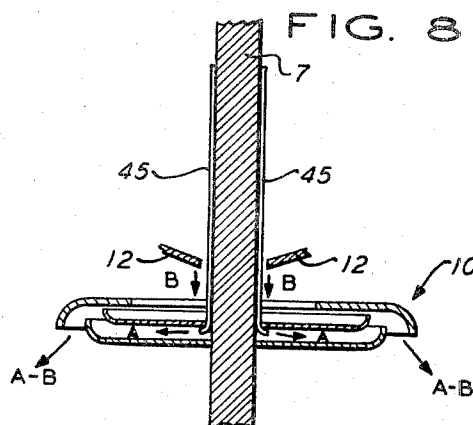
TSUNEO ONISHI ET AL

3,400,915

RAPID MIXING APPARATUS

Original Filed April 29, 1964

2 Sheets-Sheet 2



INVENTORS
TSUNEO ONISHI
YOSHIRO HIGASHIYAMA
BY KATU SO AK AO

John A. Casper
AGENT

1

3,400,915

RAPID MIXING APPARATUS

Tsuneo Onishi, Yoshiro Higashiyama, and Katsuo Akao,
Toyama, Japan, assignors to Kurashiki Rayon Co., Ltd.,
Kurashiki-shi, Okayama Prefecture, Japan, a corpora-
tion of Japan

Continuation of application Ser. No. 363,554, Apr. 29,
1964. This application Nov. 28, 1966, Ser. No. 597,475
Claims priority, application Japan, May 11, 1963,
38/24,810

3 Claims. (Cl. 259—8)

ABSTRACT OF THE DISCLOSURE

A multi-stage mixer for rapidly mixing two or more liquids of different viscosities comprising a chamber with a vertical longitudinal axis having a central vertical rotatable shaft therein mounting a first centrifugal mixer composed of three closely-spaced horizontal plates followed by a funnel-shaped stage partition below, which, in turn, is followed by one or more centrifugal mixers each composed of two closely-spaced horizontal plates, with other funnel-shaped stage partitions serving to separate the mixing stages below the first. Two or more liquids are fed centrally into the first stage through separate channels and progress downwardly through the various stages, exiting through a central discharge outlet.

This application is a continuation of application Ser. No. 363,554, filed Apr. 29, 1964, now abandoned.

This invention relates to apparatus and procedures for effecting continuous mixing of solutions and is more particularly concerned with apparatus and procedures and methods for rapidly mixing solutions having different viscosities.

Many mixing devices and many mixing procedures are known in the art. While these mixing devices have merit, they are in many cases not entirely satisfactory for certain mixing problems. For example, when mixing two or more liquids, where one has a high viscosity compared to the other liquid, it has been difficult to use the conventional procedures and equipment to obtain satisfactory mixing in a short period of time. Further, when the liquids being mixed react and form a solid reaction product, one encounters problems if satisfactory and uniform mixing is not obtained in a short time; in that the reaction may proceed to the point where the solid reaction products will be present in the mixing machine and interfere with the mixing procedures. In this case it is desirable that uniform mixing take place in as short a period as possible, in order that solid reaction products will not be present in the mixing apparatus. This problem becomes especially important with regard to the production of polyvinyl alcohol. For example, polyvinyl alcohol may be prepared by mixing a solution of polyvinyl acetate-methanol with a caustic soda solution, whereby the polyvinyl acetate is saponified. In preparing polyvinyl alcohol by these procedures it has been found that it is especially desirable that the polyvinyl acetate-methanol solution and the caustic soda solution be uniformly mixed within a short period of time in order that a polyvinyl alcohol of uniform quality will be obtained and the polyvinyl alcohol solids produced do not interfere with the mixing procedures. In summary, the prior art devices and procedures do not solve all of the problems relating to high speed and rapid mixing.

It is, therefore, an object of this invention to provide improved apparatus and procedures for rapid mixing of liquids.

2

Another object is to provide improved mixing apparatus and procedures for the mixing of liquids of high viscosity.

A further object is to provide improved systems and procedures for the mixing of high viscosity polyvinyl acetate solutions and saponification catalyst solutions whereby uniform and rapid mixing of the solutions are obtained.

A still further object is to provide improved apparatus and procedures for the mixing of reactant solutions in the preparation of polyvinyl alcohol.

These and other objects, as well as other advantages and benefits of the invention, and other novel and specific features and details of the invention will become apparent and will be clarified, and will be more specifically detailed and described in the following description, details, and illustrations, examples, and in connection with the accompanying drawings in which like references, characters, and symbols referring to similar structures, members, parts, apparatus, or materials, throughout the several views, and in which:

FIGURE 1 is a generalized sectional elevation of mixing apparatus embodying the principles of this invention;

FIGURE 2 is a sectional view of the first stage mixing zone or mixing disc means used in the procedures of the invention;

FIGURE 3 is a sectional view similar to FIGURE 2 illustrating a modified form of the first stage disc means;

FIGURE 4 is a sectional view illustrating the second stage mixing zone or mixing disc means;

FIGURE 5 is a sectional view similar to FIGURE 4 illustrating a modified form of the second stage disc means;

FIGURE 6 is a top plan sectional view taken generally along line 6—6 of FIGURE 5;

FIGURE 7 is a partial sectional view similar to FIGURE 1, illustrating a modified form of solution feed means to the first stage mixing zone; and,

FIGURE 8 is similar to FIGURE 7, illustrating another modification of solution feed means.

In accordance with this invention one of the liquids to be mixed is introduced to and flows as a thin film down and along the upper portion of the mixer stirring shaft. The thin film layer then flows to a first stage mixing zone. The other or second liquid to be mixed is passed down and along the mixer shaft by suitable passage means that are not in fluid communication with the first liquid. At the end of the passage means the second liquid is introduced into the first step mixing zone. In the first stage mixing zone the two liquids come together for the first time and are mixed as thin films and passed from the first stage mixing zone to strike the side walls of the mixer or mixer chamber for further mixing. The mixed liquids in the form generally of a thin film, falls down along the inner walls of the chamber or mixing apparatus. This thin film is then guided to a cup-shaped mixing vane or disc which is the second mixing zone. Further mixing takes place in the second mixing zone and the mixed liquids are again sprayed or passed to the interior walls of the mixer for further mixing. More than one second stage mixing zone may be used and two or more liquids may be mixed utilizing the procedures and devices of this invention. Finally the mixed liquids are passed out of the mixer.

Shown in FIGURE 1 is a generalized sectional elevation view of a typical mixer or typical mixing apparatus employing the principles of this invention. The mixer or mixing apparatus is identified generally by the reference numeral 1. The mixing unit 1 has a cylindrical casing 2 or outer cylindrical container 2. Located in the upper or top portions of casing 2 is aperture 3 or passageway 3 for the introduction of a first fluid A into the interior of the mixing apparatus 1. The first liquid or first solution is

identified by the reference letter A. Second passageway 4 is for the introduction of the second solution or second fluid B. The vertical agitator shaft 7 or central mixing shaft 7 is supported in the mixer 1 by fitting 8. The mixing shaft 7 may be rotated at high speeds by any conventional driving or power means which are not shown in the drawings. In the embodiment illustrated in FIGURE 1 there is shown in the shaft 7, passage means 9 communicating with the first mixing zone 10 and the passageway 3. The passageway 9 is inside the shaft 7. Passageway 11 in the fitting 8 allows fluid communication between the passageway 9 and the passageway 3. The funnel-shaped fitting 12 is attached to the upper part of casing 2, and the lower part of fitting 12 surrounds but is spaced from shaft 7. The fitting 12 in conjunction with the upper part of casing 2 provides a chamber 13 in fluid communication with passageway 4, whereby liquid B may be introduced into chamber 13 and passed down along shaft 7 as a thin film to mixing zone 10. The mixture of liquids A and B formed in mixing zone 10 passes to the interior side walls of casing 2 and flows as a thin film down said interior chamber walls and down partition 14 or funnel-shaped walls 14. The funnel-shaped guide walls 14 or partition plates 14 are secured to casing 2 and direct the mixed liquids axially inwardly to the annular aperture 15 surrounding shaft 7. The mixed liquids pass through aperture 15 to mixing zone 16 where they are further mixed and passed to the interior walls of casing 2. The mixed liquids may then be passed along second funnel-shaped guide walls 17 through aperture 18 and to another second stage mixing zone 19, where they are further mixed and are then passed to the interior walls of casing 2. The mixed liquids then pass along the interior walls of casing 2 and out of the mixer through discharge opening 20.

In FIGURE 2 there is illustrated apparatus comprising the first stage mixing zone 10. The first stage mixing zone 10 consists of a first lower disc 25 with cup-shaped sides 26 extending around the periphery of disc 25. Disc 25 is positioned below the discharge outlet of passageway 9 in the shaft 7. Positioned above disc 25 is a slightly smaller similar disc 27, which is positioned above the discharge outlet of passageway 9. Positioned above disc 27 is a similar shaped disc 29 larger than disc 25. Disc 29 is inverted and overlies disc 25 and disc 27. Disc 29 contains an annular opening 30 surrounding shaft 7 whereby liquid B flowing down shaft 7 may pass through disc 29 and into the chamber of disc 27.

The second stage mixing zone apparatus 16 is illustrated in FIGURE 4. This apparatus consists of disc 32 and disc 33. Disc 32 has cup-shaped sides 34 extending along the periphery of disc 32. Positioned above disc 32 is disc 33 similar in shape but larger than disc 32. Disc 33 is inverted and overlies disc 32. Disc 33 contains an annular aperture 35 surrounding shaft 7.

A modified form of the first stage mixing disc means is illustrated in the sectional view of FIGURE 3. Shown is a flat circular blade or plate 36 or flat circular disc 36 attached to shaft 7, and positioned on shaft 7 whereby the discharge outlets of passageway 9 are below disc 36. Disc 36 contains no annular openings surrounding shaft 7 and provides a flat surface extending from shaft 9 to the periphery of disc 36.

FIGURES 5 and 6 illustrate a modified form of the second stage mixing zone apparatus 16. The apparatus shown in FIGURES 5 and 6 is similar to the construction of the device previously described with reference to FIGURE 4. In addition to disc 32 and disc 33 this modified second stage device includes mixing plates 38 or shielding plates 38 or fixed plates 38 attached to disc 32 and disc 33. The plates 38 extend generally from the side outer wall 34 of disc 32 inwardly to about the aperture 35. The series of plates 38 are positioned vertically. Four shielding plates 38 or four plates 38 are shown in FIGURES 5 and 6 but any appropriate number may be used in this modification. The plates 38 improve the mixing effect

obtained in the second stage mixing device, by providing a pumping action.

A modified form of liquid feed means to the first stage mixing device is illustrated in FIGURE 7. In FIGURE 7 there is illustrated the central mixing shaft 7 surrounded by an outer cylinder 40. The cylinder 40 is spaced from shaft 7 to provide an annular passageway 41. Outer cylinder 40 contains apertures 42 and apertures 43. Apertures 42 provide fluid communication with passageway 11 in the fitting 8 and apertures 43 allow the liquid to be mixed to be introduced to the first stage mixing zone device 10.

In FIGURE 8 there is illustrated another modification of the liquid feed means that is also useful in the mixer 1. In this embodiment pipes 45 or fluid conduits 45 are attached to the mixing shaft 7 whereby fluid A entering the mixer 1 through passageway 3 may be introduced to the first mixing zone 10. The conduits 45 are attached to shaft 7, and allow liquid A to be introduced through conduits 45 into the first stage mixing zone 10.

The functions and operations of the devices of this invention may be described with reference to the drawings. As shown, a liquid A to be mixed is fed or introduced into the top or upper portion of the mixer 1. The fluid A to be mixed passes to the center of the mixer 1 whereby passageway means are provided associated with the central mixing shaft 7. The passageway passes along the mixing shaft 7 and down along the mixing shaft 7, where it is introduced into the first stage mixing zone 10. The second liquid to be mixed is identified by the reference letter B and a separate passageway is provided in the top of mixer 1 for introducing the liquid B into the interior of the mixer. The passageway for liquid B terminates in an annular aperture surrounding shaft 7. As a result of this annular aperture, liquid B flows as a thin film along and down the outside of shaft 7. As shown in FIGURE 2 by reference arrows, the liquid B is fed or flows along shaft 7 as a thin film and through annular aperture 30 into disc 27. The liquid B collecting in the chamber of cup-shaped disc 27 is sprayed or splashed to the upper walls of disc 39 along the outer edges of disc 29. The liquid B forms a thin film on the walls of disc 29 and passes to the peripheral walls of disc 29. Liquid A introduced into the chamber of disc 25 by the passageway means in shaft 7, is sprayed or splashed along the outer walls or peripheral walls of disc 25 whereby it is forced to come in contact with liquid B proceeding down the peripheral walls of disc 29. At this point liquids A and B collide and are mixed and fall along the extreme periphery of disc 29. The mixture of liquids A-B passes out of the first stage mixing zone from the end of the disc 29, and because of the strong centrifugal force, the mixture A-B is projected or splashed or sprayed to the peripheral or inner walls of mixer 1 where further mixing takes place. The mixed liquids A-B then fall as a thin film along the inner walls of the mixer 1. The falling mixed liquid A-B falls along the funnel-shaped partition surfaces 14 in the interior of mixer 1 to the second stage mixing zone. The second stage mixing zone consisting of disc 32 and disc 33, includes an aperture 35 in disc 33 allowing the mixture A-B to pass into mixing disc 32. The mixture A-B rises along the chamber of disc 32 and passes along outer walls 34 where it is sprayed or splashed to the inner surface of upper disc 33, which results in further mixing. This further mixed liquid A-B then passes along the outer peripheral wall of disc 33 and from the second mixing zone where it is projected or sprayed against the inner walls of mixer 1. The splashing of the mixture A-B against the inner walls of mixer 1 results in further mixing. The mixed liquid can then be passed along another funnel-shaped wall area into additional second stage mixing zones where the process previously described is repeated or the mixed liquid from the second stage mixing zone may be passed to the discharge port 20.

As previously described, any suitable passage means

may be provided for introducing the liquid A along shaft 7 into the first stage mixing zone, as for example the passageways described in FIGURE 1, and FIGURES 7 and 8. The first stage mixing zone may comprise the apparatus described with regard to FIGURES 2 and 3. Similarly, the second stage mixing zone can include the modifications described in FIGURES 4 and 5.

The functions and operations of the mixer of this invention may be described in greater detail with regard to a particularly advantageous use of this invention, relating to the production of polyvinyl alcohol. In specific procedures for the production of polyvinyl alcohol, preliminary steps involve the mixing of polyvinyl acetate-methanol solutions with caustic soda solutions, whereby the caustic soda acts as a saponification catalyst and results in the saponification of the polyvinyl acetate. Representative procedures are described in U.S. Patent 3,072,464 and U.S. Patent 3,072,624. In any case, it is desirable that the alcoholic solution of polyvinyl acetate be mixed rapidly with the caustic soda solution. The viscosity of the polyvinyl acetate solution will normally be substantially higher than that of the aqueous caustic. It is desirable to be able to use mixing apparatus that allows extremely high viscosity solutions of polyvinyl acetate to be used and the procedures of this invention allow extremely high viscosity solutions of polyvinyl acetate to be mixed with aqueous caustic solutions. The mixing of polyvinyl acetate-methanol solutions and aqueous caustic solutions will be described in more detail with regard to the accompanying drawings. The polyvinyl acetate solution corresponds to liquid B and is fed into mixer 1 through passage means 4 and passage means 13 and through the annular aperture formed by fitting 12 surrounding shaft 7. The polyvinyl acetate solution then flows along the exterior surface of shaft 7 into first mixing zone 10, and passes along shaft 7 through aperture 30 into the cup-shaped chamber formed by disc 27. The polyvinyl acetate fills the chamber or the cup-shaped chamber of disc 27 and overflows from this chamber as a spray or film and is projected to the interior periphery surfaces of disc 29 where it flows along said inner surface as a film. The aqueous caustic soda solution corresponds to liquid A and is passed into the mixer by separate passage means and is passed along the shaft 7 by separate passage means into mixing zone 1. The aqueous caustic flows from the passageway associated with shaft 7 into the cup type chamber of disc 25 and overflowing said chamber, it is sprayed or projected to the interior periphery surface of disc 29. The polyvinyl acetate solution and the aqueous caustic solution meet at the inner peripheral surface of disc 29 and are mixed. The mixed polyvinyl acetate-caustic falls down from the interior peripheral surface of disc 29 and is projected or sprayed or splashed against the interior wall surface of the mixer 1, where further mixing takes place. The mixed liquids or mixed solutions then pass along the interior wall of the mixer and along the funnel-shaped guide walls 14 towards the center of the mixer. The mixed liquids then pass through the annular aperture 15 surrounding shaft 7 and then pass through aperture 35 in the second stage mixing device. The mixed liquid rises along the cup-shaped chamber formed by disc 32 and passes along the peripheral walls 34 to collide or encounter the interior peripheral walls of disc 33 where further mixing takes place. The mixed liquids then pass from the periphery of disc 33 and again are projected by strong centrifugal force to the interior walls of mixer 1. The mixture of polyvinyl acetate and caustic soda can then be passed to a discharge port or passed along a second funnel-shaped wall surface 17 and through an aperture 18 into another second stage mixing zone 19 that is constructed the same as the previously described mixing zone 16 and operates in the same manner. By providing mixing shielding plates 38 in the mixing zone apparatus of the second stage, one may further stimulate the mixing action by the pumping effect that is obtained by the use

of the plates 38. The apparatus of this invention is especially advantageous in mixing an alcoholic polyvinyl acetate solution and an aqueous caustic solution, in that rapid mixing and uniform mixing takes places and said mixing is rapid enough in order that the saponification of the polyvinyl acetate does not proceed to the extent that solid polyvinyl alcohol is formed in the mixer. The mixer of this invention is especially advantageous in that extremely high concentrations of the polyvinyl acetate and the caustic alkali may be used and solutions of polyvinyl acetate having extremely high viscosities may be mixed by the procedure of this invention.

While preferred embodiments of the invention have been described and illustrated, it is to be understood that widely different modifications of this invention may be made without departing from the spirit and scope of the invention. The invention is not to be limited by the foregoing examples and illustrations and descriptive details except as defined in the following claims.

We claim:

1. Mixing apparatus comprising a mixing chamber with a vertically disposed longitudinal axis; a longitudinal central shaft rotatably passing into said chamber; mixing means within said chamber and connected to said shaft to rotate therewith, said mixing means comprising:
 - (a) a first horizontal plate with an upturned periphery,
 - (b) a second horizontal plate above said first plate to define a first liquid zone therebetween, said second plate having an upturned periphery disposed within said first plate upturned periphery,
 - (c) a third horizontal plate above said second plate to define a second liquid zone therebetween, said third plate having a downturned periphery disposed outside said first plate upturned periphery;
- a funnel-shaped partition below said mixing means and spaced from said shaft; liquid discharge means below said partition for discharging liquid from said chamber; means for introducing a liquid from outside said chamber into said first liquid zone; and means for introducing a liquid from outside said chamber into said second liquid zone; whereby liquid in said first liquid zone overflows said first plate upturned periphery to impinge upon said third plate downturned periphery and liquid in said second liquid zone overflows said second plate upturned periphery to impinge upon said third plate downturned periphery to mix with liquid from said first liquid zone.
2. Mixing apparatus as claimed in claim 1 in which said third plate includes an opening adjacent said shaft to permit liquid to enter said second liquid zone.
3. Mixing apparatus as claimed in claim 1 further comprising second mixing means within said chamber and connected to said shaft to rotate therewith below said first mixing means, said second mixing means comprising a fourth horizontal plate with an upturned periphery and a fifth horizontal plate above said fourth horizontal plate to define a third liquid zone therebetween, said fifth plate having an opening adjacent said shaft to permit liquid to enter said third liquid zone and a downturned periphery disposed outside said fourth plate upturned periphery whereby liquid in said third liquid zone overflows said fourth plate upturned periphery to impinge upon said fifth plate downturned periphery to be further mixed.

References Cited

UNITED STATES PATENTS

2,787,447	4/1957	Crawford	259—8
3,072,464	1/1963	Akaboshi et al.	
3,110,646	11/1963	Mayhew et al.	259—7 X
3,163,402	12/1964	Yamashita	259—8 X

FOREIGN PATENTS

838,593 5/1952 Germany.

WALTER A. SCHEEL, *Primary Examiner.*

J. M. BELL, *Assistant Examiner.*