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2,840,355

MIXING VESSEL

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3 Sheets-Sheet 2

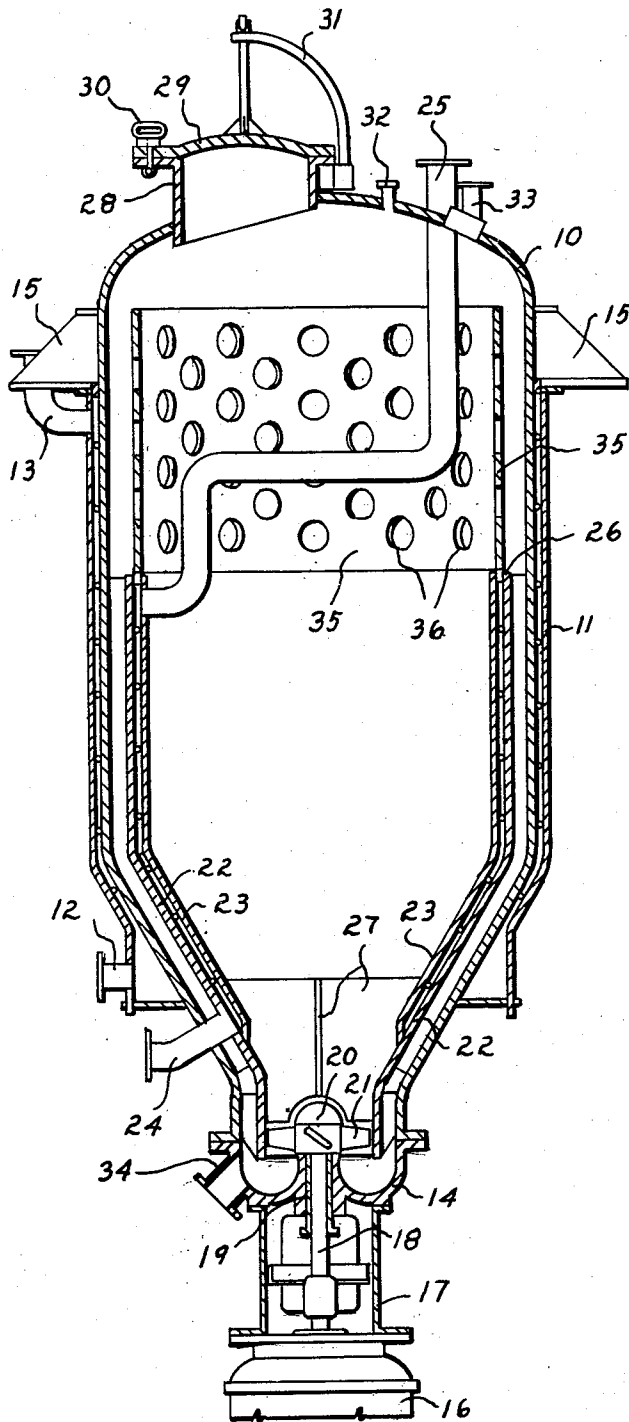


Fig. 3.

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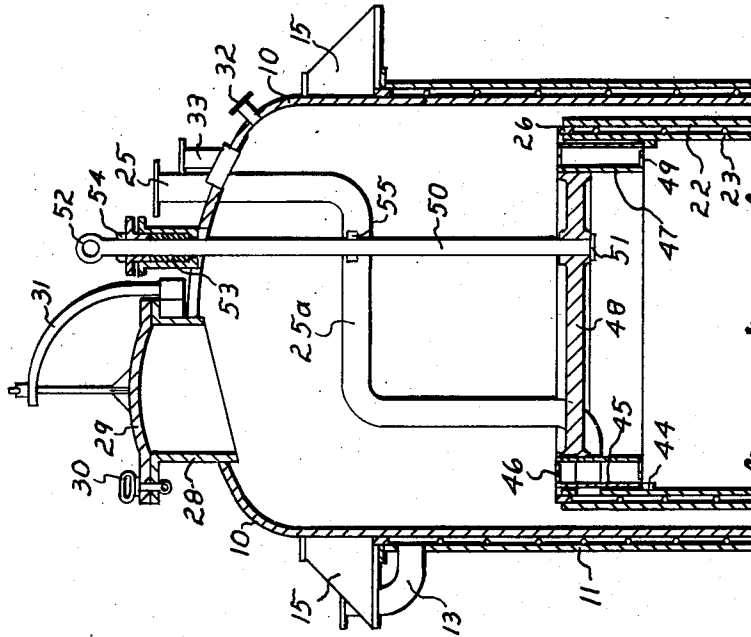


Fig. 5.

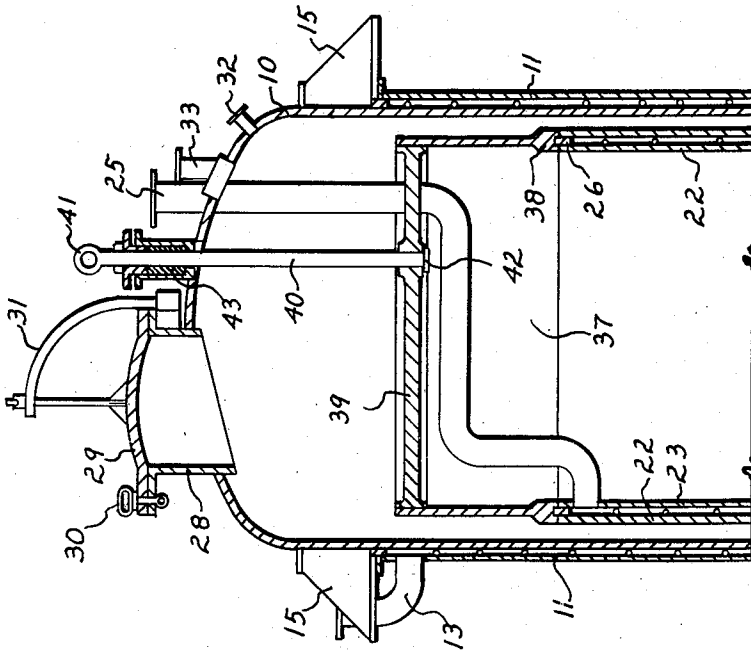


Fig. 4.

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This invention relates to apparatus for circulation mixing processing of liquids or liquids and finely divided solids and refers more particularly to such apparatus wherein it is desirable to pull off from such circulating mixture a gaseous component contained therein.

Vertical mixing or contactor kettles are well known in the art wherein a mechanical impeller forces relatively viscous liquids to circulate around a circulating tube positioned within a concentric outer shell. In such kettles, the impeller is conventionally positioned in the lower constricted end of the circulating tube and drives the fluid into a reversing hydraulic head which directs the fluid upwardly along the outside surface of the circulating tube. When the fluid passes to or over the upper end of the circulating tube it is pulled inwardly thereof to the impeller for recycle. Conventionally, the circulating tube and the outer shell are jacketed for heat exchange. Such kettles are often used for the manufacture of grease and grease soaps and the like. Thus, the saponification processes employed in the manufacture of grease soaps are often carried out in such circulating kettles.

A number of problems have arisen relative this type of kettle which have led to the developments comprising the instant invention. (1) Such kettles are not adaptable to the processing of variable amounts of material, especially amounts in excess of the quantity required to fill the vessel above the top of the circulating tube. When the kettle is employed with a batch amount which is of a volume to maintain a level well below the top of the circulating tube in the interior thereof, the impeller is of such power conventionally that it will circulate the viscous fluid so long as it is kept covered by liquid. However, in the opposite situation, many vessels have a shell capacity far above the circulating tube but if they are filled thereabove and circulation begun, a noncirculating stagnant zone forms at the top fluid level, particularly if there are different specific gravity materials in the charge to the kettle. In such cases, uniform circulation is not achieved and the nature of the product becomes uncontrollable and unpredictable. Also where there is considerable circulation volume in the outer shell above the circulating tube it would be desirable to have means for achieving complete circulation for any desired flow level above the top of the circulating tube. (2) In conventional circulation mixing kettles for viscous liquids, it is difficult to remove vapor fractions from the circulating fluids no matter at what level the fluid stands within the circulating tube. This is because in the high velocity circulation there most often is a liquid thickness of three inches or more over the top or weir of the circulating tube which presents insufficient surface area to the kettle interior for withdrawal of the vapor components from the liquid. Even when the liquid level within a circulating tube is very low such sheet flow over the top of the circulating tube does not give sufficient surface area for vapor fraction withdrawal and there is frothing and foaming due to turbulence and internal kettle pressure variations when the vapor component is

taken off. If, during vapor component take off, froth, foam or liquid spray itself is carried into the vapor withdrawal or vacuum line, the composition of the product becomes variable and indeterminate and contamination of the fluid lines and vacuum pressure lines results.

Therefore, an object of the present invention is to provide means for achieving complete circulation in mixing and circulating kettles for liquids when the fluid level therein is above the upper end of the circulation tube.

Another object of the present invention is to provide means for achieving complete circulation in mixing and circulating kettles for liquids when the fluid level in the kettle is at any variable level above the top of the circulation tube of the kettle.

Another object of the invention is to furnish means for providing complete circulation in mixing and circulating kettles for liquids at any fluid level within the kettle while simultaneously providing greatly increased surface area exposure in the circulating fluid to increase vapor drawoff therefrom and permitting vapor withdrawal from the kettle without liquid or solid entrainment therefrom, thereby permitting greater accuracy of batch and product control and avoiding pressure relief and vacuum line fouling with components of the mixture.

Other and further objects of the invention will appear in the course of the following description thereof.

In the drawings, which form a part of the instant specification and are to be read in conjunction therewith, there are shown embodiments of the invention and, in the various views, like numerals are employed to indicate like parts.

Fig. 1 is a cross-sectional view through a preferred modification of the invention.

Fig. 2 is a reduced view taken along the lines 2—2 in the direction of the arrows in Fig. 1.

Fig. 3 is a cross-sectional view through a second modification of the inventive structure.

Fig. 4 is a partial cross-sectional view of a third modification of the invention.

Fig. 5 is a partial cross-sectional view through a fourth modification of the invention.

Referring to the drawings, the modifications shown in Figs. 3, 4 and 5 will be first described and then the preferred modification of Fig. 1. Since the various modifications of the invention are all illustrated in mixing kettles of the same construction, parts common to all the kettles have been given the same numbers.

Fig. 3 shows a vertical jacketed contactor or mixing kettle comprising an outer shell 10 having thermal jacket 11 with heat transfer medium inlet pipe 12 and outlet pipe 13 attached thereto. Outer shell 10 has hydraulic head 14 at the lower end thereof. The outer shell is constricted at its lower end. Beam supports 15 are attached to the upper end of the kettle and serve partially to support it in its upright position. Motor 16 is fastened relative to the lower end of the kettle by structural members 17 and drives shaft 18 through bearing gland 19. Hub 20 of shaft 18 carries impeller or propeller blades 21. The pitch of the blades 21 and the direction of rotation of the shaft 18 are such that fluids above the impeller blades in the kettle are driven downwardly into the hydraulic head 14. Circulating tube 22 having inner thermal jacket 23 therein with input pipe 24 and output pipe 25 for heat transfer medium thereon is positioned within the outer shell 10 and runs circumferentially therein. The lower end of the circulating tube is constricted as in the lower end of the outer shell and its lower edge penetrates the hydraulic head 14. The path of fluid circulated by the impeller blades 21 is downwardly into the hydraulic head, upwardly outside the circulating tube, then over the upper edge 26 of the circulating tube 23 and back inside

thereof. The impeller motor 16 conventionally is of such power that so long as the blades 21 are kept covered with liquid, the fluid will be circulated up over the edge 23 of the circulating tube. Right angled baffle 27 is positioned within the lower end of the circulating tube and immediately above the hub 20 to reduce turbulence above the blades 21. Hatch 28 is positioned at the top side of the jacket 10 to permit feed of solids into the interior of the kettle. Hatch 28 has lid 29, locking key 30 and lid arm 31 fixed to the lid 29. Pipe 32 serves as pressure medium input pipe if it is desired to run the circulating kettle under superatmospheric pressure. Pressure relief pipe and vacuum connection pipe 33 is also attached to the top end of the outer shell 10. A liquid or slurry feed line is attached to the outer shell 10 above the top edge of the heat exchange jacketed oven. This line is not shown in the drawings. Product withdrawal line 34 connects into the hydraulic head 14.

The previous description describes a vertical contactor or mixing kettle as conventionally used in the art. Such a contactor is employed for batch or continuous processing of viscous liquids or liquids and finely divided solids. It is useful in the grease industry for soap and grease manufacture and is also used in such processes as clay contacting of oils, alkylation of aromatics with olefins in the presence of aluminum chloride, sulfurization of cutting oils, ester formation such as by the reaction of acids and anhydrides with alcohols and glycols, etc. Heating or cooling is performed by the circulation of a heat transfer medium such as hot oil, steam, Dowtherm, or water, through both the jacketed shell and the double walled circulation tube, to provide rapid heating, cooling or reaction temperature control. Since a turbulent flow is maintained within the kettle, heat transfer rates are high both in the jackets and the cyclic stream within the kettle. Processing may be conducted under pressure or vacuum, and with or without gas or vapor release.

As previously mentioned, where the mixing kettle is run with a fluid level therein extending over and above the top of the circulating tube, there is a tendency for the formation of a stagnant layer, especially if there are materials of different specific gravities within the mix. It would be desirable to be able to extend the circulating tube up as close to the top of the jacket 10 as possible to minimize the volume available for the formation of a stagnant layer. However, this modification would make it impossible to process volumes of liquid less than a certain minimum level as the impeller blades 21 must be kept covered with liquid during circulation for the circulation to be maintained. The greater the upward extension of the circulating tube, the greater the required volume of the fluid within the circulating tube. In the production of grease, for example, it is very often desirable to work batchwise in producing greases of specific qualities. In such a process, carefully measured quantities of hydrocarbon oil, fatty acids, alkali earth and a small amount of water are charged into the kettle to be mixed into a saponified soap. It would be very expensive if every batch of grease had to be of a certain minimum size, especially when that minimum size would be the full volume of a conventional kettle contactor.

Therefore, I have provided the modification which is shown in Fig. 3 to permit the circulation of variable volumes of liquids within the contactor kettle from a volume essentially equal to that minimum now processable with a conventional contactor kettle up to essentially the full volume of the conventional or a vertically elongated contactor kettle, while in the meantime providing means for completely avoiding any formation of a stagnant layer above the circulating tube. This means comprises (as shown in Fig. 3) vertical tube sheet 35 fixed to the top end 26 of the circulating tube which has a plurality of relatively large perforations 36 evenly spaced throughout its area.

The function of the tube sheet 35 and the holes 36 75

therein is to provide a partial barrier to the flow of fluid over the top of the circulating tube which barrier creates a level differential of a predetermined amount which requires the liquid on the outside of the circulating tube to rise a certain amount higher to pass through the holes in the tube sheet 35 than if the tube sheet 35 were not present. The holes 36 are sized so as to create this fluid level differential. "Relatively large" holes here is taken to mean preferably in the 1" to 3" range. Assuming that the holes 36 are sized so as to create a 12 inch level differential, the minimum volume which may be circulated in the kettle is increased to some slight degree. However, should the operating level without a tube sheet 35 extend above the normal height 26 of the circulating tube, the additional level differential created by the tube sheet 35 will force the circulating liquid upwardly around the tube sheet 35 so that it will flow through the holes 36. Since, even at the levels wherein the tube sheet 35 may be completely covered with the circulating fluid, some liquid will pass through the holes 36 in order to reach the inside of the circulating tube for recirculation, and, therefore, there will be no formation of a static layer above the said circulating tube. It is evident that the kettle, still assuming a 12 inch height differential created by the circulation tube, may be filled to a level within 12 inches of the top of the tube sheet 35 before there will be any overflow over its top.

Figs. 4 and 5 illustrate two partial sectional views of kettles similar to that described in Fig. 3, all features of the kettles in Figs. 3, 4 and 5 being identical with the exception of the means provided for extending the length of the upper end of the circulating tube.

Referring to Fig. 4, unperforated tube sheet 37 having enlarged lower end 38 to fit on top of the closed end of the jacketed circulating tube 22, is positioned within the space above the end 26 of the jacketed circulating tube. Spider 39 is internally fixed to the inner side of tube sheet 37 and is engaged by rod 40 essentially centrally thereof. Rod 40 has engaging ring 41 at the upper end thereof and enlarged stud 42 at the lower end thereof. Rod 40 is also fitted through packing gland 43 at the top end of the kettle shell 10.

The operation of the Fig. 4 modification consists in lowering the tube sheet 37 to engage the top end of the circulating tube 22 when a level sufficient to create a stagnant layer above the circulating tube is to be circulated. Thus the liquid circulating outside the circulating tube has to rise to the additional height afforded by the tube sheet 37 to reach the inner portion of the circulating tube for recirculation. When the volume of the liquid in circulation reaches only a level insufficient to create a stagnant layer above the circulating tube, the tube sheet 37 is lifted by rod 40 acting through gland 43 upwardly adjacent the top portion of the kettle jacket 10. This permits the liquid to circulate thereunder. It is obvious that the modification of Fig. 4 will not handle as great a volume as that of Fig. 3 and, additionally, requires manipulation of the tube sheet 37.

Referring to the modification of the invention shown in Fig. 5, again, all of the structural features of the kettle are identical with that of Fig. 3 with the exception of the means for handling circulation volumes greater than those extending above the top of the circulating tube 22. In this instance, a telescoping type of tube sheet is furnished to permit more precise and higher adjustment of the level of the extension above the upper end 26 of the circulating tube than in the Fig. 4 modification. It will be seen that, in Fig. 4, when in use, the tube sheet 37 necessarily elevates the level differential a fixed amount. Such may not be desirable if the excess of volume of liquid is only slightly above the top of the tube sheet 26. It is also evident that the construction shown in Fig. 4 requires a certain amount of clearance thereabove to permit sufficient raising thereof when not in use.

In the Fig. 5 modification, mounting ring or shelf

5

44 is positioned on the inner face of the circulating tube jacket 23 below the top 26 of the circulating tube. Outer tube sheet 45 having inwardly angled upper face 46 rests on mounting ring 44. Inner tube sheet 47 has spider 48 fixed to the inner face thereof and flanged outwardly extending lower edge 49. Tube sheets 45 and 47 are slotted to permit pipe 25 to extend therethrough. The slot in tube sheet 47 extends through its lower edge 49 as does slot in tube sheet 45. Pipe 25 has its horizontal extension 25a moved upwardly to permit the vertical movement of the tube sheets 47 and 45 thereunder. Spider 48 is engaged near the center thereof by vertical rod 50 having stud 51 at the lower end thereof and suspension ring 52 at the upper end thereof. Rod 50 is received in packing gland 53 at the top of the shell 10. The inner tube sheet 47 is supported solely by spider 48 and rod 50 from the top of the shell 10. When rod 50 is fully extended downwardly so that the tube sheets 47 and 45 both are below the top of the circulating tube 26, the fluids in the shell circulate as in conventional operation. The inner tube sheet 47 is entirely supported by the rod 50 and the upper stop 54 may be provided fixedly attached to rod 50 to limit the lower movement of the rod. Similarly, the lower stop 55 may be attached to the rod 50 to limit the upward motion of the rod.

In operation of the Fig. 5 modification, if the volume of circulating fluid rises above the tube sheet 26, the rod 50 may be drawn upwardly out of the gland 53 by the attachment ring 52 thus raising the inner tube sheet 47 above the circulating tube 22. In this manner, the formation of a stagnant zone in the circulating fluid at the top thereof may be avoided. Should the level of the circulating liquid be quite a bit greater than the height of the circulating tube 22, the rod 50 may be withdrawn so that the lower edge of the tube sheet 47 engages the upper edge 46 of the outer tube sheet 45 and thereby raising the tube sheet 45 off retainer rim 44 to further increase the height of the total circulating tube. The rod 50 may be raised until the total height of both of the tube sheets 47 and 45 is above the top of the circulating tube 26. Stop 55 is provided so that the lower edge of tube sheet 45 will not pass over the top 26 of the circulating tube 22. Thus in the Fig. 5 modification complete control of the height of the circulating tube is possible.

The previously described modification of Figs. 3, 4 and 5 all have the purpose of avoiding the formation of a stagnant zone in the circulating liquid above the top of the circulating tube 22. The other key problem which exists in contactor kettles of the type described relates to the release of moisture by pressure reduction or vacuum application in the upper zone of the kettle. Where there is a smooth uninterrupted flow of fluid over the top of a circulating tube there is little opportunity for sufficient vapor release from the circulating liquid. The only construction in the modifications of Figs. 3, 4 and 5 which in any appreciable way contributes to the solution of this problem is that of Fig. 3. In this modification, the provision of the plurality of orifices 36 in tube sheet 35 increases slightly the surface area of the liquid exposed to the atmosphere within the top of the vessel, thus permitting greater efficiency in the removal of the vapor fraction. However, these orifices are very large and do not contribute greatly to such increase of surface area.

Referring to the preferred modification of the invention as shown in Figs. 1 and 2, tube sheet 56 is fixed to the top 26 of the circulating tube 22 and extends upwardly therefrom essentially the entire vertical length of the outer shell 10 above said top 26. A plurality of relatively small holes 57 are formed in the tube sheet 56 throughout its entire surface area. "Relatively small" here is intended to include openings in the $\frac{1}{4}$ " to $\frac{3}{4}$ " range preferably. The tube sheet 56 provides a continuation of the annulus between the circulating tube 22 and the outer shell 10. This annulus is sealed at its top by horizontal wall 58

6

fixed circumferentially around the inside of the kettle. Thus, fluid passing upwardly between the circulating tube and the outer shell 10 has access to the interior of the circulating tube only through the plurality of relatively small holes 57 and cannot flow over the top of the tube sheet 56.

The operation of the preferred modification of the invention shown in Fig. 1 is essentially the same as that described relative the modification of Fig. 3 except that no liquid may pass over the top of the tube sheet 56 and, the holes 57 being very much smaller in diameter than the holes 36, the circulating viscous liquid is broken up into a series of relatively fine jets which spray out into the interior of the kettle between the walls of the circulating tube 22 and its jacket 23. In this manner, a very large amount of surface area of the liquid being circulated is exposed to the atmosphere within the kettle. The wall 58 at the top of the circulating tube-kettle wall annulus prevents any passage or flow of the circulating liquid over the top of the tube sheet 56 as in the normal case over the top of the circulating tube 22 in conventional installations. The sizing of the holes 57 in the tube sheet 56 creates a much greater level differential between the liquid inside the circulating tube and that outside the circulating tube. Thus, if the holes in Fig. 3 could be described as creating a 12 inch level differential (in the case when ordinarily the liquid circulating level in the kettle would be at the top of the circulating tube), then the holes 57 in the tube sheet 56 would create a level differential of approximately 3 to 4 feet. When the liquid level outside of the circulating tube reaches the top wall 58 in the annulus, a greater force from the impeller or addition of more circulating liquid to the kettle would result in the forcing of a greater volume of liquid through the holes and stronger jet action through the perforations 57. There is a limitation to the amount of fluid that may be forced through the holes 57 and thus the modification of Fig. 1 cannot handle the volume of circulation that the Fig. 3 modification could handle, unless the number and spacing of holes 57 provided in tube sheet 56 made the proportional volume moved through the holes 57 equivalent to that moved through the holes 36 and over the top of tube sheet 35.

The main function of the holes 57 in the tube sheet 56 is to provide the spray or jet effect which breaks up the solid volume of the circulating fluid into a series of smaller sprays having much greater total surface area exposed to the inner atmosphere of the kettle. In such case, the vapor fraction in the circulating liquid may be much more efficiently removed by release of superatmospheric pressure held on the kettle or pulling of a vacuum on the kettle. I have found that the circulation of the fluid through these relatively small holes 57 causes far less froth and foaming in the entire volume and especially the upper volume of the kettle and thus in the vapor fraction withdrawal or the pulling of a vacuum on the upper volume there is much less hazard of drawing froth and foam and material into the pressure reduction and vacuum lines. This also greatly contributes to precise control of the composition of the product. Since it is possible to increase greatly the number of relatively small holes in the tube sheet 56 to approximate essentially the volume characteristics of the holes 36 in the tube sheet 35 of the modification of Fig. 3, the Fig 1 modification can be constructed to handle essentially the circulatory volume of the Fig. 3 modification with the exception of the instance when there is circulation over the top of the tube sheet 35 in Fig. 3. The outer shell 10 of the kettle shown in Fig. 1 may be elongated as desired above the top of the circulating tube 26 to provide any volume circulating characteristics desired. Generally, I have found it is better to employ, in the relatively small hole modification shown in Fig. 1, the greater the level differential in the circulating fluid between the inside and outside of

the circulating tube the more efficient the vapor fraction withdrawal therefrom.

From the foregoing it will be seen that the invention is well adapted to attain all of the ends and objects hereinbefore set forth together with other advantages which are inherent to this structure.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter hereinabove set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim:

1. A mixing kettle for liquids comprising a vertical shell, a circulating tube positioned within said vertical shell and essentially concentric thereto, said tube extending vertically only part of the height of said shell, impeller means for circulating liquids downwardly in said tube and upwardly outside of said tube, a power source for said impeller, product component input and output lines connected to said shell, a vertically extending tube sheet positioned on top of the circulating tube as an extension thereof into the space in the kettle thereabove, a plurality of relatively large holes formed in said tube sheet, whereby to create a level differential between the inside and outside of the circulating tube when the kettle is operated less than liquid full.

2. A mixing kettle as in claim 1 wherein said holes are evenly positioned in said tube sheet at a given level.

3. A mixing kettle as in claim 1 wherein said holes are positioned in said tube sheet at a plurality of levels thereon.

4. A mixing kettle as in claim 1 wherein said holes are positioned in the area of said tube sheet at a plurality of levels thereon and through essentially the entire height of said tube sheet.

5. A mixing kettle as in claim 1 wherein said tube sheet is of a height whereby to fill essentially the entire clearance above the circulating tube in the mixing kettle outer shell.

6. A mixing kettle as in claim 5 wherein the holes in said tube sheet are sized so as to create a relatively small level differential between the inside and outside of the circulating tube when the kettle is operated less than liquid full.

7. A mixing kettle for liquids comprising a vertical shell, a circulating tube positioned within said vertical shell and essentially concentric thereto, said tube extending vertically only part of the height of said shell, impeller means for circulating liquids downwardly in said tube and upwardly outside of said tube, a power source

for said impeller, product component input and output lines connected to said shell, pressure release means connected to said shell, a vertically extending tube sheet positioned on top of the circulating tube as an extension thereof into the space of the kettle thereabove, the top of said tube sheet sealed to the kettle shell, whereby to prevent flow of liquid over the top of said tube sheet, a plurality of relatively small holes formed in said tube sheet, whereby to create a level differential between the inside and outside of the circulating tube when the kettle is operated less than liquid full and also to break up the circulating flow of liquid into a plurality of relatively small jets.

8. A mixing kettle as in claim 7 wherein said holes are relatively evenly positioned on a given level in said tube sheet.

9. A mixing kettle as in claim 7 wherein said holes are positioned at a plurality of levels in said tube sheet.

10. A mixing kettle as in claim 7 wherein said holes are positioned on a plurality of levels of said tube sheet and over essentially the entire height of the tube sheet.

11. A mixing kettle as in claim 7 wherein the height of said tube sheet is such as to essentially fill the entire clearance in the kettle above the top of the circulating tube.

12. A mixing kettle as in claim 7 wherein the number and size of said holes are such as to create a relatively large level differential between the inside and outside of the circulating tube when said kettle is operated less than liquid full.

13. In a mixing kettle for liquids having a vertical shell, a circulating tube positioned within said vertical shell and essentially concentric thereto, said tube extending vertically only part of the height of said shell, impeller means for circulating liquids downwardly in said tube and upwardly outside of said tube, a power source for said impeller, product component input and output lines connected to said shell, and pressure release means connected to said shell, the improvement which comprises a vertically extending tube sheet positioned on top of the circulating tube as an extension thereof into the space of the kettle thereabove, a plurality of holes formed in said tube sheet whereby to create a level differential between the inside and outside of the circulating tube when the kettle is operated less than liquid full and to break up the circulating flow of liquid into a plurality of relatively small jets.

References Cited in the file of this patent

UNITED STATES PATENTS

1,891,122	Urch	Dec. 13, 1932
2,102,548	Stratford	Dec. 14, 1937