June 29, 1954 C. H. HOLDER ET AL 2,682,453

MIXER-SETTLER CONTACT APPARATUS

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FIG. 1.

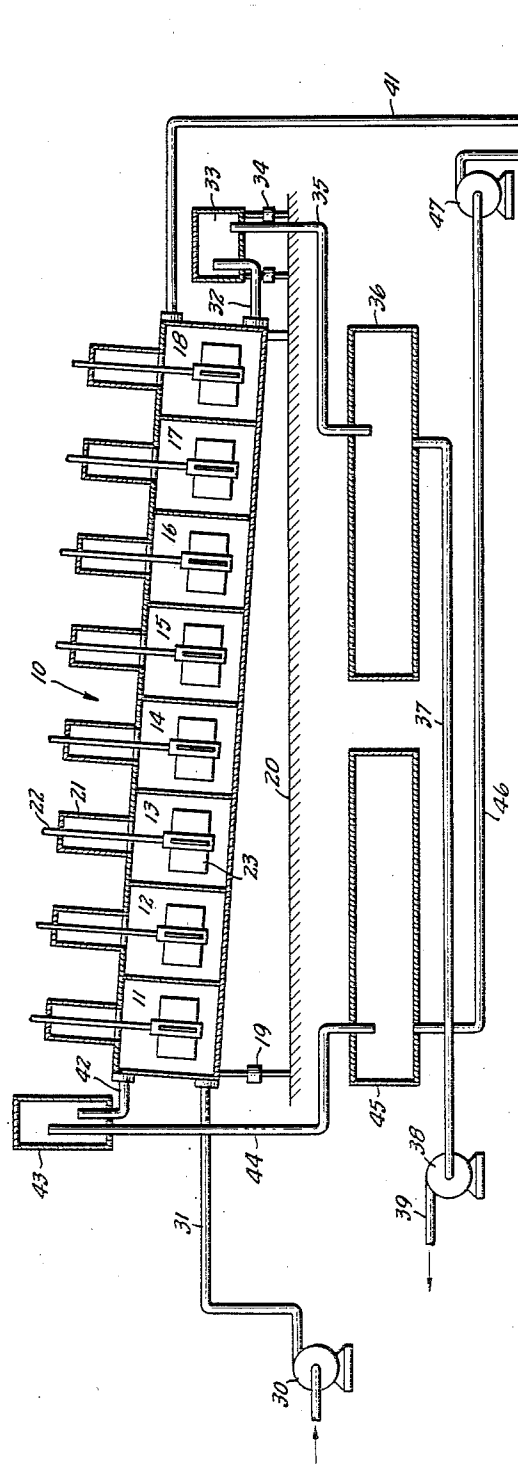


FIG. 8.

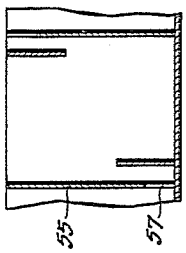


FIG. 4.

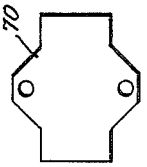
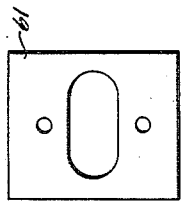


FIG. 3.



INVENTOR.
CLINTON H. HOLDER
CHANNING G. NELSON
ROBERT C. MORBECK
BY Roland A. Anderson
ATTORNEY

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FIG. 5.

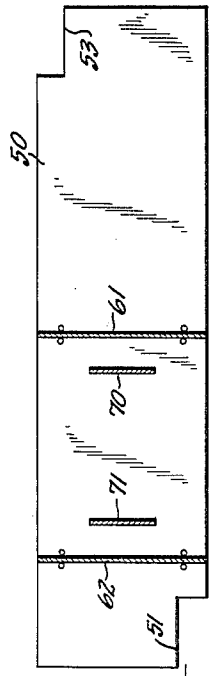


FIG. 6.

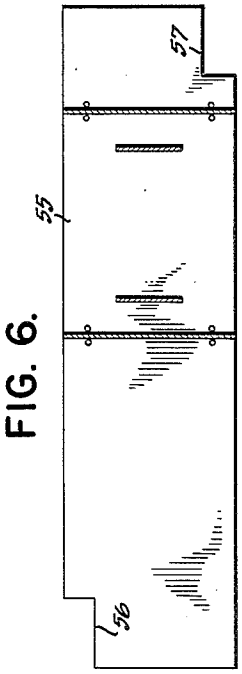


FIG. 7.

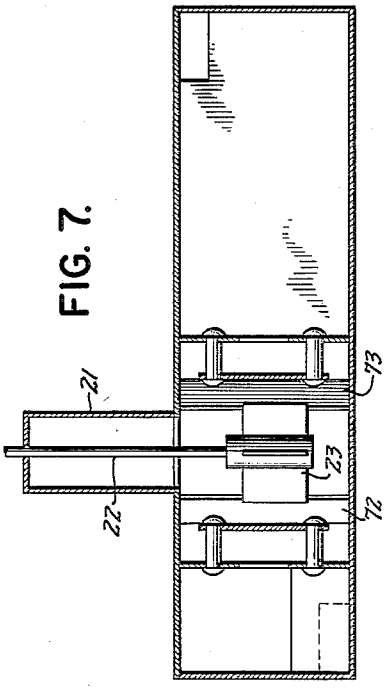
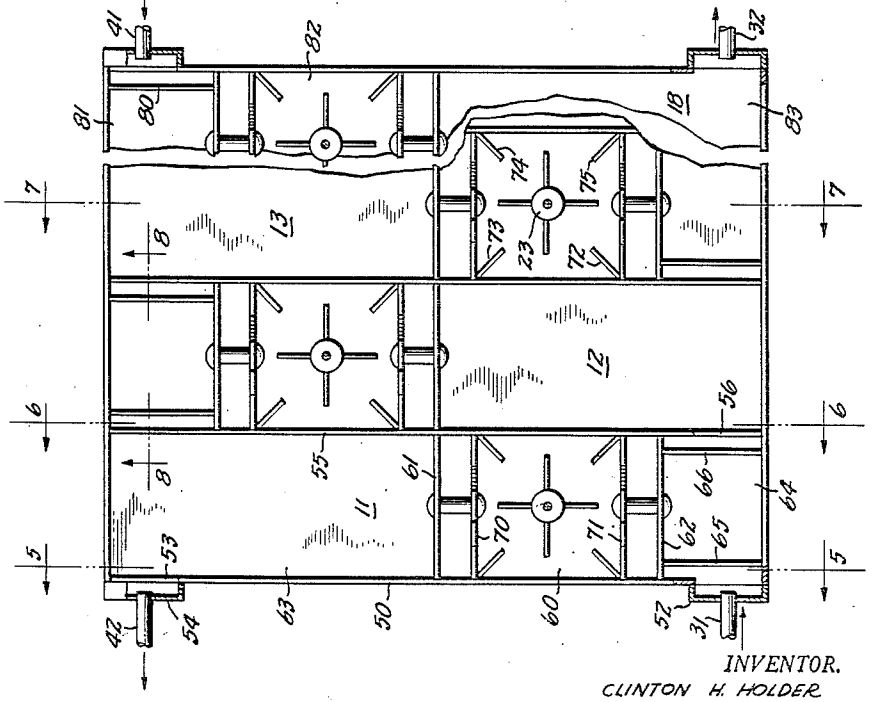


FIG. 2.



INVENTOR.
CLINTON H. HOLDER
CHANNING C. NELSON
ROBERT C. MORBECK
BY Roland A. Anderson
ATTORNEY

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MIXER-SETTLER CONTACT APPARATUS

Clinton H. Holder, Westfield, Channing C. Nelson, Cranford, and Robert C. Morbeck, Fanwood, N. J., assignors, by mesne assignments, to the United States of America as represented by the United States Atomic Energy Commission

Application March 19, 1952, Serial No. 277,348

7 Claims. (Cl. 23—270.5)

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This invention relates to a new and improved fluid contact apparatus of the well known mixer-settler type. It has especial application to the art in which two non-miscible or only partly miscible fluids of different specific gravities, preferably liquids, can be continuously and countercurrently contacted, one with the other. Frequently apparatus of this type is usefully employed for the object of withdrawing one or more components from one liquid with the aid of the other liquid, as in extracting, washing or chemical treating operations, and the present invention is well suited for operations of this character.

One object of the invention is to provide an improved, multistage contact apparatus suitable for liquid extraction usage and embodying an overall countercurrent flow of liquids with intermediate concurrent flow of the same through each of the several stages.

Another object is to provide an improved contact apparatus suitable for handling liquids under a wide range of flow rates.

Another object is to provide an improved contact apparatus including symmetrically formed mixing zones in which back-mixing of the fluid flow is held to a minimum.

A further object is to provide an improved contact apparatus comprising an assembly of standard mixing and settling chambers with the assembly mounted for gravitational flow of the heavier fluid therethrough.

A still further object is the provision of an improved contact apparatus adapted for flexibility of operation and in which fluid flows may be interrupted and restarted without adversely affecting the fluid treatment.

In accordance with the preferred form of apparatus embodying the invention, an even number of similar elongated contact chambers having a mixing means, located nearer one end of the chamber than the other, are mounted side by side with the longitudinal axis of each chamber being horizontally disposed. The chambers are alternately arranged end-for-end thus providing a zig-zag flow of the fluids from one end of the assembly to the other and the assembly preferably is inclined thus permitting gravitational flow therethrough. The walls of the several chambers are provided with apertures, or equivalent connecting means, establishing communication between adjacent chambers near the ends thereof and the arrangement of apertures is such as to direct the fluids concurrently through each chamber, but countercurrently through the assembly as a whole.

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For a better understanding of the invention reference may be had to the following description and drawings in which

Figure 1 is a diagrammatic view showing the general assembly of an apparatus capable of carrying out the invention.

Figure 2 is a plan view of the mixer-settler apparatus with the top cover plate removed.

Figure 3 is an elevation view of a partition plate.

Figure 4 is an elevation view of a baffle.

Figure 5 is a side elevation of one chamber wall taken along line 5—5 of Figure 2.

Figure 6 is a side elevation of a wall of the adjacent chamber taken along line 6—6 of Figure 2.

Figure 7 is a sectional view taken along line 7—7 of Figure 2 and

Figure 8 is a sectional view taken along line 8—8 of Figure 2.

As shown in Figure 1 a mixer-settler contact apparatus, generally designated at 10 and comprising a series of interconnected elongated chambers 11, 12, 13, 14, 15, 16, 17 and 18, is adjustably mounted by any suitable means 19 upon a support surface 20. Each chamber is closed at its top by a suitable cover means having upwardly extending hollow chimneys through which extend the shafts of a mixer means, such as illustrated by chimney 21 and shaft 22 attached to mixer 23. As will later become apparent, any desired number of chambers may be employed, but for a compact arrangement we prefer an even number of chambers, shown in the present form as eight.

By means of a suitable pump 30 a first fluid, which is heavier than the other fluid which it is to contact, is supplied by conduit 31 to the lower portion of chamber 11, herein called the first chamber, and thereafter flows by gravity through the apparatus, emerging through conduit 32. This latter conduit preferably extends into a fluid level control receptacle 33 which is adjustably mounted by any suitable means 34. From this receptacle the first fluid thereafter may flow through overflow conduit 35 into a sump 36, whence it may be removed by pump 38 through conduits 37 and 39.

Simultaneously by means of a suitable pump 40 a second fluid, which is lighter than the first fluid, is supplied by conduit 41 to the upper portion of the last chamber 18. This second fluid thereafter flows through the apparatus being continually displaced by the heavier fluid as it moves from chamber to chamber and emerges through the conduit 42. This latter conduit extends into a receptacle 43, which may be fixed in position,

it being understood that suitable flexible connections for conduits 42, 41, 31 and 32 are provided to accommodate the adjustable apparatus 10 and the adjustable receptacle 33. From receptacle 43 the light fluid may then flow through conduit 44 to sump 45 and thence through conduit 46, pump 47 and conduit 48.

With the foregoing general arrangement in mind reference now is made to Figure 2 showing the relationship of the several contact chambers, only chambers 11, 12, 13 and 18 being shown. For purposes of standardization and compactness each chamber is preferably of uniform dimensions and is mounted with the longitudinal axis thereof arranged horizontally, although the apparatus 10 as a whole preferably is mounted in an inclined position. In a preferred form of our invention each chamber is subdivided into pre-mixing, mixing and settling sections or zones, although in its broader aspects the invention can be employed without the pre-mixing section at a sacrifice of efficiency due to back-mixing effects. The spacers or walls between adjacent chambers may conveniently be made of a standard size and form, and by alternate reversal of the walls end-for-end may thus place the pre-mixing section and settling sections of the adjacent chambers in direct communication with each other.

As shown in Figures 2 and 5, the outer wall 50 of the chamber 11 is provided with a cutaway corner 51 forming an aperture adapted to communicate with the header 52 to which conduit 31 is attached. The same wall is provided with a diametrically opposite cutaway corner 53 adapted to communicate with the header 54 to which conduit 42 is attached. As seen in Figure 6, a similar wall member 55 serving as a mirror image of wall member 50 is provided with equivalent cutaway corners 56 and 57.

As will thus be apparent, the heavier first fluid supplied to chamber 11 through conduit 31 and entering through the cutaway lower corner 51 of wall 50 is thus directed through chamber 11 adjacent the bottom thereof and passes into the end of adjacent chamber 12 through the cutaway lower corner 57 of wall 55. Similarly, the lighter fluid leaving chamber 12 through the cutaway upper corner 56 of wall 55, is directed through chamber 11 adjacent the top thereof and passes into the outlet conduit 42 through the cutaway upper corner 53 of wall 50. A similar juxtaposition of other apertured walls is preferably employed to form the other chambers of the apparatus with the result that the useful feature of having both fluids flow concurrently through each chamber, but countercurrently through the apparatus is achieved.

While the arrangement of walls thus described would in itself provide a reduction of back-mixing of fluids over that encountered in various forms of conventional contact apparatus, we have found that better extraction efficiencies can be secured when a pre-mixing section is provided for the fluids entering the several chambers. As shown in Figure 2, the mixing section 60, formed by spaced apertured partition plates 61 and 62, is so located within chamber 11 as to provide a settling section 63 and a pre-mixing section 64, the setting section preferably being of substantially larger size than either the mixing or pre-mixing sections. Upon entering pre-mixing section 64 the heavier fluid is directed over a weir baffle 65 rising upwardly from the floor of the chamber and the lighter fluid is directed under a weir baffle 66 extending downwardly from the top of the chamber in the manner shown in Figure 8. These baffles serve to form wells which break up mass flow of the fluids.

As an important feature of the invention the mixing section has symmetrically located inlets and outlets which may take the form of substantially horizontal slots centrally disposed in the partition plates 61 and 62. Preferably these slots are of the same size and are equally distant from the bottom of the chamber. The partition plate 61 shown in Figure 3 is adapted to be removably mounted between pins extending from the sides of the facing walls and whenever desired, as when handling different fluids or for using different retention times, other plates can be substituted therefor. Each partition plate may also be provided with a pair of holes adapted to contain spacer pins which in turn may extend through and hold in place a smaller baffle plate located within the mixing section. As shown in Figure 2, such baffles 70 and 71 are supported by the partition plate 61 and 62, respectively, and one suitable form of such a baffle 70 is shown in Figure 4.

A simple mixing means 23 such as shown in Figure 7, and consisting of a plurality of paddles mounted upon a shaft 22 extending upwardly through chimney 21 and passing through a suitable bearing seal at the top of the chimney, is disposed at the center of each of the several mixing sections and is driven from any suitable external source of power. The adjustable inclination of the entire apparatus preferably need not be reflected in any change of the mounting of such shafts and drive, all of which may be simultaneously inclined as the apparatus itself is adjusted, or may be arranged in any suitable mechanical relation known to the art. For the purpose of preventing mass flow of the liquids through the slots in the partitions a series of radially disposed anti-swirl baffles 72, 73, 74 and 75 as indicated in chamber 13, may be disposed in the mixing sections of each chamber for cooperation with the mixing means.

With the above described structure in mind, the operation of an extraction process employing the apparatus and illustrating the several advantages of the invention may now be followed. After first setting the assembly at an incline found satisfactory for normal flow conditions and proper retention times for the liquids under treatment, the hydraulic head thus established is sufficient for gravity flow through the apparatus and no inter-stage pumps or valves are needed. The actual degree inclination, however, does not have to be substantial since satisfactory results can be secured with a gradient in the order of one and one half inches rise per eight inches linear width of stage.

Following the path of the heavy liquid introduced at conduit 31, it will be seen that this untreated liquid rising over weir 65 is brought into contact with the previously treated light liquid flowing under weir 66 and that an interface between the two liquids is formed in the pre-mixing section 64. This interface is opposite the horizontal slot or aperture in partition plates 61 and 62 and permits a flow of both the light and heavy liquids into mixing chamber 60. However, in passing into or out of the mixing section the liquids must first flow over and under the interposed baffles 71 and 70. Depending upon hydraulic head the mixed fluids also rise

to a suitable height in the hollow chimney above the mixing section and thus serve to overcome pressure drops through the unit. The mixing means, which may take any of several forms, as for example, the simple paddle arrangement shown, a double-cone-shaped stirrer, or a vibratory perforated plate mixer, then causes an intimate mixing without any appreciable pumping action and without any unnecessary emulsifying action. Mass flow of the mixed fluids is further inhibited by the presence of the anti-swirl baffle in the mixing section. After being mixed and thereafter moving through the slot in partition 61 and around baffle 70 the light liquid which by this time has received its full treatment then separates from the mixed liquids and flows outwardly through aperture 53 in the top wall and into outlet conduit 42. Meanwhile the heavy liquid separating from the mixture drops to the bottom of the settling section and moves outwardly by gravity through aperture 57 in wall 55 into the adjacent chamber 12 at a somewhat lower elevation than that of chamber 11. The interface between the two liquids in settling section 63 is opposite the slot in partition plate 61. This interface is governed by the position of such slot in the plate and each such apertured plate behaves as a dam which further establishes the interface level in the next lower stage.

In similar fashion the heavy liquid progresses serially through each of the chambers finally emerging at the lower end of the settling section of the last chamber 18 and passing into conduit 32 whence it is directed into the receptacle 33. This receptacle is adjustably mounted as to its height above the support 20. Preferably the overflow outlet end of conduit 32 emptying into receptacle 33 will be located at such position as to be lower than the bottom of the horizontal slot of the partitions in last chamber 18 but higher than the point where conduit 35 opens into the receptacle 33. The fully treated heavy liquid thereupon can flow by gravity through conduits 35 and 37 and sump 36 to the pump 38 whereafter its flow no longer is subject only to gravitational force.

Following the path of the light liquid introduced through conduit 41 it will be seen that this untreated liquid entering the top of the last chamber 18 passes under a weir 80 in the premixing section 81, contacts previously treated heavy liquid entering the bottom of that premixing section over another weir, and forms an interface with that heavy liquid. The two liquids then flow into mixing section 82, are mixed therein as above described, and flow into settling section 83 from which the heavy liquid flows into outlet conduit 32 and the light liquid rises into the adjacent chamber 17 on a somewhat higher elevation.

Among the many advantages resutling from the thus described apparatus are the elimination of an undesirable pumping head of pressure in the mixing sections, due to the symmetrical design thereof. For example, it has been found upon test liquids that the use of a mixing zone having horizontal slots in the partitions and baffles associated therewith will result in the differential in interface heights at the two ends of the chamber of only about 0.1 inch with the mixer means rotating at 300 R. P. M. In contrast, with the same liquids, same mixer speed and without a pre-mixing section, but with the partition having a diagonal rather than a horizontal slot, it was found that an interface height differential of 0.8 inch would result. By elimination of the undesired pumping pressure head a more flexible control of the apparatus may be accomplished solely by modifying the inclination thereof. When used as an extractor the apparatus may be employed at widely varying rates of flow without adversely affecting the extraction efficiency, in one case at least a fivefold variation having been achieved.

It has also been found that an unusual degree of stability in extraction operation is present in that the interruption of the flow of the two fluids does not require the draining of the apparatus, and refilling of the same. On the contrary, due in part to the prevention of back-mixing, the operation may be interrupted and restarted without appreciable change in the quality of the fluids emerging from the apparatus after restarting operation. As will be apparent to those skilled in the art, the features permitting concurrent flow through each of the chambers gives rise, in the aggregate, to an appreciable time of contact between the two liquids under treatment with a resulting efficient extraction.

Various adaptations of the structure may, of course, be used without affecting the utility of the invention, one such modification being the substitution of externally extending conduits connecting the adjacent chambers in lieu of the apertured walls.

While the salient features of our invention have now been described and a particular and preferred embodiment thereof has been disclosed, it will be understood that various modifications may be made, and it is intended that the appended claims shall cover all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. Apparatus of the class described including a plurality of contact chambers arranged side by side and adapted to contain a first fluid and a second fluid, each chamber being provided with walls arranged to establish an elongated space axially of said chamber, a partition plate disposed transversely within said chamber thereby to establish a mixing section and a settling section within said space, said plate having an elongated aperture therein with the major axis of said aperture being disposed substantially horizontally, a baffle spaced from said plate and interposed in the path of flow of mixed fluids from the mixing section into the settling section, agitator means disposed in the mixing section, means establishing series communication between said chambers and connecting the fluids exit end of an intermediate chamber adjacent its bottom to the fluids entrance end of one adjacent chamber near its bottom and the fluids entrance end of said first mentioned chamber adjacent its bottom to the fluids exit end of the other adjacent chamber near its bottom for flow of one fluid and further connecting the fluids entrance end of the first mentioned chamber adjacent its top to the fluids exit end of the one adjacent chamber near its top and the fluids exit end of the first mentioned chamber adjacent its top to the fluids entrance end of the other adjacent chamber near its top for countercurrent flow of the second fluid through the respective chambers but concurrently with the first fluid through substantially the entire length of the first mentioned chamber, and means for introducing and removing said first and second fluids into and from said apparatus.

2. Apparatus of the class described including a plurality of separate elongated contact chambers adapted to contain a continuously moving first fluid and a continuously moving second fluid, each chamber being provided with walls arranged to establish an elongated space axially of said chamber, an apertured partition plate disposed transversely within said chamber thereby to establish a mixing section and a settling section within said space, agitator means disposed in the mixing section, means establishing series communication between said chambers including apertured chamber walls, said apertured walls being alternately arranged lengthwise and comprising an outlet opening therein adjacent one end of the chamber and adjacent the top of the wall for passage of said second fluid and an inlet opening therein adjacent the other end of the chamber and adjacent the bottom of the wall for passage of the first fluid, said first and second openings communicating with the same adjacent chamber thereby to provide concurrent flow of the fluids through substantially the entire length of each chamber and countercurrent flow of the fluids through the assembly of chambers, means mounting said apparatus in an inclined position with the longitudinal axis of each chamber horizontally disposed, means continuously supplying said first fluid to the fluids entrance end of a first chamber at the higher position and withdrawing said first fluid from the fluids exit end of a last chamber at the lower position and means continuously supplying said second fluid to the fluids entrance end of said last chamber and withdrawing said second fluid from the fluids exit end of said first chamber thereby to provide a countercurrent flow of said fluids through said apparatus.

3. Apparatus as set forth in claim 2 wherein said apertured plate comprises an elongated aperture with a generally horizontal major axis.

4. Apparatus of the class described including a plurality of separate elongated contact chambers adapted to contain a continuously moving first fluid and a continuously moving second fluid, each chamber being provided with walls arranged to establish an elongated space axially of said chamber, a pair of spaced apertured partition plates disposed transversely with said chamber thereby to establish a premixing section, a mixing section and a settling section within said space, agitator means disposed in the mixing section of each chamber, means establishing series communication between said chambers including a first outlet from each settling section communicating with the pre-mixing section of one adjacent chamber for passage of said first fluid and a second outlet from said settling section communicating with the pre-mixing section of the other adjacent chamber for passage of said second fluid, said first and second outlets being located at the same end of the contact chamber thereby to effect concurrent flow of the first and second fluids through the chamber, means continuously supplying said first fluid to the premixing section of a first chamber and said second fluid to the pre-mixing section of a last chamber, and conduits receiving said second fluid from the settling section of said first chamber and said first fluid from the settling section of said last chamber.

5. Apparatus as set forth in claim 4 wherein said apertured partition plates extend across the entire transverse cross section of the chamber and separate said mixing from said pre-mixing and settling sections, said apertures being of symmetrical size and location and having a generally horizontal major axis.

6. Apparatus as set forth in claim 4 wherein a plurality of substantially vertically disposed anti-swirl baffles are located within the mixing section thereby to minimize any pumping action caused by operation of said agitator means.

7. Apparatus as set forth in claim 4 wherein a pair of baffles are located within the pre-mixing section and adapted to establish an interface of liquids opposite the apertures within the partition plates, one baffle extending upwardly from the chamber floor adjacent one outlet in one wall and the other baffle extending downwardly from the chamber top adjacent an opposite outlet in the other wall.

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