

APPARATUS AND PROCESS FOR TREATING A FLUID

This invention relates to a novel apparatus and process for treating a fluid containing a less dense liquid component and a more dense liquid component, the components being substantially immiscible in each other, and the less dense component being present as a contaminant. Specifically, this invention relates to the removal of the less dense liquid component from the liquid mixture.

10 Background Art

It is known to treat a liquid mixture containing a less dense liquid component and a more dense liquid component, the components being substantially immiscible in each other. Illustrative of this type of prior art are U.S. Patent 3,125,106 to Brucken et al; 15 U.S. Patent 3,559,297 to Figiel, U.S. Patent 3,589,023 to Figiel, U.S. Patent 3,710,450 to Figiel, U.S. Patent 3,733,710 to Kearney et al. and U.S. Patent 4,136,217 to Henley. The Kearney et al. patent shows 20 treatment of the liquid mixture using a conventional water separator to separate water from the more dense liquid. The Henley patent shows an overflow pipe 26 for overflowing a top portion of a liquid mixture that has an oil emulsion as the top portion and wash water as the bottom portion. The liquid overflow is allowed 25 to reach a quiescent condition so that there is formed an oil layer and a water layer. The oil layer is

removed by a conventional rotating belt oil skimmer 30.

The Figiel patents show a process in which the liquid mixture thereof is allowed to overflow from one tank into a second tank. The second tank has an overflow pipe for removing the less dense liquid, and a drainpipe for removing the more dense liquid. Drainpipe 7 in U.S. Patent 3,710,450 to Figiel runs upwardly and parallel to wall 8 before turning to empty into reservoir 9. The height of drainpipe 7 determines the level of solvent in water separating pump 4. Overflow pipe 6 is connected to the water separating pump at a point slightly above the level of drainpipe 7.

This prior art and the other prior art of which we are aware fails to provide an apparatus and process for treating a liquid mixture containing a less dense liquid component and a more dense liquid component, the components being substantially immiscible in each other, that provides for rapid separation of the liquid mixture into an upper layer of the less dense liquid and a lower layer of the more dense liquid and for rapid restriction in cross-sectional area of the interface between the upper and lower layers. Rapid separation and cross-sectional area restriction of the interface are of substantial importance since dissolution of one liquid by the other is minimized and substantially complete removal of the less dense liquid is made possible.

It is accordingly one object of the present invention to provide a novel apparatus and process for treating a liquid mixture of the type described above that provides for rapid separation of the liquid mixture into an upper layer of the less dense liquid and a lower layer of the more dense liquid and that provides for restriction in cross-sectional area of the upper as compared with the lower layer.

In accordance with the invention, there is provided apparatus for treating liquid mixtures of a less dense liquid component and a more dense liquid component, the

components being substantially immiscible in each other, and the less dense component being present as a contaminant, such apparatus including a tank, a separator chamber provided with an exit channel, a weir separating the tank
5 from the separator chamber, and a holding chamber for holding the denser component after separation of the less dense component therefrom, the holding chamber being partitioned into a first subchamber and a second subchamber by a chamber-partitioning weir having an upper lip that is
10 at a height slightly below said exit channel; the separator chamber being provided with an upper portion that converges toward an opening leading to a riser tube, the liquid-exit channel and an air lock-preventing vent, the liquid-exit channel being situated at a height below the upper edge of
15 said tank weir; an overflow channel downstream of said tank weir being in liquid communication with said separator chamber through an outlet and the separator chamber being in liquid communication with said first subchamber through a lower channel the cross-sectional area of which is
20 greater than the cross-sectional area of the outlet, said lower channel extending from side to side at the bottom of the apparatus and being defined at the top by the lower edge of a wall dividing said separator chamber from said holding chamber. In one embodiment preferred for some
25 purposes there is provided a second separator chamber having an upper portion that converges in an opening leading to a second riser tube, said second riser tube having a second liquid-exit channel and a second air lock-preventing vent, said second liquid-exit channel being
30 situated at a height below the upper lip of ~~a second said~~ chamber-partitioning weir, and a second holding chamber having therein a ^(second) chamber-partitioning weir having an upper lip that is at a height slightly below said second liquid-exit channel, said ^(second) chamber-partitioning weir dividing said
35 second holding chamber into a first subchamber and a second

subchamber; said second separator chamber being positioned between, and in liquid communication with, said second subchamber of said first holding chamber and said first subchamber of said second holding chamber; said second
5 subchamber of the first holding chamber serving as a second overflow channel having an outlet that is located at a height below said outlet of said first overflow channel; and a second lower channel being provided from side to side of the bottom of said apparatus beneath the lower end of a wall dividing
10 said second separator chamber from said second holding chamber, the cross-sectional area of said ^(second) lower channel being greater than the cross-sectional area of said outlet of said second overflow channel.

Another aspect of the invention provides a process
15 of treating a fluid containing a less dense liquid component and a more dense liquid component, the components being substantially immiscible in each other, and the less dense component being present as a contaminant, said process comprising the steps of overflowing the liquid from the
20 tank of the apparatus of the invention over said weir, removing from the overflow liquid at least a portion of said less dense liquid component by (a) channelling said overflow liquid from said overflow channel into the converging upper portion of the separator chamber whereby (1) said
25 overflow liquid is separated into an upper layer of the less dense liquid and a lower layer of the more dense liquid and (2) the interface between the upper and lower layers is restricted in cross-sectional area as it passes into said ^{converging upper portion} ~~narrowed area~~, and (b) then passing an upper portion of the
30 layered overflow liquid through said less dense liquid-exit channel, passing a lower portion of said layered overflow liquid from said separator chamber into the holding chamber through said lower channel which has a cross-sectional area sufficiently greater than the cross-sectional area of ~~an~~ the
35 outlet of said overflow channel from said weir for pressure

build-up to be avoided in the event of a surge of said liquid through said apparatus.

Reference is hereby made to the accompanying drawings, in which:

5 Figure 1 of the drawing is a plan view of a preferred embodiment of the invention, showing an apparatus having one separator chamber.

Figure 2 is a cross-sectional view of the apparatus shown in Figure 1, taken along the line 2-2 of Figure 1.

10 Figure 3 is a plan view of another preferred embodiment of the invention, showing an apparatus having two separator chambers.

Figure 4 is a cross-sectional view of the apparatus shown in Figure 3, taken along the line 4-4 in Figure 3.

15 Figure 5 is a partial cross-sectional view of the apparatus shown in Figure 1, taken along the line 5-5 of Figure 1. This figure shows underflow channel 62.

Figure 6 is a partial cross-sectional view of the apparatus of Figure 3, taken along the line 6-6 of Figure 20 3. This figure shows underflow channel 130.

Figure 7 shows an alternate embodiment of a portion of the apparatus shown in Figure 2.

Best Mode for Carrying Out the Invention

As explained above, in accordance with the invention, 25 there is provided a novel apparatus and process for treating a fluid containing a less dense liquid component and a more dense liquid component. The components are substantially immiscible in each other, and the less dense component is present as a contaminant.

30 Referring to Figures 1 and 2, a preferred embodiment of an apparatus 10, in accordance with the present invention, is provided that includes a tank 12, a separator chamber 14 and a holding chamber 16. Tank 12 has a weir 18 of preselected height that separates the tank 35 from an overflow channel 20, which leads to separator

chamber 14. Preferably, an upper part 22 of weir 18 is sloped in the direction of overflow channel 20 in order to provide good sweeping action for separation of contaminants introduced into tank 12 from a cleaning solvent contained 5 therein.

Tank 12 is illustratively used for cleaning work pieces by immersing the work pieces in the solvent contained therein. The solvent is, for example, at room temperature, and is illustratively a halogenated solvent such as an 10 azeotrope of trichlorotrifluoroethane with isopropanol and/or ethanol or an azeotrope of trichlorotrifluoroethane and methylene chloride. The halogenated solvent may also be an azeotrope of trichloromonofluoromethane with any of or a mixture of isopropanol, ethanol and methylene chloride.

15 Separator chamber 14 has an upper portion 26 that converges upwardly as an opening 28 leading to a riser tube 30. The riser tube has a fluid-exit channel 32 and an air lock-preventing vent 34. Fluid-exit channel 32 is situated at a height below an upper edge 35 of weir 18.

20 Vent 34 is located at a height above fluid-exit channel 32.

Overflow channel 20 has an outlet 36 that has an upper edge 38. Preferably, upper edge 38 is below a point 40 at which a side 42 of upper portion 26 begins converging toward riser tube 30. Side 42 is the side of upper portion 25 26 closest to tank 12. Alternatively, the point at which side 42 begins converging toward riser tube 30 could coincide with upper edge 38, as shown in Figure 7. However, the preferred embodiment of this aspect of the apparatus, described above, has the advantage of reducing turbulence 30 in the area of V-shaped opening 28 and thus promotes better separation of the less dense liquid component and the more dense liquid component.

The configuration of separator chamber 14 provides for rapid separation of the fluid stream entering chamber 14 35 into an upper layer of the less dense liquid and a lower

layer of the more dense liquid, and provides for restriction in cross-sectional area of the upper as compared with the lower layer. Riser tube 30 to which the converging opening leads, provides for facile removal of the upper layer since the cross-sectional area thereof is relatively small. Thus, a relatively small amount of contaminant will provide a layer several inches (about 7-9 centimeters) deep in riser tube 30. Contaminant is removed from the apparatus through exit channel 32. Insoluble particulate matter that is entrained by the liquid contaminant is also removed through exit channel 32.

Holding chamber 16 has a weir 44 having an upper lip 46 that is at a height slightly below exit channel 32. The height difference depends, for example, upon the specific gravity of the liquids involved. If, for instance, the immiscible liquids are water and a halogenated solvent such as a fluorocarbon, upper lip 46 is minimally about one half inch (1.3 centimeter) below exit channel 32. Weir 44 partitions holding chamber 16 into a subchamber 48 and a subchamber 50. Preferably, an upper part 51 of weir 44 is sloped in the direction of subchamber 50 in order to provide good sweeping action. Holding chamber 16 preferably has a top portion 52 so that loss of treated fluid contained therein, into air surrounding holding chamber 16 is prevented. As shown in the drawing, the configuration of the apparatus prevents solvent vapor loss except in the vicinity of tank 12. Loss of vapors of the more dense solvent is negligible through vent 34 since the aperture of the vent is relatively small and since the less dense liquid component is situated between the more dense liquid component and vent 34.

Referring to Figure 5, a bottom portion 53, a side portion 54, a side portion 56 (each of apparatus 10) and a lower end 58 of a wall 60 form an underflow channel 62. Wall 60 divides separator chamber 14 from holding chamber 16.

The cross-sectional area of channel 62 is sufficiently greater than the cross-sectional area of outlet 36 of overflow channel 20 so that pressure build-up is avoided in the event of surge of fluid through apparatus 10.

5 Preferably, apparatus 10 includes a pump 66 for returning the treated fluid from subchamber 50 to tank 12. Pump 66 communicates with subchamber 50 and tank 12 through line 68, which exits in a sparger 70. Line 68 preferably further includes a filter 72 for removing any unseparated
10 insoluble contaminants from the treated fluid prior to recycling to tank 12. Filter 72 is conveniently located between pump 66 and sparger 70.

Referring to Figures 3 and 4, another preferred embodiment of an apparatus 74 is provided that is
15 characterized by the presence of two separator chambers. Whether this apparatus or the one just described is used to remove contaminants, depends upon factors such as the ease of separating the less dense liquid component from the more dense liquid component. For example, if separation is not
20 too difficult, the apparatus of Figures 1 and 2 is satisfactory. However, where the separation is difficult, then the apparatus of Figures 3 and 4 should be used. In situations where extremely difficult liquid separation is involved, an apparatus in accordance with the present
25 invention could have three or more separator chambers.

Apparatus 74 has a tank 76, a separator chamber 78, and a holding chamber 80 that are identical to tank 12, separator chamber 14 and holding chamber 16, described above, except that subchamber 82 of holding chamber 80
30 serves as an overflow channel. Overflow channel 82 has an outlet 84 that is located at a height below outlet 86 of overflow channel 88.

In addition to tank 76, separator chamber 78 and holding chamber 80, apparatus 74 includes separator chamber
35 89 and holding chamber 90. Separator chamber 89 has an

upper portion 91 that converges in an upwardly converging opening 92 that leads to a riser tube 94. Riser tube 94 has a fluid-exit channel 96 and an air lock-preventing vent 98. Exit channel 96 is situated at a height below an upper lip 100 of a weir 102. Vent 98 is located at a height above exit channel 96.

Preferably, an upper edge 104 of outlet 84 of overflow channel 82 is below a point 106 at which a side 108 of upper portion 91 begins converging toward riser tube 94. Side 108 is the side closest to holding chamber 80. Alternatively, the point at which side 108 begins converging toward riser tube 94 could coincide with upper edge 104, in the very same way as shown in Figure 7 for the apparatus of Figures 1 and 2. However, the preferred embodiment of this aspect of the apparatus has the advantage of reducing turbulence in the area of converging opening 92 and thus promotes better separation of the less dense liquid component and the more dense liquid component.

As can be understood from the above description, separator chamber 89 has the same configuration as separator chamber 14 of the earlier described embodiment. Thus, separator chamber 89 provides the advantages described above such as rapid separation of the liquid stream of an upper and a lower layer.

Holding chamber 90 has therein a partition 110 having an upper lip 112 that is at a height slightly below exit channel 96. The relative height of upper lip 112 and exit channel 96 is the same as that described above for upper lip 46 and exit channel 32. As can be seen from this description, the apparatus has been provided with a configuration that provides for a downstream flow of the fluid stream exiting tank 76. Specifically, a fluid-exit channel 113 of separator chamber 78 is below an upper edge 114 of weir 115 of tank 76, upper lip 100 of weir 102 is slightly below exit channel 113, exit channel 96 is below upper lip 100, and upper lip 112 is slightly below exit

channel 96. Also, overflow channel 82 has an outlet 84 that is located at a height below outlet 86 of overflow channel 88.

Partition 110 of holding chamber 90 divides chamber 90 into subcompartment 116 and subcompartment 117. An upper part 118 of partition 110 is preferably sloped in the direction of subcompartment 117. Holding chamber 90 preferably has a top portion 119 for preventing loss of treated fluid contained therein into air surrounding chamber 90. As can be seen from Figure 4, vapors of the more dense liquid component are subject to loss into the surrounding air only in the vicinity of tank 76.

Referring to Figure 6, a bottom portion 120, a side portion 122, a side portion 124 (each of apparatus 74), and a lower end 126 of a wall 128 form an underflow channel 130. Wall 128 divides separator chamber 89 from holding chamber 90. The cross-sectional area of underflow channel 130 is sufficiently greater than the cross-sectional area of outlet 84 of overflow channel 82 so that pressure build-up is avoided in the event of a surge of fluid through apparatus 74.

Preferably, apparatus 74 includes a pump 134 for returning treated fluid from subcompartment 117 to tank 76. Pump 134 communicates with subcompartment 117 and tank 76 through line 136, which exits in sparger 138. Preferably, line 136 further includes a filter 140 for removing any unseparated insoluble contaminants from the treated fluid prior to recycling to tank 76. Filter 140 is conveniently located between pump 134 and sparger 138.

A process for treating a fluid comprising a less dense liquid component and a more dense liquid component, and using the apparatus of Figures 1 and 2, will now be described. The liquid components are substantially immiscible in each other, and the less dense component is present as a contaminant.

In the first essential step of the process, the fluid

is allowed to flow over weir 18. In the next essential step, the less dense liquid component is removed from the overflow liquid. Removal is achieved by channelling the overflow liquid from overflow channel 20 into upwardly
5 converging opening 28 as a result of which the overflow liquid is rapidly separated into an upper layer of the less dense liquid and a lower layer of the more dense liquid, and as a result of which the interface between the upper and lower layers is so located that the upper layer is
10 restricted in cross-sectional area. Removal then involves passing an upper portion of the layered overflow liquid through exit channel 32.

In the third step, a lower portion of the layered overflow liquid is passed from separator chamber 14 into
15 holding chamber 16. The lower portion is passed through underflow channel 62 into subchamber 48. In the fourth essential step, the underflow liquid is allowed to flow over weir 44 into subchamber 50 to provide a purified overflow liquid.

20 Preferably, the process further includes the step of recycling the purified overflow liquid from subchamber 50 to tank 12 via sparger 70. When the process includes recycling, it is preferable to filter the recycled liquid.

A process using the apparatus shown in Figures 3 and
25 4 will now be described. This process includes the essential steps described above and the following additional steps. In this process, some of the less dense liquid is not removed in separator chamber 78. In the first additional essential step of the process of this
30 embodiment, there is removed any unseparated less dense liquid from the purified overflow liquid. Removal is achieved by channelling the purified overflow liquid from subchamber 82, which serves as overflow channel 82, into the converging opening 92 of separator chamber 89. As a
35 result, the purified overflow liquid is rapidly separated into an upper layer of the remaining less dense liquid and

a lower layer of the more dense liquid. Also, as a result, the interface between the upper and lower layers is so located that the upper layer is restricted in cross-sectional area. Removal then involves passing an upper
5 portion of the layered, purified overflow liquid through exit channel 96.

In the next additional essential step, a lower portion of the layered, purified overflow liquid is passed from separator chamber 89 into subcompartment 116 of holding
10 chamber 90. The lower portion is passed through underflow channel 130. In the final additional, essential step, the purified underflow liquid is allowed to flow over upper lip 112 of partition 110 into subcompartment 117 to provide a more purified overflow liquid.

15 Preferably, this process further includes the step of recycling the overflow liquid from subcompartment 117 to tank 76, via sparger 138. When the process includes the step of recycling, it preferably includes the step of filtering the recycled liquid to remove any particulate
20 matter therefrom.

Work pieces that have been cleaned by immersion in the cleaning solvent of tank 12 or 76 may be transferred to a vapor degreaser for final cleaning. The vapor degreaser may range from a simple vapor degreaser to a multi-stage
25 liquid-liquid-vapor degreaser with ultrasonics. The combination of equipment provided for cleaning by immersion in a solvent followed by vapor spray treatment is particularly useful for the removal of water-based cutting oils and water films from metal, glass and plastic
30 substrates.

The apparatus is conveniently constructed of metal. Suitably, each riser tube is provided with a glass window so that the level of the interface between the upper and lower layers may be observed. Conveniently, the cross-
35 sectional area of an underflow channel is at least about twice as great as the cross-sectional area of an outlet of

the upstream overflow channel.

In this disclosure, there is shown and essentially described only two preferred embodiments of the invention. It is to be understood that the invention is capable of 5 modifications or changes within the scope of the inventive concept expressed herein. Several changes or modifications have been briefly mentioned for purpose of illustration.



CLAIMS

1. Apparatus for treating liquid mixtures of a less dense liquid component and a more dense liquid component, the components being substantially immiscible in each other, and the less dense component being present as a contaminant, 5 such apparatus including a tank, a separator chamber provided with an exit channel, a weir separating the tank from the separator chamber, and a holding chamber for holding the denser component after separation of the less dense component therefrom, the holding chamber being 10 partitioned into a first subchamber and a second subchamber by a chamber-partitioning weir having an upper lip that is at a height slightly below said exit channel; the separator chamber being provided with an upper portion that converges toward an opening leading to a riser tube, the liquid-exit 15 channel and an air lock-preventing vent, the liquid-exit channel being situated at a height below the upper edge of said tank weir; an overflow channel downstream of said tank weir being in liquid communication with said separator chamber through an outlet and the separator chamber being 20 in liquid communication with said first subchamber through a lower channel the cross-sectional area of which is greater than the cross-sectional area of the outlet, said lower channel extending from side to side at the bottom of the apparatus and being defined at the top by the lower 25 edge of a wall dividing said separator chamber from said holding chamber.

2. Apparatus according to claim 1, wherein there is provided a second separator chamber having an upper portion that converges in an opening leading to a second riser tube, 30 said second riser tube having a second liquid-exit channel and a second air lock-preventing vent, said second liquid-exit channel being situated at a height below the upper lip of said chamber-partitioning weir, and a second holding chamber having therein a second chamber-partitioning



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weir having an upper lip that is at a height ^(slightly) ~~(slightly)~~ below said second liquid-exit channel, said second chamber-partitioning weir dividing said second holding chamber into a first subchamber and a second subchamber; said second separator chamber being positioned between, and in liquid communication with, said second subchamber of said first holding chamber and said first ^(subchamber) ~~(chamber)~~ of said second holding chamber; said second subchamber of the first holding chamber serving as a second overflow channel having an outlet that is located at a height below said outlet of said first overflow channel; and a second lower channel being provided from side to side of the bottom of said apparatus beneath the lower end of a wall dividing said second separator chamber from said second holding chamber, the cross-sectional area of said ^(second) ~~(lower)~~ channel being greater than the cross-sectional area of said outlet of said second overflow channel.

3. Apparatus according to claim 1 or 2, wherein a pump is provided in a line connected to return liquid from said second subchamber of the holding chamber or the second subchamber of the second holding chamber to said tank, filter means being situated in said line between said pump and said tank.

4. Apparatus according to any preceding claim, wherein the or each holding chamber has a top portion and an upper part of said weir therein is sloped in the direction to widen the top of said first subchamber.

5. A process of treating a liquid comprising a less dense liquid component and a more dense liquid component, the components being substantially immiscible in each other, and the less dense component being present as a contaminant, said process comprising the steps of overflowing said liquid from the tank of the apparatus of claim 1 over said weir, removing from the overflow liquid at least a portion of said less dense liquid component by (a) channelling said overflow liquid from said overflow channel into the converging upper portion of the separator chamber whereby (1) said overflow liquid is separated into an upper layer of the less dense



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liquid and a lower layer of the more dense liquid and (2) the interface between the upper and lower layers is restricted in cross-sectional area as it passes into said ^{converging upper portion} ~~narrowed area~~, and (b) then passing an upper portion of the layered overflow liquid through said less dense liquid-exit channel, passing a lower portion of said layered overflow liquid from said separator chamber into the holding chamber through said lower channel which has a cross-sectional area sufficiently greater than the cross-sectional area of ^(the) ~~an~~ outlet of said overflow channel from said weir for pressure build-up to be avoided in the event of a surge of said liquid through said apparatus.

6. A process according to claim 5, which is carried out using the apparatus of claim 2 and includes the steps of removing from the liquid in the first holding chamber which comprises said more dense liquid and any unseparated less dense liquid, at least a portion of said any unseparated less dense liquid by (a) channelling said liquid from said second subchamber, which serves as a second overflow channel, into ~~an opening of~~ the second separator chamber, whereby (1) said liquid is rapidly separated into an upper layer of said less dense liquid and a lower layer of a more dense liquid and (2) the upper layer is restricted in cross-sectional area, and (b) then passing an upper portion of the layered liquid through the second less dense liquid-exit channel; passing a lower portion of the layered liquid from said second separator chamber into said second holding chamber; and flowing the liquid over said second chamber-partitioning weir into said second subcompartment to provide a purified overflow liquid.

7. A process according to claim 5 or 6, wherein liquid is filtered while being recycled from said second subchamber to said tank.



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8. Apparatus for treating a fluid constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

5 9. A process of treating fluid substantially as hereinbefore described with reference to the accompanying drawings.
