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SYSTEM AND METHOD FOR SEPARATING HEAVIER AND
LIGHTER COMPONENTS OF LIQUID MIXTURES
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FIG. 1.

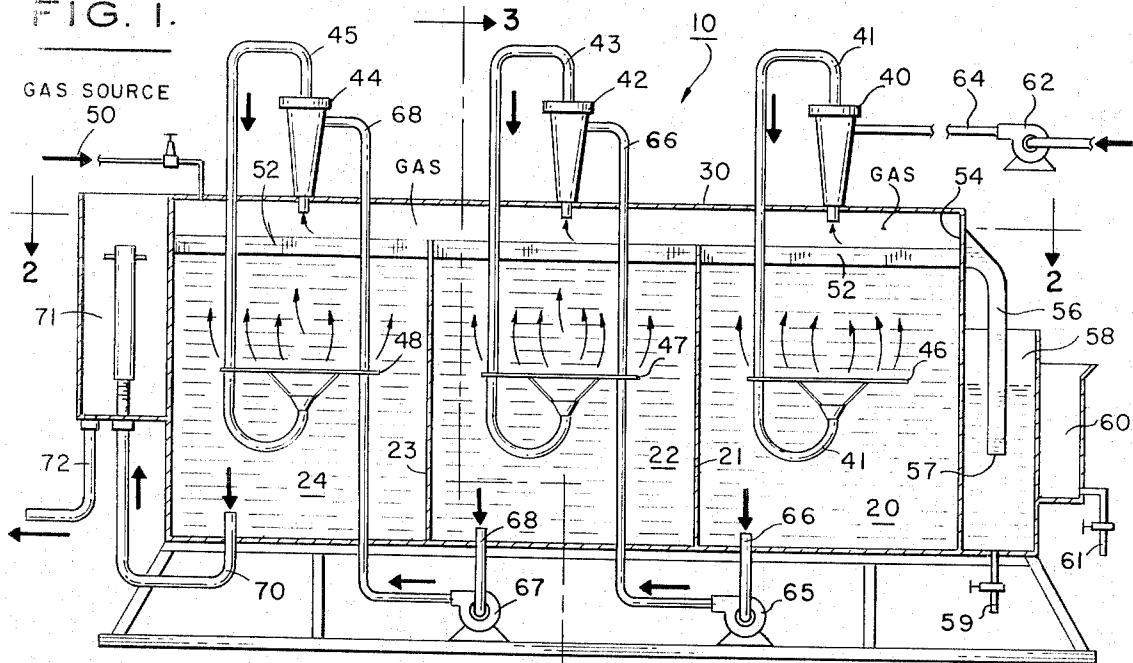


FIG. 2.

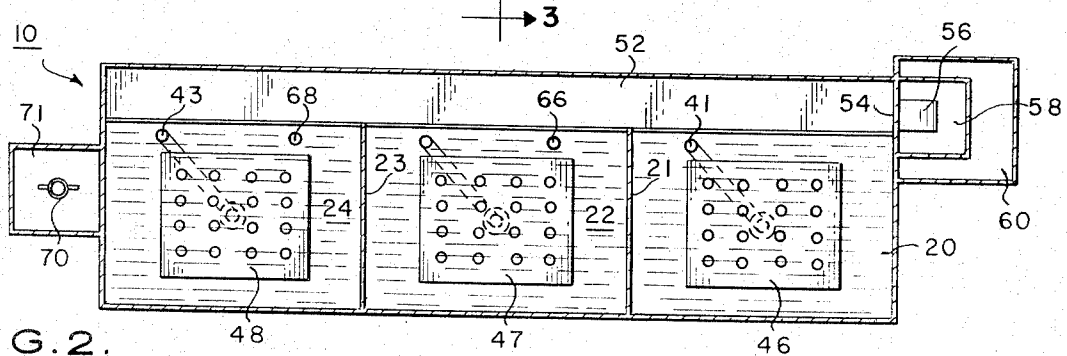


FIG. 3.

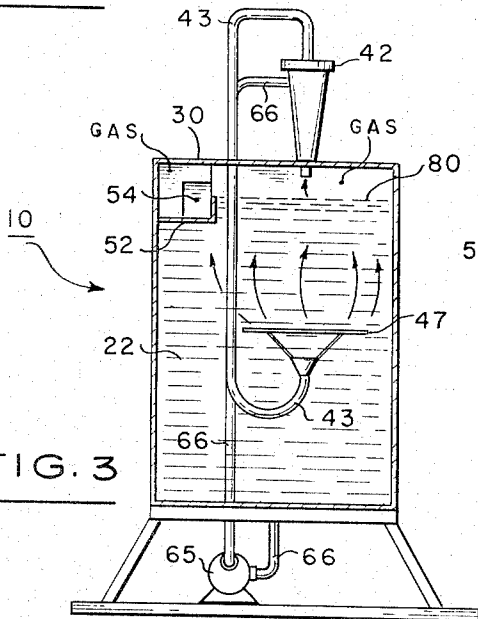
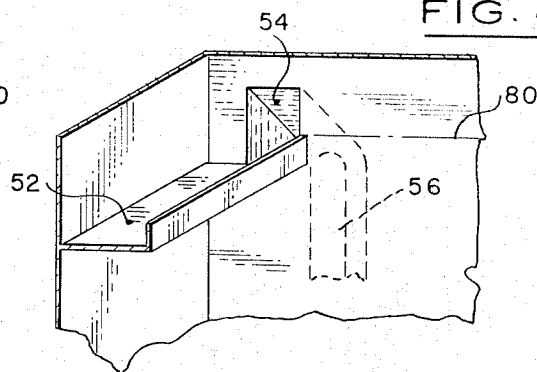


FIG. 4.



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SYSTEM AND METHOD FOR SEPARATING HEAVIER AND LIGHTER COMPONENTS OF LIQUID MIXTURES

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14 Claims

ABSTRACT OF THE DISCLOSURE

A mixture of liquids capable of gravity separation, such as oil and water, is charged with gas or aerated in a cyclone. The aerated liquid mixture is then separated in a flotation chamber or cell. The lighter liquid component floats to the surface of the liquid mixture in the flotation cell aided by the rising gas in the liquid mixture. Several cyclone-flotation cells may be connected together in series in which arrangement the heavier separated component mixed with the lighter unseparated component is cycled from a particular flotation cell to the next succeeding cyclone-flotation cell.

BACKGROUND OF THE INVENTION

The present invention is broadly directed to a method and system for separating the components of a liquid mixture in which cyclones are used to force gas into the liquid mixture for the purpose of later aiding in floating the lighter component of the mixture in a flotation cell.

SUMMARY OF THE INVENTION

In accordance with the teachings of the invention, the separation system comprises, briefly, a flotation cell; a cyclone for aerating a mixture of liquids; means for introducing the liquid mixture into the cyclone; means for introducing gas into the cyclone for aerating the liquid mixture in the cyclone; means for transferring the liquid mixture charged with gas from the cyclone to the flotation cell; means for discharging the separated lighter liquid component from the flotation cell; and means for discharging the separated heavier liquid component from the flotation cell. The invention also encompasses the method involved in operating the separation system.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of an arrangement of the liquid-liquid separator of the invention;

FIG. 2 is a view taken along lines 2—2 of FIG. 1;

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 1; and

FIG. 4 is an isometric view showing the overflow trough with its outlet duct.

DETAILED DESCRIPTION OF THE INVENTION

As shown in FIG. 1, a liquid-liquid separation system indicated at 10 separates liquid components having different specific gravities from each other.

A series of flotation chambers, cells or compartments and cyclone or vortex liquid-gas mixers are shown. A flotation compartment 20 has a common wall 21 with another flotation compartment 22, which in turn has a common wall 23 with another flotation compartment 24. Compartments 20, 22 and 24 are covered by a gas tight top 30. A vortex or cyclone 40 is mounted above compartment 20 and a liquid delivery tube 41 extends from the upper end of cyclone 40 into compartment 20. Another similar cyclone 42 is mounted above compartment 22 and a liquid delivery tube 43 extends from the top of cyclone 42 into compartment 22. A third cyclone 44 is

mounted above compartment 24 and a liquid delivery tube 45 extends from cyclone 44 into compartment 24. As shown tubes 41, 43 and 45 terminate below the surface of the liquid in their respective compartments. Positioned just above the outlet of tube 41 is a perforated distribution plate 46. Each of the other tubes 43 and 45 is similarly provided with a perforated liquid distribution plate 47 and 48, respectively.

Gas is supplied to the compartments from a source indicated at 50. The gas is located between the top 30 of the compartments and the level of the liquid indicated at 80 (FIG. 3). The bottom of each cyclone is immersed in a gas layer as shown. Each of the compartments 20, 22 and 24 overflow into a common trough 52 which extends the full length of the unit and which discharges into a discharge duct or conduit 56 through opening 54 in the end wall of the unit. The up-turned lip of trough 52 determines the maximum liquid level in the compartments. Duct 56 extends downwardly into an outer compartment 58 with its open end 57 submerged in liquid so as to maintain a gas head above the liquid in the duct and also above the liquid in the compartments 20, 22 and 24. Any solids in the overflow into compartment 58 deposit on the bottom of the compartment and may be drawn off at suitable intervals through conduit 59. As oil fills the compartment 58 it overflows into a collection chamber 60 from where it may be discharged by way of conduit 61 to a sump.

A pump 62 pumps the liquid mixture to be separated through a conduit 64 into cyclone 40. Another pump 65 located in a conduit 66 pumps liquid from the bottom of compartment 20 into cyclone 42 and still another pump 67 located in a conduit 68 pumps liquid from the bottom of compartment 22 into cyclone 44. A conduit 70 extends from the bottom of compartment 24 into a small compartment 71. Conduit 70 is adjustable in height in compartment 71 to establish the liquid level in compartments 20, 22 and 24. Clean water is discharged from compartment 71 through line 72.

OPERATION

In operation of the system a mixture of liquids and possibly some solids, such as water, oil and some sand, is delivered through conduit 64 to cyclone 40 by means of pump 62. The bottom of cyclone 40 exists in the gas environment. The vortex formed in the center of cyclone 40 sucks gas up which mixes with the swirling liquid under pressure. The aerated liquid mixture from cyclone 40 is discharged into compartment 20 through tube 41 and distribution plate 46. The rising gas charged in the liquid mixture in cyclone 40 floats oil and possibly light solids to the surface of the liquid. Heavier solids are separated in the cyclone 40 and dropped from the base thereof and remain suspended by the gaseous froth on the surface of the liquid. The floated oil and solids overflow into trough 52 and through duct 56 into compartment 58. When compartment 58 fills the oil overflows into compartment 60. Any solids carried with the oil into compartment 58 may be discharged through conduit 59. The heavier separated liquid along with the unseparated lighter liquid component mixed therewith is pumped by means of pump 65 through conduit 66 into cyclone 42 where the mixing and charging with gas is repeated. The liquids charged with gas are discharged through conduit 43 into compartment 22 through distribution plate 47. Similarly, the heavier liquid component along with the unseparated lighter liquid component in compartment 22 is pumped by means of pump 67 through conduit 68 into cyclone 44 where the liquids are again charged with gas and are discharged through tube 45 into compartment 24 through distribution plate 48. The heavi-

er component is then overflowed through conduit 70 into compartment 71 whence it is discharged from the system through conduit 72.

The action of the liquids in the cyclone causes the gas to be sucked up the center of the vortex formed by the swirling liquid mixture in the cyclone and beaten into the liquid to form small gas bubbles in the liquid.

The vortex or cyclone separators 40, 42 and 44 are of conventional design and may be suitably of the type discussed and shown on pp. 3932-3935 of the Composite Catalog of Oil Field Equipment of Services, 1966-67 ed., published by World Oil. The inner wall of each cyclone is preferably lined with a replaceable sleeve of material such as polyurethane or butyl rubber which is durable. The gas may be methane (natural gas) or any suitable nonoxidizing, inert gas. Where oxidation is not a problem air may be used.

While the invention has been described herein with reference to separating water and oil, other uses will be apparent to those skilled in this art.

Other changes and modifications may be made in the specific illustrative embodiments of the invention shown and/or described herein without departing from the scope of the invention as defined in the appended claims.

Having fully described the apparatus, operation, advantages and objects of my invention, I claim:

1. A system for separating heavier and lighter components of a liquid mixture comprising:

a flotation compartment;

a cyclone for charging said liquid mixture with gas; means for separately introducing said liquid mixture and said gas into said cyclone; and

means for transferring the liquid mixture charged with said gas from said cyclone to said flotation compartment at a location below the surface of the liquid in said flotation compartment, the gas in said liquid mixture aiding in floating the lighter liquid component to the surface of the liquid in said flotation compartment.

2. A system as recited in claim 1 in which said gas comprises air.

3. A system as recited in claim 1 in which said gas comprises a non-oxidizing gas.

4. A system for separating heavier and lighter components of liquid mixtures comprising:

a first flotation compartment;

a first cyclone for charging a liquid mixture with gas; means for introducing said liquid mixture and said gas into said first cyclone;

means for transferring said liquid mixture charged with said gas from said first cyclone to said first flotation compartment, the gas in said liquid mixture aiding in floating the lighter liquid component to the surface of the liquid in said first flotation compartment;

a second flotation compartment;

a second cyclone for charging another liquid mixture with said gas,

means for introducing said other liquid mixture from said first flotation compartment and said gas to said second cyclone, said other liquid mixture comprising said heavier liquid component separated in said first flotation compartment and any of said lighter liquid component not separated in said first flotation compartment; and

means for transferring the other liquid mixture charged with said gas from said second cyclone to said second flotation compartment, the gas and said other liquid mixture aiding in floating the lighter liquid

component to the surface of the liquid in said second flotation compartment.

5. A system as recited in claim 4 including at least a third cyclone-flotation compartment unit for charging with gas and separating the lighter liquid component from the heavier liquid mixture separated in the second flotation compartment.

6. A system as recited in claim 5 including means for discharging said lighter liquid component separated in each of said flotation compartments.

7. A system as recited in claim 6 including means for discharging said heavier liquid component from said third flotation compartment.

8. A system as recited in claim 7 including means arranged in each flotation compartment for distributing aerated liquid mixture over greater area therein.

9. A method for separating liquids having different specific gravities from a mixture thereof comprising the steps of:

introducing said liquid mixture into a cyclone;

separately introducing gas into said cyclone to charge said liquid mixture with gas; and

transferring said liquid mixture charged with gas to a flotation compartment at a location below the surface of the liquid in the flotation compartment in a manner so that the gas in said liquid mixture aids in floating the lighter liquid component to the surface of the liquid in said flotation compartment.

10. A method for separating liquids having different specific gravities from a mixture thereof comprising the steps of:

introducing a liquid mixture into a cyclone;

introducing gas into said cyclone to charge said liquid mixture with gas;

transferring said liquid mixture charged with gas to a flotation compartment, the gas in said liquid mixture aiding in floating the lighter liquid component to the surface of the liquid in said flotation compartment; aerating another liquid mixture in another cyclone, said other liquid mixture being the heavier liquid separated in said flotation compartment; and separating said heavier liquids from said lighter liquids in another flotation compartment, the gas in said other liquid mixture aiding in floating the lighter liquid component thereof to the surface of the liquid in said other flotation compartment.

11. A method as recited in claim 10 in which the mixing-aeration and flotation-separation steps are repeated until the heavier and lighter liquid components have been completely separated.

12. A method as recited in claim 9 in which the mixing-aeration and flotation-separation steps are repeated until the heavier and lighter liquid components have been completely separated.

13. A method as recited in claim 9 in which said gas is air.

14. A method as recited in claim 9 in which said gas is a non-oxidizing gas.

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MICHAEL ROGERS, Primary Examiner

U.S. Cl. X.R.

55-45, 171; 210-73, 202, 261, 512