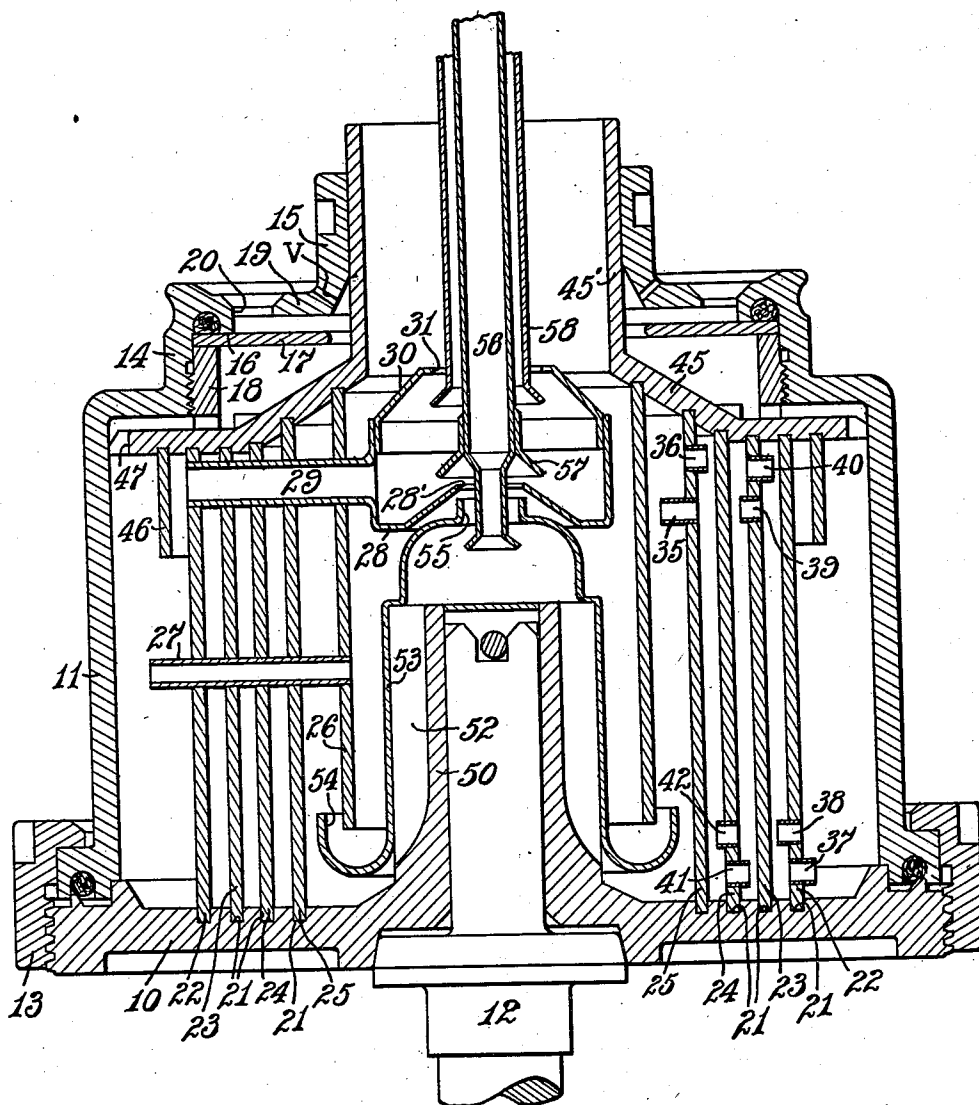


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COUNTER-FLOW CENTRIFUGE AND METHOD OF TREATING ONE LIQUID
WITH ANOTHER LIQUID OF DIFFERENT SPECIFIC GRAVITY
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COUNTERFLOW CENTRIFUGE AND METHOD
OF TREATING ONE LIQUID WITH ANOTHER
LIQUID OF DIFFERENT SPECIFIC
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In certain arts it is desirable to contact and wash the surface of one liquid with another liquid, subsequently separating the resultants into two or more well-defined and individualized liquids, rather than to produce an intimate mixture of such two liquids followed by separation and individualization.

For instance, in the purification of lubricating oil certain steps of purification involve treatment of the oil with a liquid such as phenol which has the capacity of absorbing undesirable impurities contained in the oil. Such purification has heretofore been obtained by admixing the phenol with the oil, but too long and too intimate contact of the phenol with the oil produces undesirable results and it has been recently discovered that desired purification, while avoiding most of the deleterious effects heretofore produced, may be obtained by contacting a film of the oil with a film of phenol followed by a separation of the treated oil and the treating phenol.

An object of my present invention is to provide a mechanism by which two liquids, differing in specific gravities, may be brought into surface contact only and continued in a relative sliding contact in such association for a predeterminable period of time and under predeterminable pressures, and subsequently separated one from the other.

A further object of my invention is to provide an improved method of surface treating one liquid by another liquid of different specific gravity.

The accompanying drawing is an axial vertical section of an apparatus embodying my invention.

In the drawing 10 indicates a base flange and 11 indicates a main body flange which, together form a centrifugal bowl which may be rotated at desired speeds by means of a carrying spindle 12. The body flange 11 is preferably readily separable from the base flange 10 and is conveniently held in association therewith by the ring nut 13. The body flange 11 at its upper end is provided with a reduced-diameter intermediate neck 14 and a further-reduced neck 15. Near its upper end the intermediate neck 14 is provided internally with a downwardly-presented shoulder 16, upon which may be seated any one of a number of ring dams 17 by means of a nut 18, said ring dams varying in internal diameter.

Necks 14 and 15 are connected by radial flange 19 provided with a plurality of heavy-liquid outlets 20 and a plurality of air vents V.

Removably seated in a plurality of circular

grooves 21, of different diameters, formed in the upper face of base flange 10, is a plurality of annular partitions 22, 23, 24, 25 conveniently cylindrical. These partitions may be varied in number and spacing in accordance with the particular liquids which are to be associated.

Within the smallest partition 25 is an annular partition 26 and projected radially through the several partitions 22 to 25 is a pressure-balancing tube 27 which forms a pressure-balancing conduit between the interior of partition 26 and the exterior of partition 22, the outer end of said tube 27 extending toward but not to the inner face of wall 11. There may be several of these tubes 27 circumferentially spaced from each other.

Nested within the upper end of partition 26 is a cup 28 provided with a radial conduit 29 which is projected through the several partitions 22 to 26 to form a conduit from the interior of cup 28 to the exterior of the largest diameter partition 22. There may be several of these conduits 29, circumferentially spaced. The bottom of cup 28 is medially elevated, as shown, and is axially perforated at 28'. Cup 28 is capped by an annular cap 30 having an axial perforation 31.

The smallest-diameter partition 25 near its upper end is pierced by a circumferentially spaced series of conduits 35, the inlet mouths of which are arranged about half way between partition 26 and partition 25. Partition 25 is also pierced, near its upper end by a circumferentially-spaced series of conduits 36, the inlet mouths of which lie closer to the inner face of partition 25 than the inlet mouths of conduits 35, and the outlet mouths of which lie at a point intermediate between partition 25 and partition 24.

The largest-diameter partition 22 is pierced near its bottom with a plurality of circumferentially-spaced conduits 37, the inlet mouths of which are arranged at or close to the inner face of the largest-diameter partition 22 and the outlet mouths of which are spaced outwardly beyond the outer face of said partition 22. Partition 22 is also pierced near its bottom with a plurality of conduits 38, the inlet mouths of which are arranged closer to the outer face of partition 22 than are the outlet mouths of conduits 37, and the outlet mouths of which are arranged intermediate between the inner face of partition 22 and the outer face of the next smaller partition 23.

Partition 23 near its upper end and conveniently in the plane of conduits 35, is pierced by

a plurality of circumferentially-spaced conduits 39, the inlet mouths of which are arranged intermediate the inner face of partition 23 and the outer face of partition 24. The upper end of partition 23 is also pierced by a plurality of circumferentially-spaced conduits 40, the inlet mouths of which are arranged closer to the inner face of partition 23 than are the inlet mouths of conduits 39, and the outlet mouths of which are arranged intermediate the outer face of partition 23 and the inner face of partition 22 and preferably a little closer to the inner face of partition 22 than are the outlet mouths of conduits 38.

Partition 24 near its bottom is pierced by a plurality of circumferentially-spaced conduits 41, preferably in the plane of the conduits 37, the inlet mouths of which are arranged close to the inner face of partition 24 and the outlet mouths of which are arranged at an intermediate point between partitions 24 and 23 and preferably as close to the inner face of partition 23 as are the outlet mouths of conduits 39.

Partition 24 is also pierced by a circumferentially-spaced series of conduits 42, the inlet mouths of which are arranged at an intermediate point between the inner face of partition 24 and the outer face of partition 25 and the outlet mouths of which are arranged closer to the outer face of partition 24 than are the outlet mouths of conduits 41.

The piercing conduits of any partition may be arranged in substantially the same plane and conveniently are circumferentially alternated. The conduits 36, 40 are shown at a higher level than conduits 35, 39 and 38, 42, at a higher level than 37, 41 for convenience of illustration.

For convenience in handling, the parts 22 to 42, inclusive, are secured together into a unitary structure.

Surmounting the aforesaid unitary structure is a separator bell 45 having in its lower face a plurality of circumferential grooves adapted to receive the upper ends of the aforesaid cylindrical partitions and this bell carries, beyond the largest-diameter partition, a depending annular skirt 46, the lower end of which is extended below the outer mouths of conduits 29. The diameter of this skirt 46 lies within the outer ends of the balancing tubes 27. Bell 45, at its outer diameter, conveniently has a sliding fit with the inner face of the bowl wall 11, but is radially notched as indicated at 47. Instead of the notches 47 the bell 45 may have a maximum diameter somewhere between the inner face of the bowl wall 11 and the outer face of skirt 46. Bell 45 is provided at its upper end with a tubular neck 45' which extends up through and fits neck 15.

Base flange 10 is provided with an upwardly-projecting hub 50 bored to receive the upper end of spindle 12 and this hub is externally longitudinally slotted to form a plurality of circumferentially-spaced conduits 52. Sleeved over the upper end of hub 50, so as to define the outer sides of conduits 52 for a major portion of their lengths, is a thimble 53 which, at its lower end, is outwardly and upwardly flared as indicated at 54, so that its upper edge lies between partitions 25 and 26 above the lower end of partition 26. The upper end of thimble 53 projects into the raised central portion of the bottom of cup 28 and is axially perforated as indicated at 55.

Projected down through perforations 31, 28' and 55 is a supply conduit 56 for the heavier

liquid, which, in the case of oil treatment, would be the phenol solvent. This tube 56 is provided with an outwardly and downwardly flaring skirt 57 which serves as a guard for perforation 28'.

Sleeved over the supply conduit 56 is a second supply conduit 58 the lower end of which projects down through perforation 31 but lies short of skirt 57. The supply conduit 58 is for delivery of the lighter liquid to be handled which, in the case of oil treatment, would be the oil to be treated.

The operation is as follows, the bowl being set in rotation at high speed and the light liquid delivered through supply conduit 58 until it starts to discharge through perforations 20, whereupon the supply of light liquid is temporarily suspended and the heavy liquid supplied through conduit 56. This heavy liquid will flow through conduits 52 into the lower end of the space defined by the smaller diameter partition 25, thence upwardly along the inner face of that partition, out through conduits 36; thence downwardly along the inner face of partition 24, thence outwardly through conduits 41; thence upwardly along the inner face of partition 23 and outwardly through conduits 40; thence to and down the inner face of partition 22 and outwardly through conduits 37; and thence upwardly along the inner face of bowl wall 11 and upwardly through passages 47; thence upwardly over the inner edge of dam 17 and thence through perforations 20 and out over the upper edge of the intermediate bowl neck 14. Thereupon the supply of lighter liquid will be resumed and will pass from cup 28 out through conduits 29 where it will be deflected downwardly by skirt 46, and will flow down along the outer face of partition 22, the stream of lighter liquid being held against partition 22 by reason of the accumulation of heavier liquid adjacent the inner face of bowl wall 11. At the bottom of partition 22 the lighter liquid flows inwardly through conduits 38 between the outer face of partition 23 and the film of heavier liquid on the inner face of partition 22; thence upwardly to and through conduits 39 to the outer face of partition 24, thence downwardly between said outward face and the heavier-liquid film on the inner face of partition 23 to and through conduits 42 to the outer face of partition 25; thence upwardly in surface contact with the film of heavier liquid on the inner face of partition 24 to and through conduits 35 to the outer face of partition 26; thence downwardly in surface contact with the heavier-liquid film on the inner face of partition 25 to the lower end of partition 26 and thence upwardly within partition 26 to flow upwardly past cup 28 and thence upwardly through neck 45' to be discharged from the upper end of said neck. The two liquids will, of course, fill the annular spaces between the several partitions, but the arrangement of the several conduits through the partitions maintains these two liquids in annular strata between the several partitions and between the largest diameter partition and the bowl wall, so that, instead of an intimate mixture of the two liquids there are maintained a plurality of oppositely flowing annular streams of the two liquids having sliding surface contact with each other, the centrifugal force developed by the rotation of the bowl constantly pressing the lighter liquid against the immediately adjacent outer heavier liquid. The lighter liquid flows from outer regions of the bowl toward inner regions of the bowl and the heavier liquid flows from inner regions of the bowl to outer regions

of the bowl so that the two liquids (modified by the chemical or other reaction which has occurred within the bowl as a result of the aforesaid surface contact) are finally separated and flow, respectively, over the upper end of the intermediate neck 14 and the upper end of neck 45'.

It will be noted that, when two liquids of different specific gravities are delivered to a rotating bowl such as has been described, the heavier liquid is formed into a series of annular stream sections which flow along the inner faces of the perforated partitions and finally along the inner face of the bowl wall to exit through perforations 20, and at the same time the lighter liquid is formed into a series of annular stream sections which flow along the outer face of each partition and in surface contact with the inner annular surface of each heavy-liquid stream in a direction opposite to the direction of flow of the heavy liquid, to exit through the bore of the inner partition 25 and neck 45. It will also be noted that, due to the centrifugal forces which are set up in the two liquids, the light-liquid stream is pressed against the adjacent portion of the heavy-liquid stream.

One stream therefore acts upon the other by reason of impressed surface contact, as distinguished from intermixture.

My improved method therefore comprises the establishment and maintenance of a stream of relatively heavy liquid and a stream of relatively light-liquid in surface contact, one with the other and one stream moving longitudinally relative to the other so that successive portions of one stream are brought into surface contact with successive portions of the other stream.

I claim as my invention:

1. The combination with a centrifugal bowl, of a dividing bell arranged within the bowl defining two outlet passages from inner and outer pressure regions of the bowl, a plurality of nested annular perforated partitions arranged axially within the bowl and within the bell region to form a nested series of annular chambers, the smallest diameter chamber and the largest diameter chamber communicating respectively with independent outlets from the bowl, a pair of flow-guide means perforating alternate partitions near one end, one defining inward flow from adjacent the outer face of its partition to a zone spaced from the inner face of said partition and the other defining outward flow from adjacent the inner face of its partition to a zone spaced from the outer face of said partition, a pair of flow-guide means perforating the other alternate partitions near the ends opposite the first-mentioned flow-guide means, one of said second-mentioned flow-guide means defining outward flow from adjacent the inner face of its partition to a zone spaced from the outer face of said partition and the other of said second-mentioned flow-guide means defining inflow from adjacent the outer face of its partition to a zone spaced from the inner face of said partition, an inlet conduit and flow-guide means leading from the exterior of the bowl to a zone adjacent the inner face of the smaller diameter perforated partition, and a second inlet and flow-guide means leading from the exterior of the bowl to a zone adjacent the outer face of the largest-diameter perforated partition.

2. The combination with a centrifugal bowl, of a dividing bell arranged within the bowl defining two outlet passages from inner and outer pressure regions of the bowl, a plurality of nested

annular perforated partitions arranged axially within the bowl and within the bell region to form a nested series of annular chambers, the smallest diameter chamber and the largest diameter chamber communicating respectively with independent outlets from the bowl, a pair of flow-guide means perforating alternate partitions near one end, one defining inward flow from adjacent the outer face of its partition to a zone spaced from the inner face of said partition and the other defining outward flow from adjacent the inner face of its partition to a zone spaced from the outer face of said partition, a pair of flow-guide means perforating the other alternate partitions near the ends opposite the first-mentioned flow-guide means, one of said second-mentioned flow-guide means defining outward flow from adjacent the inner face of its partition to a zone spaced from the outer face of said partition and the other of said second-mentioned flow-guide means defining inflow from adjacent the outer face of its partition to a zone spaced from the inner face of said partition, an inlet conduit and flow-guide means leading from the exterior of the bowl to a zone adjacent the inner face of the smaller diameter perforated partition, a second inlet and flow-guide means leading from the exterior of the bowl to a zone adjacent the outer face of the largest-diameter perforated partition, and a pressure-balancing conduit between inner and outer pressure regions of the bowl.

3. The combination, with a centrifugal bowl having an open upper end, a dividing bell in the upper end of the bowl having a discharge orifice leading to the top of the bowl and a skirt with an effective diameter adjacent but short of the bowl wall, an annular partition subtending the bell to a low region of the bowl, a second annular partition subtending the bell to the bowl bottom and spaced outwardly from the first-mentioned partition, a third annular partition subtending the bell to the bowl bottom and spaced outwardly from the second partition, a flow passage perforating the second partition near its upper end with its inlet end adjacent the outer face of said partition and its outlet end spaced inwardly from the inner face of said partition, a second flow-passage perforating said second partition near its upper end with its inlet end adjacent the inner face of said partition and its outlet end spaced outwardly from the outward face of said partition, a flow passage perforating the third partition near its lower end with its inlet end adjacent the outer face of the third partition and its outlet end spaced from the inner face of the third partition and the outer face of the second partition, a second flow passage perforating the third partition near its lower end with its inlet end adjacent the inner face of the third partition and its outlet end spaced from the outer face of the third partition and from the bowl wall, a fluid-supply conduit leading into the upper region of the bowl and through the several partitions to that region of the bowl beyond the third partition, a skirt depending from the bell to a region below the outlet of said last-mentioned conduit and spaced between said outlet and the bowl wall, a second fluid-supply conduit leading into the lower region of the bowl within the second partition and below the lower end of the first partition, and flow-defining means arranged between said last-mentioned conduit and the lower end of the first partition and

spaced between the first and second partitions to cause flow from the space surrounding the lower end of the first partition to the lower region within the first partition.

4. A structure of the character specified in claim 3 having a pressure-balancing conduit extending through the several partitions from the interior of the first partition to a region outside the third partition and skirt and short of the bowl wall.

5. A structure of the character specified in claim 3 having two annular partitions subtending the bell to the bowl bottom and radially spaced from each other and adjacent partitions, a flow-passage perforating the smaller of said partitions near its lower end with its inlet end adjacent the outer face of its partition and its outlet end intermediate the inner face and the next smaller partition, a second flow-passage perforating the smaller of said partitions near its lower end with its inlet end adjacent the inner face of said partition and its outlet end spaced from the outer face of said partition and the inner face of the next larger partition, a flow-passage perforating the larger of said partitions near its upper end with its inlet end adjacent the inner face of its partition and spaced from the outer face of said partition and the inner face of the next larger partition, and a flow-passage perforating the larger of said two partitions near its upper end with its inlet end adjacent the outer face of its partition and its outlet end spaced from the inner face of its partition and the outer face of the next smaller partition.

6. A structure of the character specified in claim 3 having two annular partitions subtending the bell to the bowl bottom and radially spaced from each other and adjacent partitions, a flow-passage perforating the smaller of said partitions near its lower end with its inlet end adjacent the outer face of its partition and its outlet end intermediate the inner face and the next small partition, a second flow-passage perforating the smaller of said partitions near its lower end with its inlet end adjacent the inner face of said partition and its outlet end spaced from the outer face of said partition and the inner face of the next larger partition, a flow-passage perforating the larger of said partitions near its upper end with its inlet end adjacent the inner face of its partition and spaced from the outer face of said partition and the inner face of the next larger partition, a flow-passage perforating the larger of said two partitions near its upper end with its inlet end adjacent the outer face of its partition and its outlet end spaced from the inner face of its partition and the outer face of the next smaller partition, and a pressure-balancing conduit extending through the several partitions from the interior of the first partition to a region outside the largest diameter partition and skirt and short of the bowl wall.

7. A counter-flow stratification unit for centrifugal bowls comprising three nested radially-spaced annular partitions, the outer partition being perforated near one end by two flow-passages, the inlet ends of which are respectively adjacent the outer and inner faces of their partition and the outlet ends of which are respectively spaced inwardly from the inner face and outwardly from the outer face of their partition, and the intermediate partition being perforated near the other end by two flow passages the inlet ends of

which are respectively adjacent the inner and outer faces of their partitions and the outlet ends of which are respectively spaced outwardly from the outer face and inwardly from the inner face of their partition, and a conduit perforating the several partitions near one end and formed at its inner end to receive a fluid during rotation about the axis of the group.

8. A counter-flow stratification unit of the character specified in claim 7 having a pressure-balancing conduit perforating the several partitions and forming a passage from the interior of the smallest partition to a zone outwardly spaced beyond the outer face of the largest partition.

9. The method of securing counter-current contact between a heavier liquid and a lighter fluid which comprises forcing the heavier liquid to traverse outwardly through a laterally closed passageway of increasing radius while rotating the passageway to exert centrifugal force on said liquid, said passageway having non-aligned openings whereby such centrifugal force causes an outward flow of the heavier liquid in addition to its progressive movement through said passageway, and supplying a lighter fluid to the outer extremity of the passageway under pressure to force it inwardly through the passageway and counter-current to the flow of said liquid.

10. The method of securing counter-current contact between a liquid and lighter fluid which comprises forcing the liquid to traverse a succession of laterally closed concentric passages while rotating said passages to exert centrifugal force on said liquid said passages having non-aligned openings therebetween at opposite ends of alternate passages whereby such centrifugal force causes an outward flow of the liquid from passage to passage and in addition thereto, a longitudinal movement of the liquid within each of said passages, and supplying a lighter fluid to the outer concentric passage under pressure to force it inwardly through said passages in counter-current to the flow of said liquid.

11. In apparatus for effecting counter-current contact between fluids, a rotor comprising a plurality of partitions forming therebetween laterally closed passages of enlarging radii, non-aligned openings in said partitions, means for supplying a heavier fluid within said passages, means for rotating the rotor to develop centrifugal force and cause said fluid to pass outwardly through the rotor from passage to passage, and to traverse said passages in a continuous film in its movement, and means for forcing a lighter fluid inwardly through the passages in said rotor.

12. In apparatus for effecting counter-current contact between fluids, a rotor, concentric partitions within said rotor forming concentric laterally closed passages therebetween, openings in said partitions forming passages therebetween, the openings in alternate partitions being at opposite ends thereof, means for supplying a fluid within said rotor, means for rotating said rotor to develop centrifugal force and thereby cause said fluid to traverse said passages longitudinally in a continuous film and pass outwardly from passage to passage through said openings, and means for supplying a lighter fluid and causing it to pass inwardly through the passages in said rotor counter-current to the flow of said first mentioned fluid.

13. The method of treating two incompletely miscible liquids of different specific gravities, which consists in establishing surface contact only of two definite streams of such liquids, the

components of which have not been preliminarily commingled; causing flow of said definite streams in opposite directions in surface contact only; and simultaneously pressing the stream of lighter liquid against the stream of heavier liquid by a pressure exceeding the normal weight of the lighter liquid per unit of contact area, such pressure being incrementally progressively varied during such surface contact; and finally separating one stream from the other.

14. The method of associating two liquids not readily miscible and of different specific gravities which comprises; establishment and maintenance of a definite flowing stream of the heavier liquid with an exposed lineally extending surface; establishment and maintenance of an oppositely flowing definite stream of lighter liquid in contact only with the said exposed surface of the heavy liquid stream; avoiding intermingling turbulence of the two liquids; and finally separating the two streams.

15. The method of associating two liquids not readily miscible and of different specific gravities which comprises; establishment and maintenance of a definite flowing stream of the heavier liquid with an exposed lineally extending surface; establishment and maintenance of an oppositely flowing definite stream of lighter liquid in contact only with the said exposed surface of the heavy liquid stream; avoiding intermingling turbulence of the two liquids; causing the lighter liquid to press upon the heavier stream with an incrementally varying pressure as surface contact between the two streams progresses; and finally separating the two streams.

16. The method of treating one liquid with another liquid of different specific gravity, which comprises, the establishment of a defined stream of heavy liquid without substantial commingling with a lighter liquid; the imposition on an exposed surface of said stream of a lighter liquid

which has not been preliminarily commingled with the heavy liquid and forming said lighter liquid into a defined stream in only surface contact with the heavy stream; causing exertion of successively varied pressures upon the contacted surface of one stream laterally through the medium of the other stream, causing flow of the two contacting streams in opposite directions while in said pressure contact, and subsequently withdrawing of one stream from the other.

17. The method of treating one liquid with another liquid of different specific gravity, which comprises, effecting surface contact only between two incompletely miscible liquids of different specific densities by supplying the heavier liquid in a constant stream to the inner end of a curved passageway of increasing radius; rotating said passageway about an axis to develop by centrifugal action a defined stream of heavy liquid and a propellant force in said heavier liquid to propel it outwardly in stream form through said passageway; introducing into said passageway, without preliminary commingling with the heavier liquid, the lighter liquid to form a defined stream of lighter liquid in surface contact only with said heavier liquid; and causing the two streams of liquid to flow in opposite directions in surface contact only.

18. The method of treating two incompletely miscible liquids of different specific gravities, which consists in establishing surface contact only of two definite streams of such liquids the components of which have not been preliminarily commingled; causing flow of said definite streams in opposite directions in surface contact only; and simultaneously pressing the stream of lighter liquid on the heavy liquid by pressure exceeding the normal weight of the lighter liquid per unit of contact area; and finally separating one stream from the other.

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