

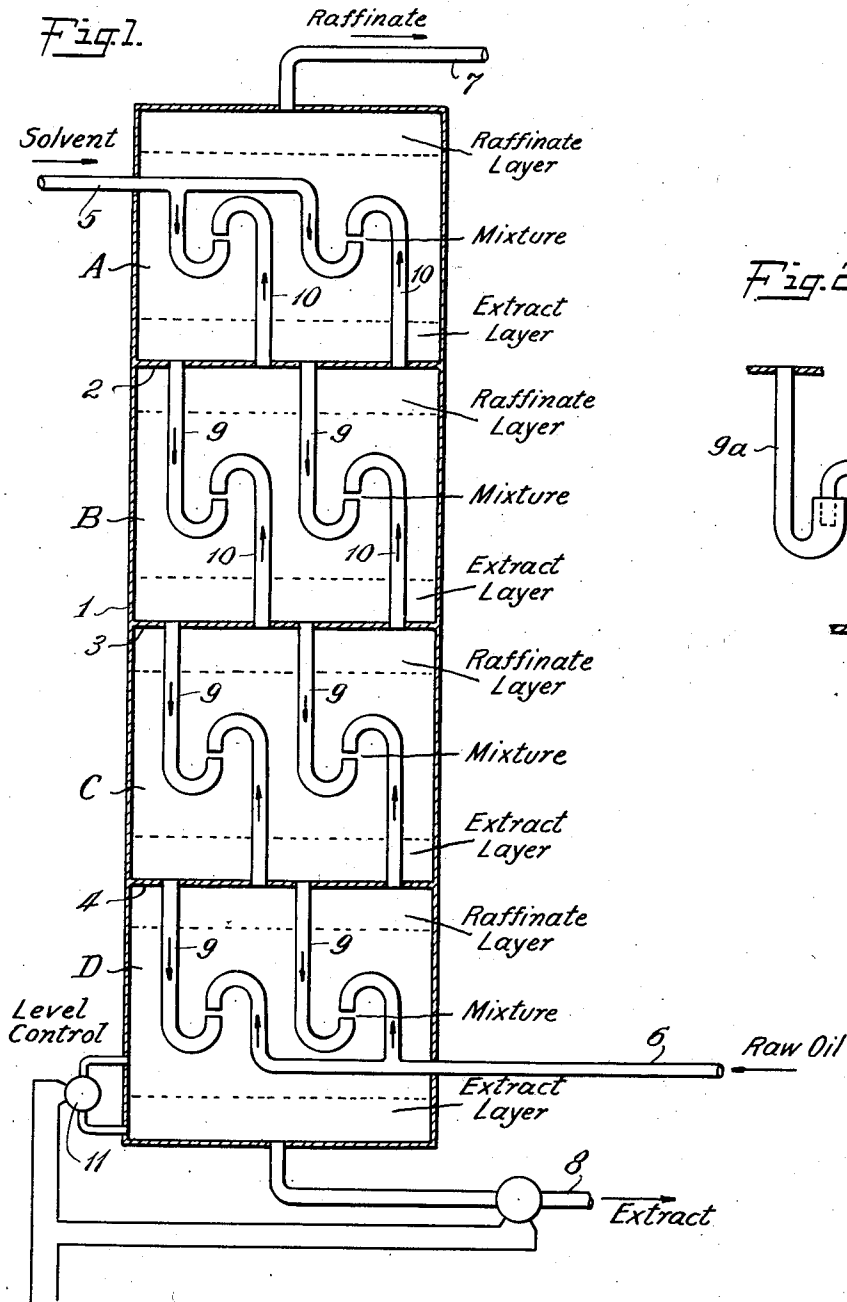
June 1, 1937.

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2,082,034

APPARATUS FOR COUNTERCURRENT CONTACT TREATMENT OF LIQUIDS

Filed Dec. 10, 1935



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UNITED STATES PATENT OFFICE

2,082,034

APPARATUS FOR COUNTERCURRENT CONTACT TREATMENT OF LIQUIDS

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Application December 10, 1935, Serial No. 53,705

3 Claims. (Cl. 23—270)

This invention relates to improvements in apparatus for countercurrent contact treatment of one liquid with another substantially immiscible liquid of different specific gravity. It is an object of the present invention to provide an apparatus adapted to subject two immiscible liquids of different specific gravities, passing in countercurrent relation, to a series of alternate mixing and settling operations. The invention provides an apparatus adapted for this purpose which is of simple and rugged construction. Its operation also is simple and does not require expensive and complicated control mechanism.

The apparatus of the present invention is of special value and utility in solvent extraction refining operations, which are now excessively used in the petroleum refining art, wherein a lubricating oil fraction, for example, is treated with a solvent such as nitrobenzene, furfural, or the like. In such processes the solvent selectively extracts undesirable constituents from the lubricating oil fraction and improves the properties of the treated oil. However, the apparatus of the invention is of general utility for effecting efficient countercurrent contact of any liquid with any other substantially immiscible liquid of different specific gravity.

The apparatus of the present invention comprises a vertically elongated housing divided transversely into a series of superimposed compartments. Connections are provided for supplying a relatively heavy liquid to an upper compartment and for discharging a relatively light liquid from the upper portion thereof. Similarly connections are provided for supplying a relatively light liquid to a lower compartment and for discharging a relatively heavy liquid from the lower portion thereof. A plurality of pipes or ducts, shaped to prevent a liquid lighter than that within the pipes from entering their lower ends and flowing upwardly therethrough, lead from the lower portion of each compartment, except the lowermost, to the central portion of the next lower compartment of the series. Similarly, a plurality of pipes or ducts, shaped to prevent a liquid heavier than that within the pipes from entering their upper ends and flowing downwardly therethrough, lead from the upper portion of each of the compartments, except the uppermost, to the central portion of the next higher compartment of the series. In each of the intermediate compartments the outlet ends of the pipes or ducts leading downwardly from the next higher compartment are disposed in immediate juxtaposition to the outlet ends of the corresponding pipes or ducts leading upwardly from the next lower compartment.

In the operation of such a device, when a heavy liquid is continuously supplied to an upper compartment and a relatively lighter liquid is sup-

plied to a lower compartment, the difference of specific gravity will cause the lighter liquid to work its way upwardly through the series of superimposed compartments and the heavier liquid to work its way downwardly through the series of compartments. In any one of the intermediate compartments the heavier liquid from the next higher compartment and the lighter liquid from the next lower compartment will be brought into contact with each other as oppositely flowing streams and intimately admixed in the central portion of the intermediate compartment. The heavier and lighter components of the mixture then will separate because of the difference in their specific gravity, the lighter liquid accumulating in the upper portion of the compartment and then passing upwardly to the central portion of the next higher compartment while the heavier liquid accumulates in the lower portion of the intermediate compartment and then passes to the central portion of the next lower compartment. This procedure of alternate admixing and settling is repeated in each of the series of compartments as the heavier liquid flows downwardly and the lighter liquid flows upwardly through the apparatus.

The invention will be further described in connection with the accompanying drawing which illustrates one form of apparatus embodying the invention.

Fig. 1 of the drawing is a sectional elevation of a countercurrent liquid contacting column embodying the invention; and

Fig. 2 shows, in section, a fragmentary elevation of a modified arrangement for conveying heavier liquid from an upper compartment and lighter liquid from a lower compartment into an intermediate compartment in such a way that the two liquids will be brought into intimate admixture and discharged into the intervening compartment while at the same time preventing short-circuiting, of either the heavier or lighter liquid, through the intervening compartment.

The countercurrent contacting column shown in Fig. 1 comprises a vertically elongated housing provided with a plurality of vertically-spaced trays 2, 3, and 4 which extend transversely across the housing 1 and divide it into a series of compartments A, B, C, and D. An inlet connection 5 communicates with the uppermost compartment A and is adapted to supply a relatively heavy liquid (for example, a solvent such as nitrobenzene or furfural) thereto. An inlet connection 6 communicates with the lowermost compartment D and is adapted to supply a relatively light liquid (for example a lubricating oil fraction) thereto. A discharge connection 7 communicates with the upper end of the uppermost compartment A and a discharge connection 8

communicates with the lower end of the lower compartment D. Pipes 9 lead from each of the compartments A, B and C, through the partitions 2, 3, and 4, respectively, into the next lower compartment B, C or D. The pipes 9 advantageously are shaped in the form of a U near their lower ends and terminate at their lower ends at a level approximating the middle of the compartments into which they depend. Similarly, pipes 10 lead from each of the compartments D, C, and B, through the partitions 4, 3, and 2, into the next higher compartment C, B or A, respectively. The pipes 10 are shaped in the form of a U at their upper ends and similarly terminate at a level approximating the middle of the upper compartment into which they extend. Each of the pipes 9 depending into any one of the intermediate compartments is positioned so that its lower end will terminate in immediate juxtaposition to the upper end of one of the pipes 10 extending upwardly from the next lower compartment. With this construction, for example, a relatively heavy liquid passing downwardly through pipes 9 from compartment A will be brought into intimate admixture with a relatively light liquid passing upwardly through the pipes 10 from compartment C, and the mixture will be discharged into the central portion of the intervening compartment B. However, the heavy liquid passing downwardly through one of the pipes 9 cannot short-circuit through the corresponding pipe 10 and pass to the next lower compartment without intervening admixture and settling in the intermediate compartment. Similarly, it is not possible for the lighter liquid passing upwardly through any one of the pipes 10 to short-circuit through the corresponding line 9 and pass upwardly to the next higher compartment without intervening admixture and settling in the intermediate compartment.

The inlet line 5 through which the lighter liquid is supplied to the upper compartment advantageously may be divided into branches at its discharge end the discharge end of each branch positioned to register with the upper end of one of the pipes 10 leading into the uppermost compartment from the next lower compartment. Similarly, line 6, through which the lighter liquid is supplied to the lowermost compartment, may be divided into branches and the discharge end of each branch positioned so as to register with the lower end of one of the lines 9 depending into the lowermost compartment.

A mechanical level controlling-device 11 arranged to control the rate of discharge from the lowermost compartment through line 8, so as to maintain approximately constant the upper surface of a body of the heavier liquid in the lower portion of the lowermost compartment, advantageously may be provided. No level controls are necessary in any of the other compartments, however, as the proper direction of flow in each of the other sections will be maintained by the gravity differential.

In the modified form of duct arrangement shown in Fig. 2, the pipes 9a and 10a correspond respectively to the pipes 9 and 10 in the apparatus shown in Fig. 1. However, the lower bent end of the pipe 9a is enlarged and the upper bent end of the pipe 10a extends into it. By this arrangement, any short-circuiting through pipe 10a of the heavier liquid flowing downwardly through pipe 9a or vice versa is effectively precluded. However, the heavier liquid flowing downwardly through one of pipes 9a and the lighter liquid

flowing upwardly through the corresponding pipe 10a are admixed before they are discharged into the intervening compartment.

In the operation of the apparatus illustrated in Fig. 1 for the treatment of a lubricating oil fraction with a solvent heavier than the oil (nitrobenzene or furfural, for example), the raw lubricating oil fraction is supplied through connection 6 and the solvent through connection 5. The lubricating oil fraction which is lighter than the solvent passes upwardly through the housing 1 and eventually is discharged through connection 7, while the heavier solvent with the extracted material dissolved therein passes downwardly through the housing 1 and eventually is discharged through connection 8. In each of the compartments a stratification of the liquid body occurs. The upper stratum consists of treated or partially treated oil with a minor amount of the solvent dispersed therein. This substance, in the refining art, is known as the raffinate. The lower stratum consists of a layer of the solvent with the extracted material selectively dissolved therein. In the refining art this substance is known as the extract. The intermediate layer consists of a mixture of raffinate particles and extract particles.

In operation, the lower or extract layer in the compartment A, for example, is heavier than the mixture of raffinate and extract particles in the intermediate portion of the compartment B and therefore the extract flows downwardly from compartment A to compartment B through the lines 9. Similarly, the upper raffinate layer in the compartment C is lighter than the mixture of raffinate and extract particles in the intermediate portion of compartment B and it therefore flows upwardly from compartment C to compartment B through pipes 10. The extract entering compartment B from compartment A, through lines 9, and the raffinate entering compartment B from compartment C, through line 10 are brought into intimate admixture as they are discharged from pipes 9 and 10, respectively, into the intermediate portion of compartment B. In compartment B the gravity differential again effects separation of the mixture into an upper layer of the lighter raffinate and a lower layer of the heavier extract. The same procedure occurs in each of the other compartments of the series. Thus the device of the present invention provides for a definite mixing and settling zone in each compartment or section, and accordingly a more efficient extraction is obtained than is possible in the ordinary packed type of column or in the normal bubble tower type of apparatus both of which have been employed to some extent for this type of operation.

It will be apparent that the details of construction can be modified without departure from the spirit of the invention. For example, the housing can be divided into any number of superimposed compartments. Similarly, the number, arrangement and shape of the pipes 9 and 10 can be varied so long as ducts are provided for bringing a lighter liquid from the upper portion of a lower compartment and a heavier liquid from the lower portion of a higher compartment into intimate admixture in the central portion of an intervening compartment, and so long as means are provided for preventing short-circuiting of either of the liquids through the intervening compartment. For example, the pipes 9 and 10 need not be bent in the form of a U if a balanced check valve is arranged in each pipe to permit flow

therethrough only in the desired direction. Similarly, if the housing 1 is divided into a relatively large number of superimposed compartments, the heavier liquid (the solvent for example) may be initially supplied to one of the upper compartments below the uppermost compartment, if desired, and the lighter liquid (the oil fraction for example) may be initially supplied to one of the lower compartments above the lowermost compartment. The uppermost and lowermost compartments in such an arrangement will function principally as stripping compartments promoting a more complete final separation of extract and raffinate.

15 I claim:

1. In apparatus for countercurrent contact treatment of one liquid with another substantially immiscible liquid of different specific gravity, the improvement comprising a series of superimposed compartments, connections for supplying a relatively light liquid to and for discharging a relatively heavy liquid from the lowermost compartment of the series, connections for supplying a relatively heavy liquid to and for discharging a relatively light liquid from the uppermost compartment of the series, a plurality of generally downwardly extending ducts connecting the lower portion of each compartment of the series except the lowermost and the central portion of the next lower compartment, said ducts being arranged to provide free and open communication into the lower compartment with which they connect from the next higher compartment, a plurality of generally upwardly extending ducts connecting the upper portion of each compartment of the series except the uppermost and the central portion of the next higher compartment, said last-mentioned ducts being arranged to provide free and open communication into the upper compartment with which they connect from the next lower compartment, the said downwardly extending ducts and the said upwardly extending ducts extending into each of the intermediate compartments of the series being arranged with their lower ends and upper ends respectively in immediate juxtaposition and shaped to prevent short-circuiting of a heavier liquid downwardly through the upwardly extending ducts and short-circuiting of a lighter liquid upwardly through the downwardly extending ducts, whereby in any intermediate compartment of the series liquid passing upwardly through the upwardly extending ducts from the next lower compartment and liquid passing downwardly through the downwardly extending ducts from the next higher compartment will be brought into intimate contact and discharged into the central portion of the said intermediate compartment, and means for controlling the rate of discharge of liquid through said connection for discharging heavy liquid from the lowermost compartment.

2. In apparatus for countercurrent contact treatment of one liquid with another substantially immiscible liquid of different specific gravity, the improvement comprising a series of superimposed compartments, connections for supplying a relatively light liquid to and for discharging a relatively heavy liquid from the lowermost compartment of the series, connections for supplying a relatively heavy liquid to and for discharging a relatively light liquid from

the uppermost compartment of the series, a plurality of generally downwardly extending ducts connecting the lower portion of each compartment of the series except the lowermost and the central portion of the next lower compartment, the lower ends of said downwardly extending ducts being bent to provide relatively short upwardly extending portions, a plurality of generally upwardly extending ducts connecting the upper end of each compartment except the uppermost and the central portion of the next higher compartment, the upper ends of said upwardly extending ducts being bent to provide relatively short downwardly extending portions, the upturned lower end of each of the said downwardly extending ducts in any one of the intermediate compartments being positioned so as to register with and adjacent to the downturned lower end of one of the upwardly extending ducts in said intermediate compartment.

3. In apparatus for countercurrent contact treatment of one liquid with another substantially immiscible liquid of different specific gravity, the improvement comprising a vertically elongated housing, a series of vertically-spaced trays extending transversely across said housing and dividing it into a plurality of superimposed compartments, a plurality of pipes depending from each tray of the series into the next lower compartment, said pipes terminating at their lower ends at a level approximating the center of the compartment immediately below the tray from which they depend and communicating through said trays with the lower portion of the next higher compartment, a plurality of pipes extending upwardly from each tray of the series into the next higher compartment, said last-mentioned pipes terminating at their upper ends at a level approximating the center of the compartment immediately above the tray from which they extend and communicating through said trays with the upper portion of the next lower compartment, means for supplying a liquid of relatively light specific gravity to the lowermost compartment of the series, means for supplying a liquid of relatively heavy specific gravity to the uppermost compartment of the series, the lower end of said depending pipes and the upper end of said upwardly extending pipes terminating in each intermediate compartment being positioned in close juxtaposition and oppositely directed, whereby a relatively heavy liquid flowing downwardly from an upper compartment and a relatively light liquid flowing upwardly from a lower compartment will be admixed as they are discharged into the intermediate compartment, means for preventing short-circuiting of heavier liquid from the depending pipes through the upwardly extending pipes and for preventing short-circuiting of lighter liquid from the upwardly extending pipes through the depending pipes, connections for supplying a relatively heavy liquid to the uppermost compartment and a relatively light liquid to the lowermost compartment, a discharge connection communicating with the upper end of said housing, a discharge connection leading from the lower end of said housing and means for controlling the rate of discharge of liquid through the last-named connection.

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