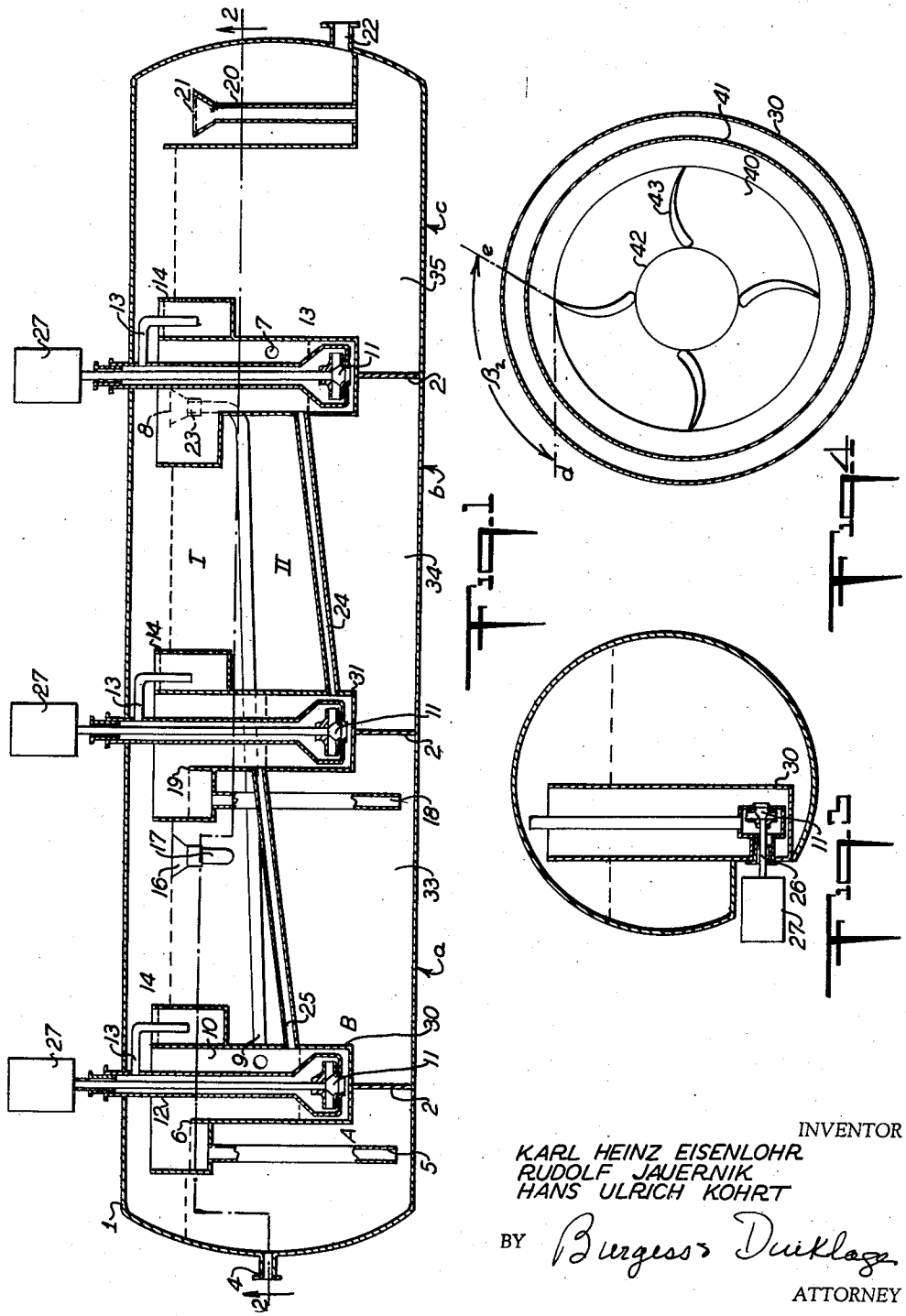
Feb. 8, 1955 KARL-HEINZ EISENLOHR ET AL 2,701,753

EXTRACTION OF CONSTITUENTS OF LIQUIDS BY MEANS OF SOLVENTS

Filed Oct. 25, 1950 2 Sheets-Sheet 1



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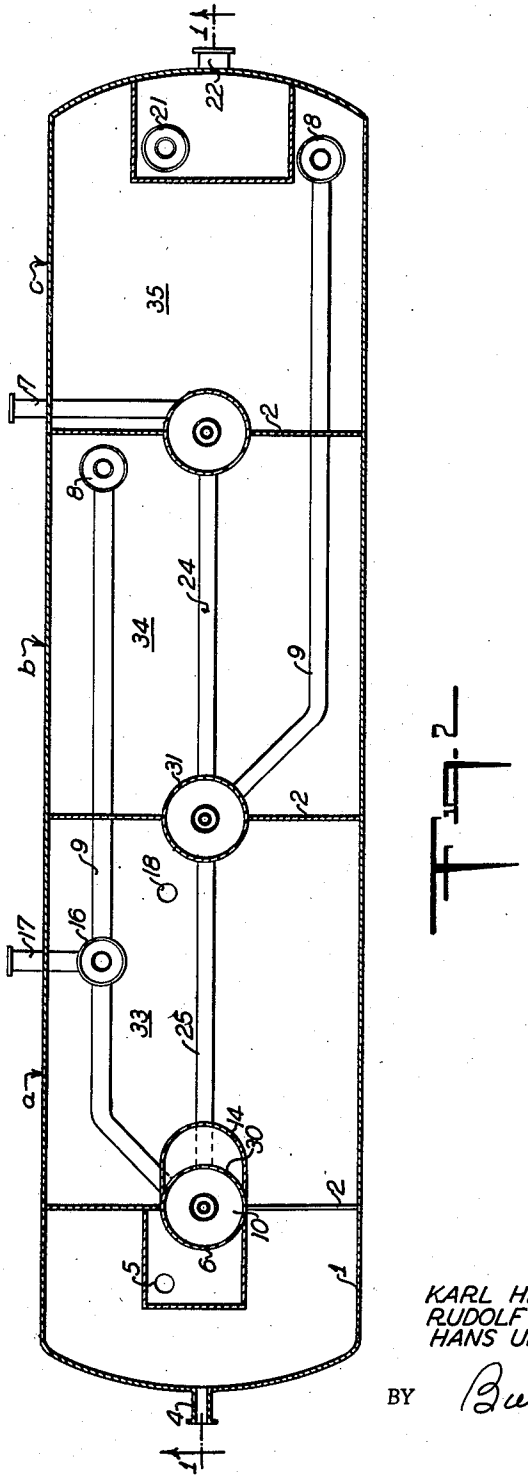


FIG. 2

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EXTRACTION OF CONSTITUENTS OF LIQUIDS BY MEANS OF SOLVENTS

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This invention relates to the extraction of constituents of liquids by means of solvents.

For a better utilization of the solvent and in order to reduce its quantity, such solvent extractions are usually carried out in a continuous countercurrent of the two liquids acting upon each other. To this end vertical extraction towers or a plurality of tanks or vessels arranged side by side may be used through which the liquids are passed in succession. For the countercurrent extraction in stages, several tanks or the like situated side by side are used in such a way that the devices for mixing the liquids of each stage (pumps, nozzles, mixers or the like) and the tanks in which the mixture of each stage is again separated for instance into two layers, are arranged separately from each other. In this case the pumps lying outside require additional relatively large storage chambers for uniform supply of the liquids to the mixing device. In the so-called "Duosol"-process (Science of Petroleum, vol. III, page 1926) the tanks required for carrying out the extraction have been combined into a horizontal apparatus, effecting the mixture right in the single tanks with the aid of mixing nozzles. Here again, outside pumps are used for conveying the liquids.

Moreover, a process is known in which the liquids acting upon each other are mixed and dissociated in adjacent chambers (U. S. Patent 2,405,158). In this case the components are mixed in each chamber by means of an impeller which is driven by a vertical shaft and surrounded by a guide tube to which the two liquid currents are supplied. The mixture of the two liquids flowing upwards in the guide tube is passed downwards by a cylinder surrounding the guide tube and enters into the chamber surrounding the mixing device; in this chamber the two components are again separated from each other by stratification. From this chamber the separated liquids flow through overflows in different directions into the succeeding chambers. The mixing in this case is effected by the principle of circulation in which large quantities of liquid are passed through the mixing device by circulation. Thus it follows that a high quantity of energy is required.

According to the present invention the solvent extraction is carried out continuously according to a countercurrent principle in adjacent chambers corresponding to the single stages of extraction, the conveying and mixing of the two flows or streams of liquid being effected within each chamber by means of a centrifugal pump. Each centrifugal pump is accommodated in a separate or partitioned room within the appertaining chamber, to which room the two streams of liquid to be mixed are supplied from the adjacent chambers. By the pumps the components are mixed and the mixture is shifted into the main room of the chambers serving for the separation of the mixture into layers or strata. The liquid level in the pump chamber thus is substantially independent from the liquid level in the separating chamber itself. By appropriate dimensioning of the depth of the pump room the delivery head or lift may be made small. By this expedient and by avoiding the circulation of the liquids the amount of energy required for the apparatus is substantially reduced.

The advantage offered by a centrifugal pump compared to a circulation mixer operating with an impeller is mainly due to the fact that the rotor of the centrifugal pump is

rotating at a high speed in a space closley surrounding the rotor while in case of the mixing by circulation the impeller has to be moved within a larger volume of liquid whereby the liquid is set in rotation and the relative speed between the impeller and the liquid and thus the mixing effect is reduced. By changing the direction of flow in centrifugal pumps a thorough mixing will be obtained. Moreover centrifugal pumps offer constructional possibilities permitting to further increase the mixing effect, for instance, by special position and shape of the blades of the stationary and/or moving blade disc.

Moreover, according to a further feature of the invention with the aid of the centrifugal pump an automatic regulation of the liquid level in the pump room can be achieved. To this end a centrifugal pump with a flat characteristic is used, i. e. a centrifugal pump in which already a slight change of the lift results in a considerable change of the amount of delivery. Thus it is achieved that the lift of the pump remains constant or nearly constant even with varying amounts of liquid conveyed, so that the pump will always operate quietly, even if the amounts of liquid supplied to the pump are varying considerably. On the other hand in this manner any sudden shocks in the quantities of liquid supplied to the pump are automatically absorbed and compensated. By the sudden supply of larger quantities of liquid at first the level of liquid in the cylindrical pump room will slightly rise so that the lift or delivery head will decrease accordingly. However, a small decrease of the lift in case of a flat pump characteristic already results in a substantial increase of the quantity delivered, so that the pump is able to meet with even larger increases in the quantities of liquid supplied to the pump. This results in the advantage that the mixing ration of the liquids to be mixed with each other is not disturbed and the extraction always takes place under most favorable conditions.

Other and further objects, features and advantages of the invention will be pointed out hereinafter and appear in the appended claims forming part of the application.

In the accompanying drawing a now preferred embodiment of the invention is shown by way of illustration and not by way of limitation.

Fig. 1 is a vertical diagrammatic section through an extracting apparatus consisting of three stages,

Fig. 2 is a plan view thereof, and

Fig. 3 is a view showing a pump provided with another drive arranged outside of the extractor,

Fig. 4 shows details of the pump.

Referring now to the drawing in greater detail it will be seen that three extraction stages, *a*, *b*, *c* are separated by partition walls **2** in the closed horizontal vessel **1**. Coaxially with the vertical center line of the walls **2** or in the vicinity of the center line the pump spaces **30**, **31**, **32** are provided. The heavier liquid is supplied, for instance, through an end wall of the extracting apparatus **4** and passes, rising in the tube or pipe **5**, through an overflow **6** into the pump room **30**. The lighter liquid enters into the pump chamber **32** of the last stage (*c*) through the pipe **7**. It passes from the stage (*c*) through (*b*) and flows from the second stage (*b*) through the funnel **8** and the pipe **9** into the pump room **30** of the first stage (*a*), at **10**. In this pump room **30** the two liquids are mixed by the centrifugal pump **11**. The mixture is conveyed through the pipes **12** and **13** into the distributing tray **14**. Through openings in the latter it passes into the separating chamber **33** of the first stage (*a*) where it is separated into two layers I and II. The liquid of the upper layer I leaves the apparatus through the overflow **16** and the pipe **17**. The liquid of the lower layer II rises in the tube **18** and passes through the overflow edge **19** into the pump room **31** of the second stage (*b*). In this stage, and in the next stage—or in the next stages where more than 3 stages are provided—the mixing and separating operations are repeated in the hereinbefore described manner. From the separating chamber **35** of the last stage (*c*) the heavier liquid discharges from the extractor through the pipe **20**, the funnel **21** and the branch **22**.

As will be seen from Fig. 1, the liquid level in the pump rooms **30**, **31**, **32** is independent of the liquid level in the single separating chambers **33**, **34** and **35**, and, unlike

the known processes, e. g., according to U. S. Patent 2,405,158, of the level of the plane of separation in these chambers. The liquid level in the pump room cannot change its position in case of a change of the quantities of the two liquids supplied. Owing to the fact that according to the invention a centrifugal pump more particularly, with a flat characteristic is used, the delivery is changing in conformity with the level, i. e., if the liquid level falls, less liquid is delivered by the pump; if the liquid level rises, the quantity of liquid delivered by the pump increases. It follows that the extraction will automatically adapt itself to the varying quantities supplied to the extraction. Especially in extractors with many stages the operation is also substantially facilitated thereby and the liquid is prevented, moreover, from rising too much in the pump room and thereby possibly causing disturbances in the separating chambers (*a*, *b*, *c*).

The position of the plane of separation in the separating chambers is determined by the overflow edges **19** for the heavier liquid and by the level of the upper rim of the funnel **8**. Therefore, by a vertically adjustable construction and arrangement of the funnel **8** it is also possible to raise or lower the position of the plane of separation, e. g., by screwing the funnel **8** into the pipe **9** with a fine thread **23**, so that the level of discharge can be adjusted by turning the funnel. The simplicity of the construction according to the invention permits the series connection of a large number of stages, should this be required for achieving the desired extraction effect.

According to a further feature of the invention the intermediate chamber—or, where the extractor comprises more than 3 chambers, the intermediate chambers—may be made smaller than the first chamber into which the liquid enters at first, and the last chamber, through which it leaves the apparatus. This is because in the intermediate chambers an absolute separation of the liquids acting upon each other is not strictly required. Oftentimes it is sufficient if such a complete separation is achieved in the inlet and discharge chambers, while the separation is only nearly complete in the intermediate chambers. This arrangement permits a still further reduction of the size of the apparatus.

It has been found, moreover, that in the event of the failure of one pump, for instance, of the intermediate stage of the extractor as per Figs. 1 and 2, it is possible by simple means to prevent interruption of the countercurrent through the apparatus of the two liquids to be treated with each other.

For instance, if one pump fails, two fluid strata will be set up very soon in the pump chamber. Now, according to the invention the pump chambers of the adjacent stages are interconnected by inclined pipe lines in such a manner that the upper one of the two liquid layers which are forming on stoppage of the pump flows through an inclined pipe into the stage into which the lighter liquid would otherwise pass from the separating room of the respective chamber, while the heavier liquid flows off into the pump room of the adjacent chamber through another inclined pipe.

In the event, for instance, of failure of the pump of the intermediate chamber (*b*), two layers or strata are formed in the appertaining pump room **31**, as shown in Fig. 1. According to the invention the liquid of the lower stratum is passed through the inclined tube **24** into the pump room **32** of the stage (*c*). The upper fluid stratum on the contrary flows through a pipe **25** into the pump room **30** of stage (*a*). The pipes **24** and **25** are arranged in inclined positions in such a manner that on operation of the pump in the respective chamber no liquid flows off through these pipes. By operation of the pumps the liquid level in the pump chamber will fall. The orifices of the pipes are arranged in such a way that at least one orifice of each pipe is positioned above the liquid level setting itself while the pump is in operation. A passage of liquid through the tube in this case takes place only when the level in the pump room rises by ceasing of the delivery.

The pumps may be driven in any desired manner. For instance in the apparatus according to Figs. 1 and 2 the drive of the centrifugal pump **11** is disposed outside of the extractor at **27**. It is also possible to have the drive acting not vertically from the top through the pump but, as shown in Fig. 3, in a horizontal direction or from underneath. In the pump room **3** the pump **11** is driven from the motor **27** through the shaft **26**. It is also possible to accommodate the motor or any other suitable driving device within the extractor.

In Fig. 4 which is a section according to line A—B in Fig. 1, **40** is the rotor and **41** the casing of the centrifugal pump **11**. The mixture of the liquids enters the pump **11** by the opening **42** and is forced by the blades **43** of the rotor through the casing **41** into the pipe **12**. To obtain a flat characteristic of the pump the free ends of the blades **43** shall have such a direction that the angle β_2 between the tangent *d* to the periphery of the rotor and the tangent *e* to the free end point of each blade amounts to about 45–135°.

What is claimed is:

1. In the method for the continuous multi-stage counter-current extraction of liquids with solvents of different specific gravities than the liquids, the improvement which comprises, establishing at least a first and a last separation zone said separation zones being substantially horizontally positioned with respect to one another, establishing at least one mixing zone for each said separation zones positioned in said separation zones, said mixing zones having a liquid level independent of the liquid level in said separation zones, continuously passing the specifically heavier of said liquid and solvent to said mixing zone for said first separation zone, continuously overflowing the specifically lighter to the same mixing zone from the immediate adjacent separation zone, centrifugally pumping said liquid and said solvent to effect mixing thereof for distribution in said first separation zone and to maintain a substantially lower liquid level in said mixing zone than in said separation zone, allowing layer separation therein, substantially continuously removing the specifically lighter of said liquid and solvents from said first separation zone, substantially continuously passing the specifically heavier to the mixing zone for the next adjacent separation zone, substantially continuously passing the specifically lighter of said liquid and solvent to said mixing zone for said last separation zone, substantially continuously passing the specifically heavier from the immediate preceding separation zone to said mixing zone for said last separation zone, centrifugally pumping said liquid and solvent to effect mixing thereof from said mixing zone for said last separation zone for distribution in said last separation zone and to maintain a substantially lower liquid level in said mixing zone than in said separation zone, allowing layer separation in said last zone, removing the specifically heavier of said liquid and solvent from said last separation zone, and overflowing the specifically lighter to the mixing zone for the immediately preceding separation zone.

2. Improvement according to claim 1 which includes establishing at least one intermediate separation zone substantially horizontally positioned with respect to said first and last separation zones with an intermediate mixing zone therefor, the liquid level in said intermediate mixing zone being independent of the liquid level in said separation zone, and in which the specifically lighter of said solvent and liquid is overflowed from said last separating zone to the immediately adjacent intermediate mixing zone, and in which the specifically heavier liquid is passed from said first separating zone to the immediately adjacent intermediate mixing zone, the liquid and solvent being centrifugally pumped from the intermediate mixing zone to effect mixing thereof for distribution in said intermediate separation zone and to maintain a substantially lower liquid level in said mixing zone than in said separation zone, liquid and solvent being allowed to separate into layers in the intermediate separation zone with the specifically lighter being overflowed to the mixing zone for the immediate preceding separating zone and the specifically heavier being passed to the mixing zone for the immediately following separating zone.

3. Improvement according to claim 2 which includes establishing a multiple number of intermediate separation zones substantially horizontally positioned with respect to said first and last separation zones, each said intermediate separation zone having an intermediate mixing zone with an independent liquid level.

4. Apparatus for the continuous multi-stage countercurrent extraction of liquids with solvents which comprises means defining a substantially horizontally extending liquid chamber, partition means substantially vertically positioned for dividing said chamber into at least a first and last separation stage, means defining a separate

pump room for each said stage adapted for maintaining therein a substantially lower liquid level than in said stage, each said pump room having centrifugal pump means positioned at the lower portion thereof, said pump room being positioned in said chamber, conduit means positioned for passing a specifically heavier liquid to said pump room for said first stage, an overflow drain and associated conduit means positioned for overflowing specifically lighter liquids from the immediately following separation stage to said pump room for said first separation stage, conduit means positioned for passing a specifically lighter liquid to the pump room for said last separation stage, means for conveying specifically heavier liquid from the immediately preceding separation zone to the pump room of said last stage, conduit means associated with each said centrifugal pump means for pumping liquid from each said pump room to the separation stage associated with that pump room, means defining a liquid exit for specifically heavier liquid from said last separation stage, and drive means positioned for driving each centrifugal pump means.

5. Apparatus according to claim 4 including partition means substantially vertically positioned in said chamber defining at least one intermediate separation stage, means defining a pump room for each intermediate separation stage having centrifugal pump means positioned at the lower portion thereof adapted for maintaining therein a substantially lower liquid level than in said stage, said pump rooms being positioned in said chamber, an overflow drain and associated conduit means positioned for passing specifically lighter liquid to each said pump room from the immediately following separation stage, means for conveying specifically heavier liquid to each said pump room from the immediately preceding separation stage, and conduit means associated with each centrifugal pump means for pumping liquid from said pump room to the separation stage associated therewith.

6. Improvement according to claim 5 in which said means for conveying specifically heavier liquid to said pump room includes a vertical conduit extending from a partial chamber with an overflow weir positioned therein.

7. Apparatus according to claim 6 in which said conduit means associated with said centrifugal pump means are positioned for passing liquid into a distribution device for distribution in the separation stage associated therewith.

8. Apparatus according to claim 7 in which said pump rooms are positioned at said partition means.

9. Apparatus according to claim 8 including means for adjusting the level of said overflow drains in said separation stages.

10. Apparatus according to claim 4 in which said means for driving the centrifugal pump means are positioned for the driving thereof through the shortest possible distance.

11. Apparatus according to claim 10 in which said means for driving said centrifugal pump means are positioned beneath said centrifugal pump means.

12. Apparatus according to claim 4 in which said means for driving said centrifugal pump means are positioned in a recess in said chamber for driving said centrifugal pump means through the shortest possible distance.

13. Apparatus according to claim 4 in which said means for driving said centrifugal pump means are positioned for the driving thereof from the side through the shortest possible distance.

14. Apparatus according to claim 4 in which said means for driving said centrifugal pump means are positioned in said chamber.

15. Apparatus according to claim 4 in which said centrifugal pump means is a centrifugal pump dimensioned and positioned with a flat characteristic whereby a substantial change in the pump delivery is caused by a change in the liquid level in the pump room.

16. Apparatus according to claim 14 in which said centrifugal pump means is a centrifugal pump having a guide blade disk and rotors, the blades of said guide blade disk and rotors being dimensioned and positioned to effect mixing of liquids along with the pumping thereof.

17. Apparatus according to claim 4 including conduit means connecting at least two of said pump rooms.

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