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R. B. BANKS ET AL

2,813,074

CLARIFYING APPARATUS AND PROCESS

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Figure 1

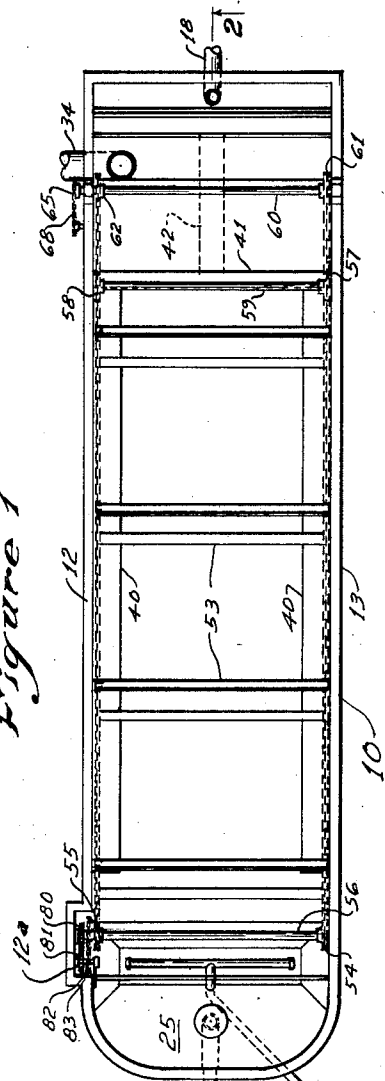


Figure 2

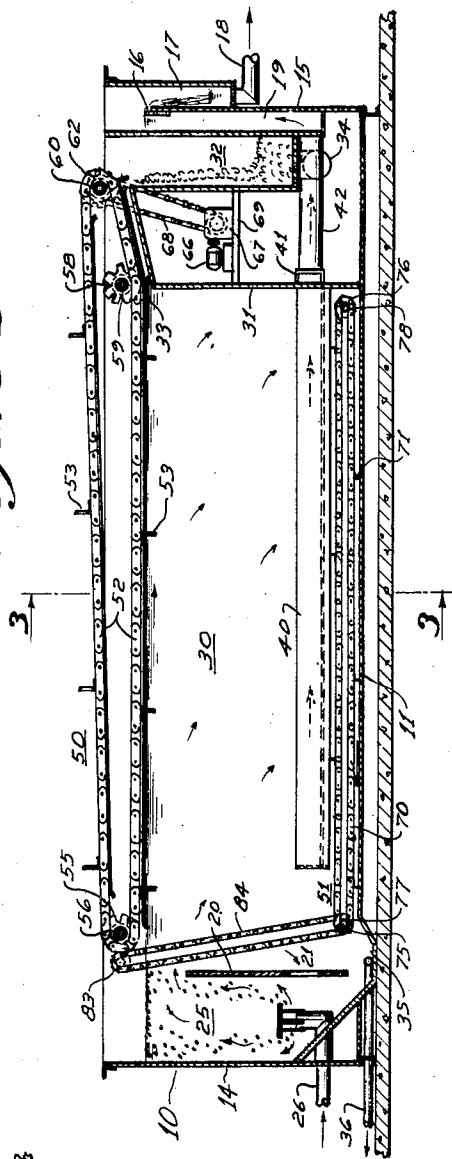
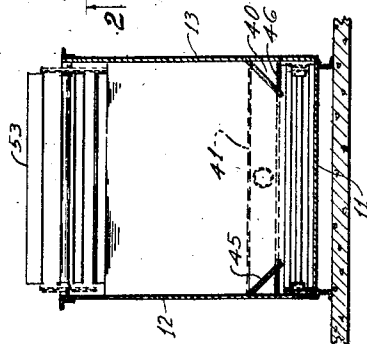


Figure 3



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2,813,074

CLARIFYING APPARATUS AND PROCESS

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This invention relates to an improved apparatus and method for clarifying liquids by flotation and sedimentation.

It is an object of this invention to provide an improved apparatus for clarifying liquids by air flotation of floatable material and sedimentation of settleable solids in a common basin.

Another object of the invention is to provide a clarifying apparatus of the type referred to wherein the common basin is of generally rectangular form.

Another object is to provide an apparatus for clarifying liquids by air flotation and sedimentation including a primary flotation zone wherein flotation starts a substantial distance below the liquid surface, and a certain degree of turbulence is permitted, and a quiescent secondary flotation and sedimentation zone. Another object is to provide an apparatus of this type means for recirculation of material from the secondary to the primary zone.

Another object of the invention is to provide in a method of clarifying liquids by flotation and sedimentation recirculation of material from a secondary flotation and sedimentation zone to a primary flotation zone in order to improve the characteristics of the material for flotation or settling.

Another object of the invention is to so locate the solids sump in an apparatus of the type referred to that heavy solids, such as grit, entering the apparatus with the liquid to be clarified can immediately deposit therein, while the lighter settleable solids are scraped into it.

Another object is to provide in a clarifying apparatus of this general type novel means for withdrawing the clarified liquid.

Other objects will become apparent upon consideration of the detailed description and of the claims which follow.

In a preferred form of the apparatus a tank of generally rectangular shape includes in its confines, in sequence from the inlet end to the outlet end, a primary flotation compartment, a secondary flotation and settling chamber, a scum trough, and an outlet well. Settled solids are scraped into a sump underlying in part the primary flotation compartment and in part the secondary flotation and settling chamber. Scum is pushed by skimmers into the scum trough over an upwardly sloping wall, and below this wall, utilizing an otherwise dead space, the motor means for driving the skimmer and the scraper are supported.

The invention will be more readily understood by reference to the drawings which form a part hereof and wherein:

Figure 1 is a plan view of an apparatus according to the invention;

Figure 2 is a vertical sectional view taken along line 2—2 of Figure 1; and

Figure 3 is a vertical sectional view taken along line 3—3 of Figure 2.

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The tank 10 is of generally rectangular shape, having a substantially flat bottom 11, side walls 12 and 13, and end walls 14 and 15. The end wall 14 at the inlet end of the tank may be rounded, and the side wall 12 formed with a recess 12a, as shown in Figure 1. The outlet end wall 15 is fitted with an adjustable weir 16, which determines the liquid level in the tank 10. Liquid passing over the weir 16 flows into a launder 17, from which a clarified effluent conduit 18 leads to a point of storage or use, not shown. On the upstream side of the weir, a weir chamber or outlet well 19 is provided.

A partial partition 20 extends across the inlet end portion of the tank from an elevation spaced above the bottom 11 to an elevation below the liquid level as established by the weir 16 and has an apertured area 21 intermediate its upper and lower edges. The partition 20 forms with the end wall 14 a primary flotation compartment 25 into which an inlet conduit 26 for gas-charged liquid leads. The outlet end of conduit 26 is baffled, as shown, so that the gas-laden liquid is discharged laterally and is uniformly distributed over the cross sectional area of the compartment 25.

A secondary flotation and sedimentation chamber 30 is formed between the partial partition 20 and a partition 31, which in effect constitutes the end wall of the treating basin proper. Between the partition 31 and the outlet well 19 is a scum trough 32 to which an inclined deck or ramp 33 leads. The scum deposited in trough 32 is withdrawn through an outlet 34. A sump or depression 35 in the bottom 11 underlies in part the primary flotation compartment 25 and in part the secondary flotation and sedimentation chamber 30. Sludge is removed from the sump 35 through a sludge outlet conduit 36.

Clarified liquid is withdrawn through a pair of collectors 40. The collectors 40 extend along the side walls 12 and 13 in the chamber 30 and through the partition 31, and discharge to a manifold 41 from which a conduit 42 leads to the lower part of the outlet well 19. As best shown in Figure 3, each collector 40 is of triangular configuration, and is formed by a plate 45 sloping downwardly from the respective side wall 12 or 13 which forms one wall of the respective collector. To enter a collector, the liquid must pass around the lower edge of the sloping plate 45 and through a perforated plate 46 which protects the bottom inlet of the collector.

Flloating material is removed from the liquid surface in chamber 30 by a skimming assembly generally designated by the numeral 50; and solids depositing on the bottom of the chamber 30 are scraped to the sump 35 by a scraping assembly generally designated by the numeral 51.

The skimming assembly 50 comprises a flight conveyor including a pair of endless chains 52 on which flights or skimming blades 53 are mounted. The chains 52 are guided by idler sprockets 54 and 55, keyed to a shaft 56, and idler sprockets 57 and 58 keyed to a shaft 59. A third shaft 60 has take-up and drive sprockets 61 and 62 keyed to it. The shafts 56, 59 and 60 are supported in suitable bearings, mounted on the side walls 12 and 13 at an elevation such that the flights on their lower run extend into the scum layer and move the scum toward, and upwardly over, the ramp 33 to its edge, over which it flows into the scum trough 32. On their return run the flights are above the scum level. One end of shaft 60 extends beyond the side wall 12, and has at its end a drive sprocket 65 keyed to it. The drive sprocket 65 is driven by a motor 66 through a reducer 67 and chain connection 68 to move the flights 53 in counterclockwise direction, as indicated by the arrow in Figure 2. The

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motor 66 and reducer 67 are housed in the space below the ramp 33 and are carried by a support 69.

The scraping assembly 51 also comprises a flight conveyor, including a pair of endless chains 70 on which scraping blades or flights 71 are mounted. The chains 70 are guided by a pair of idler sprockets, one of which is shown at 75, and a pair of take-up and idler sprockets, one of which is shown at 76. The sprockets 75 and 76 are mounted on shafts 77 and 78, respectively, which are supported in suitable bearings, not shown, from the side walls 12 and 13, at an elevation such that the flights on their lower run will extend into the layer of sludge deposited on the bottom of the tank. The scraper assembly may be driven independently by a separate motor. In the preferred embodiment, however, it is driven from the motor 66 which drives the skimmer assembly 50. The shaft 56 of the skimmer assembly extends through its bearing into the recess 12a, and has a pinion 80 affixed to its end. A spur gear 81 meshing with the pinion 80 is affixed to a shaft 82, to which is also keyed a sprocket 83 which is connected to the idler sprocket 75 of the scraper assembly by a chain 84. Thus, when the skimming assembly 50 moves counterclockwise, the scraper assembly 51 is driven clockwise, and the flights on their lower run move the sludge deposited on the bottom 11 to the sump 35.

The operation of the apparatus will be readily understood. The liquid arriving through inlet conduit 26 may have been charged with gas under pressure by any suitable means, such as, for example, an air injector connected to the suction and discharge sides of a pump, and may have passed through a conventional saturation tank to release undissolved excess gas. Such means are well known in the art and need not be described or illustrated. The gas with which the liquid has been charged prior to its entry still may be in solution; preferably, however, a pressure release valve, not shown, is provided on the conduit 26 a suitable distance upstream of the clarifying apparatus so that the gas is at least partly out of solution and in the form of fine bubbles when it is discharged with the liquid in compartment 25 a substantial distance below the liquid surface. These gas bubbles immediately attach themselves to solid particles, so that flotation starts instantaneously in compartment 25. If necessary, the liquid may also be dosed with a coagulant prior to its entering the treating unit.

The liquid and gas bubbles rise in compartment 25 and flow over the upper edge of the partition 20 into the secondary flotation and sedimentation chamber 30. Under the quiescent conditions of this large chamber the gas bubbles with attached particles separate from the liquid flowing toward the clarified liquid outlet collectors 40 and rise to the liquid surface, where they form a layer of float or scum which is moved by the skimming assembly 50 to the scum trough 32. This separation is enhanced by the repeated change in the direction of flow of the liquid, first when the liquid enters the chamber 30 and thereafter when it flows downwardly to the collectors 40. Heavy particles sink to the bottom of the tank, where they deposit as a sludge and are scraped by the scraping assembly 51 to the sump 35. Some particles will neither float nor sink, but remain suspended in an intermediate layer of the liquid because they are too light to deposit by gravity and insufficient air bubbles have become attached to them to float them. The gas lift action in the primary flotation compartment continuously draws a portion of this intermediate layer of liquid through the ported area 21 into the compartment 25, where it is mixed with the incoming liquid and gas. While recirculating through the compartment 25 these particles may grow by agglomeration with other particles, so that they can settle when they re-enter the chamber 30, or more gas bubbles may become attached to the particles, so that they will be floated to the liquid surface. This recirculation provided in the apparatus plays an important part in the clarification of the liquid.

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Any undissolved gas bubbles entering compartment 25 can escape to the atmosphere before the liquid enters the quiescent chamber 30, where such gases would disturb flotation. Grit and similar solids which are too heavy to be carried over the partition by the liquid, slide directly into the sump 35, from which they are removed along with the sludge.

The compartment 25 should be of sufficient size that the upward flow is relatively slow. Further, while the partition 20 must be of sufficient height to shelter the secondary flotation and sedimentation chamber 30 from turbulence occurring in compartment 25, its upper edge must be sufficiently submerged to prevent a high flow velocity over the edge, which would disturb the flotation and sedimentation in the chamber 30.

Obviously, in some instances it will be sufficient to charge only a part of the incoming liquid with gas, or some of the effluent of the clarifier can be charged with gas and mixed with the incoming liquid, as is well known in the art. In the practice of such partial pressurization of the liquid, the charged and uncharged liquid streams may be mixed before entering the tank 10 and be discharged together through inlet conduit 26 in the same manner as described above. Sometimes, however, it is preferable to introduce the two streams of liquid separately and mix them in compartment 25.

The apparatus lends itself readily to the treatment of many types of liquid wastes. For example, a waste from parts cleaning and paint stripping operations of an aircraft factory was treated at a throughput of 1100 G. P. D./sq. ft. (gallons per day per square foot), using 48 G. P. G. (grains per gallon) of ferric sulfate. The results were the following:

	Phenol, p. p. m. ¹	B. O. D., p. p. m.	Suspended Solids, p. p. m.	Ether Solubles, p. p. m.
Influent.....	640	3,933	176	1,476
Effluent.....	261	670	51	42
Percent Removal.....	59	83	71	97

¹ Parts per million.

The float volume was 15% of the throughput.

Many modifications of the embodiment of the invention shown and described herein can be made without departing from the spirit and scope of the invention. Thus, for example, the partition 31 could be the end wall of tank 10 and the scum trough 32, outlet well 19, weir 16, and launder 17 be arranged outside the tank, instead of within its confines, as shown. Further, while the invention has been shown and described in connection with a rectangular tank, and some of its novel structural features require such a tank, the improvement of the solids characteristics by recirculation of solids which neither sink nor float from the secondary flotation and sedimentation chamber to the primary flotation compartment are not bound to a rectangular tank, but can be realized in a basin of any desired configuration, such as, for example, a round basin. Accordingly, it is to be understood that the invention is not limited to the exact structural details shown and described for purposes of illustration and exemplification but not of limitation.

We claim:

1. In an apparatus for clarifying liquids by flotation and sedimentation, comprising a basin, means for removing settled solids from said basin, means including an overflow for withdrawing clarified liquid from said basin, and means for removing floating scum from said basin, a partial partition having an overflow edge at an elevation below said overflow and separating in said basin a primary flotation compartment from a secondary flotation and sedimentation chamber, said compartment and said chamber being in hydraulic communication over the overflow edge of said partial partition for unrestricted flow of liquid from said compartment to said chamber, inlet means for

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liquid charged with gas discharging in a lower portion of said primary flotation compartment, and a passageway through said partition for return of liquid from said chamber to said compartment.

2. In an apparatus for clarifying liquids by flotation and sedimentation, comprising a basin, means for removing settled solids from said basin, means including an overflow for withdrawing clarified liquid from said basin, and means for removing floating scum from said basin, a partial partition in said basin and having an upper edge at an elevation spaced below said overflow, said partition separating in said basin a primary flotation compartment from a secondary flotation and sedimentation chamber, said compartment and said chamber being in hydraulic communication for unrestricted flow of liquid from said compartment to said chamber over said upper edge, inlet means for liquid charged with gas discharging in a lower portion of said primary flotation compartment, a passageway for return of liquid from said chamber to said compartment, and a depression in the bottom of said basin partly underlying said compartment and partly said chamber, said means for removing settled solids from said basin leading from said depression.

3. In an apparatus for clarifying liquids by flotation and sedimentation, including a basin of generally rectangular shape, inlet means for liquid charged with gas, an overflow for clarified liquid establishing a liquid level in said basin, means for removing scum from said basin, and means for withdrawing solids from said basin, partition means across the width of said basin and separating therein a primary flotation compartment from a secondary flotation and sedimentation chamber in hydraulic communication with one another for flow from an upper portion of said compartment to said chamber, said inlet means discharging into a lower portion of said compartment at atmospheric pressure plus the static liquid head over said inlet means, a pair of clarified liquid collectors in a lower portion of said chamber extending along the side walls of said basin, each collector being formed by a portion of the respective side wall and by a plate sloping outwardly and downwardly from said portion and having an open bottom and a perforated plate across said bottom, a manifold receiving liquid from said collectors, and means for withdrawing liquid from said manifold over said overflow.

4. Apparatus for clarifying liquids by flotation and sedimentation, comprising an open tank having a bottom, a pair of side walls and a pair of end walls, a first partition in said tank forming with one of said end walls a primary flotation compartment, a second partition forming with said first partition a secondary flotation and sedimentation chamber, a weir mounted on the other of said end walls, a launder on the outside of said end wall receiving liquid flowing over said weir, an effluent conduit leading from said launder, an outlet well on the side of said weir opposite said launder, outlet means for clarified liquid extending horizontally in a lower portion of said chamber and through said second partition and discharging into said outlet well, a scum trough vertically extending in said tank adjacent said outlet well, said trough having an outlet, skimming means in said chamber adapted to move scum to said scum trough, a depression in said bottom underlying in part said compartment and in part said chamber, said depression having an outlet, scraping means in said chamber adapted to move sludge over said bottom to said depression, and motor means connected to said skimming means and to said scraping means, said motor means being supported in the space between said scum trough and said second partition.

5. In an apparatus for clarifying liquids by flotation and sedimentation, comprising a basin, means including a depression in the bottom of said basin for removing settled solids from said basin, and means for removing floating scum from said basin, a partial partition in said

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basin, said partition separating in said basin a primary flotation compartment and a secondary flotation and sedimentation chamber, said compartment and said chamber being in hydraulic communication over the upper edge of said partial partition for unrestricted flow of liquid from said compartment to said chamber, said depression underlying in part said primary flotation compartment and in part said secondary flotation and sedimentation chamber, inlet means for liquid charged with gas discharging into a lower portion of said compartment, a passageway through said partition for return of liquid from said chamber to said compartment, collection means for liquid extending horizontally in a lower portion of said chamber, and means including an overflow for withdrawing clarified liquid from said collection means.

6. A method of clarifying turbid liquids by flotation and sedimentation, comprising introducing liquid charged with gas at a pressure permitting gas to come out of solution into the lower portion of, and upwardly through, a primary flotation zone wherein gas bubbles attach themselves to solid particles in the liquid, then flowing the liquid and gas into a quiescent secondary flotation zone wherein floatable particles are floated by the gas bubbles to the liquid surface and settleable particles deposit, removing the floating and deposited particles from said secondary zone, withdrawing clarified liquid from said secondary zone, and recirculating a portion of liquid containing solids which neither deposit nor are floated to the liquid surface from said secondary zone to said primary zone for repassage therethrough with the newly entering gas-charged liquid to improve the characteristics of said solids and make them suitable for flotation or sedimentation.

7. In a method of clarifying turbid liquids by flotation and sedimentation, comprising introducing liquid and gas into a primary zone wherein gas bubbles attach themselves to solid particles in the liquid, then flowing the liquid into and through a quiescent secondary zone wherein floatable particles are floated by the gas bubbles and settleable particles deposit removing scum from said secondary zone, withdrawing deposited solids from said primary and secondary zones, and withdrawing clarified liquid from said secondary zone, the improvement which comprises recirculating a portion of liquid from a level of said secondary zone intermediate its bottom and its top to said primary zone for repassage therethrough with the newly entering liquid and gas.

8. A method of clarifying turbid liquids by flotation and sedimentation, comprising introducing liquid and gas into a primary zone wherein gas bubbles attach themselves to solid particles in the liquid, then flowing the liquid into and through a quiescent secondary zone wherein floatable particles are floated by the gas bubbles and settleable particles deposit removing scum from said secondary zone, depositing heavy solids from said primary zone into a solids collecting zone, scraping solids deposited in said secondary zone to said solids collecting zone, withdrawing collected solids from said solids collecting zone, and withdrawing clarified liquid from said secondary zone, characterized by recirculating a portion of liquid from a level of said secondary zone intermediate its bottom and its top directly to said primary zone for repassage therethrough with newly entering liquid and gas.

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