

[54] **CONTINUOUS FLOW COUNTER-CURRENT
LIQUID AND SOLID CONTACT
APPARATUS**

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[51] Int. Cl. **B08b 3/08**

[58] Field of Search 134/65, 132, 60, 66;
23/270 R; 259/9, 10, 104; 127/5-7; 416/124,
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[56] **References Cited**

UNITED STATES PATENTS

34,770 3/1862 Palmer..... 416/175

266,011	10/1882	Blackman	416/203 X
1,866,030	7/1932	Green	23/270 R
2,238,690	4/1941	Fell	134/65 X
2,698,742	1/1955	McCoy	259/9 X
3,297,043	1/1967	Adams	134/65 X

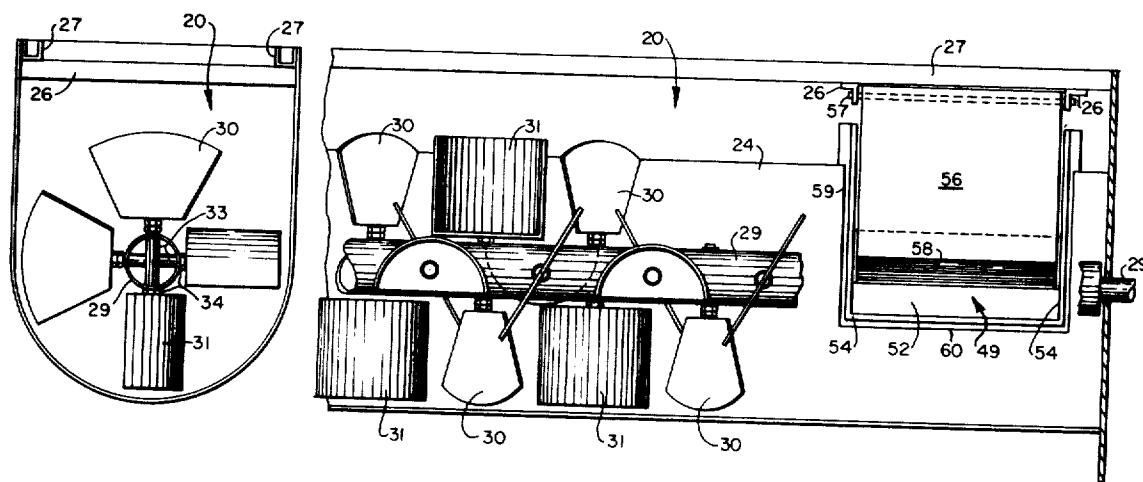
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Bello

[57] **ABSTRACT**

A counter-current liquid and solids continuous contact apparatus comprises a trough for flowing the liquid in one direction and a helical arrangement of paddles for tumbling and advancing the solids in the opposite direction upstream. The paddles include flat vanes for advancing the solids and curved scoops for tumbling the solids, the coaction between the vanes and the scoops being such as to provide greatly enhanced large area contact between the liquid and the solids.

8 Claims, 9 Drawing Figures



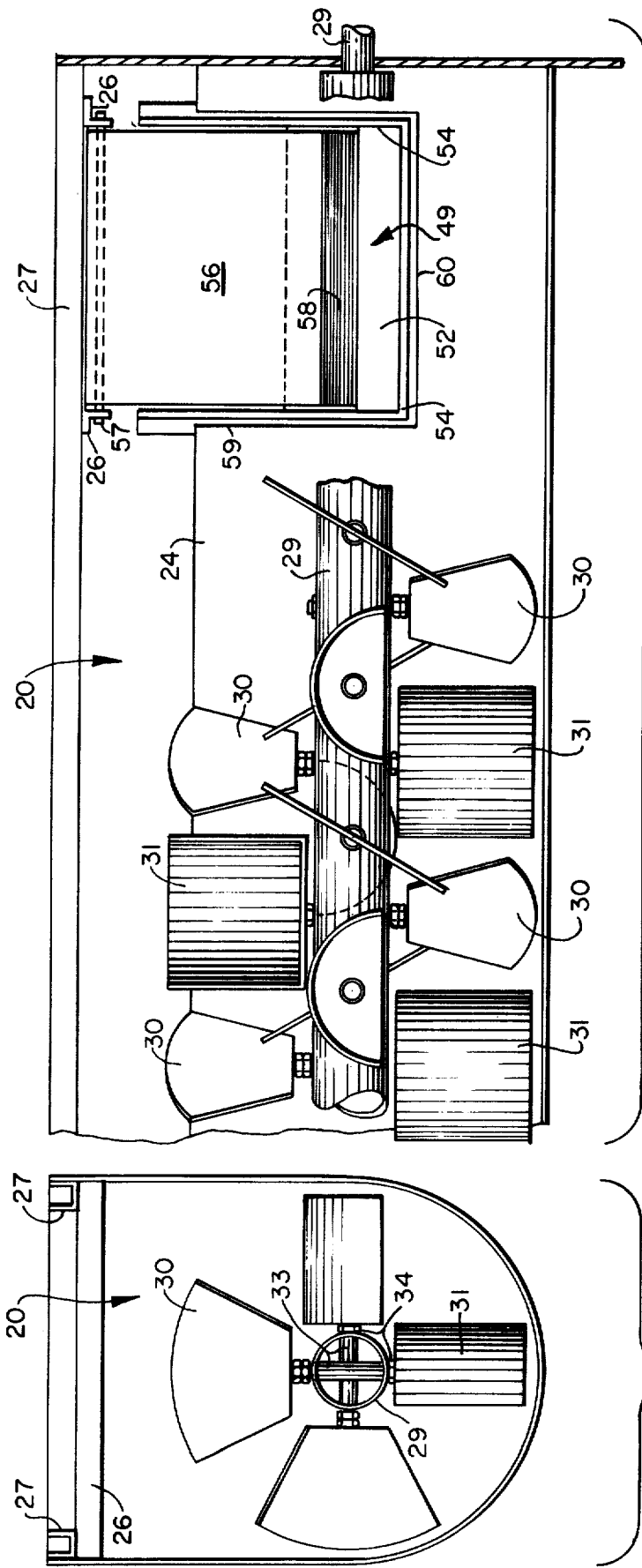


FIG. 1

FIG. 2

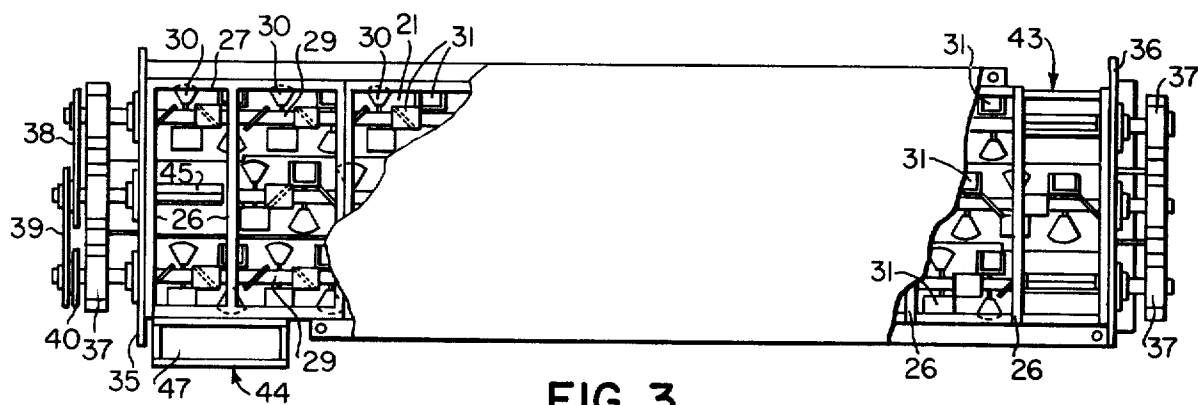


FIG. 3

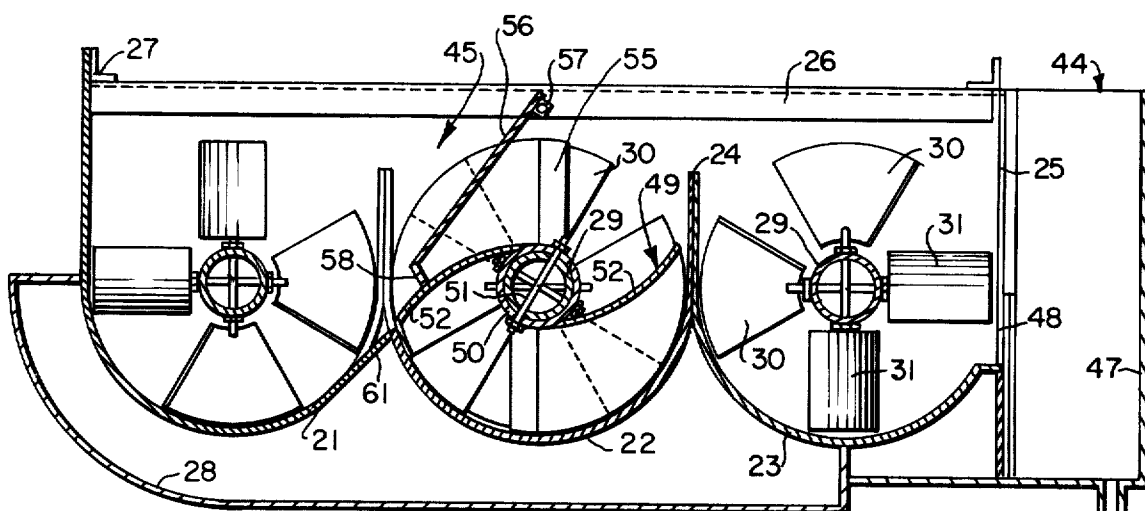


FIG. 4

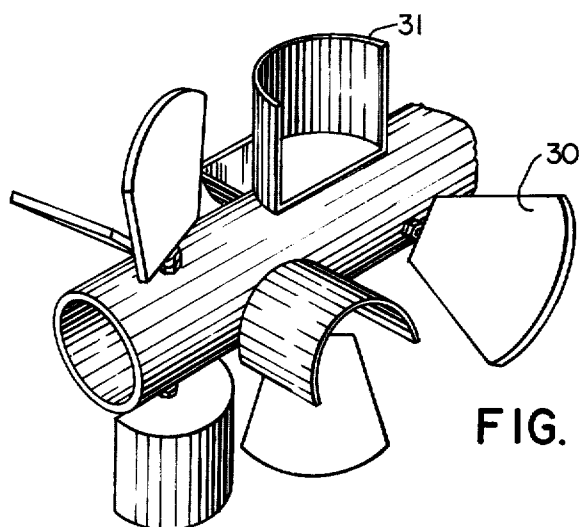


FIG. 5

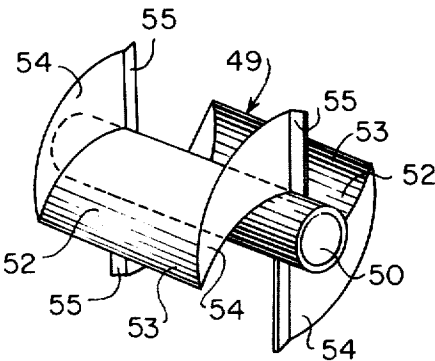


FIG. 6

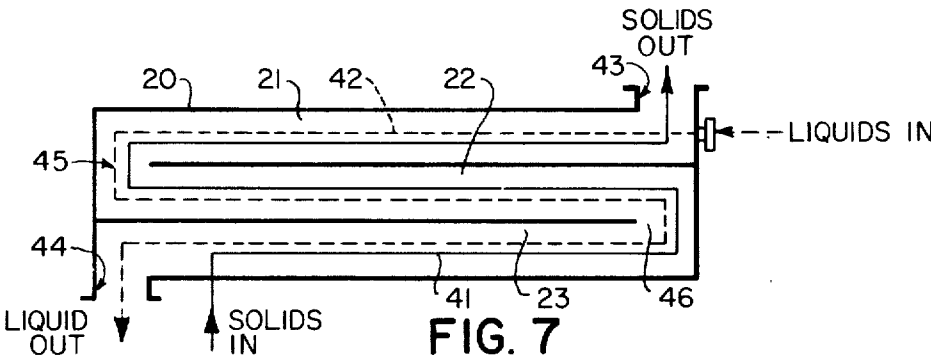


FIG. 7

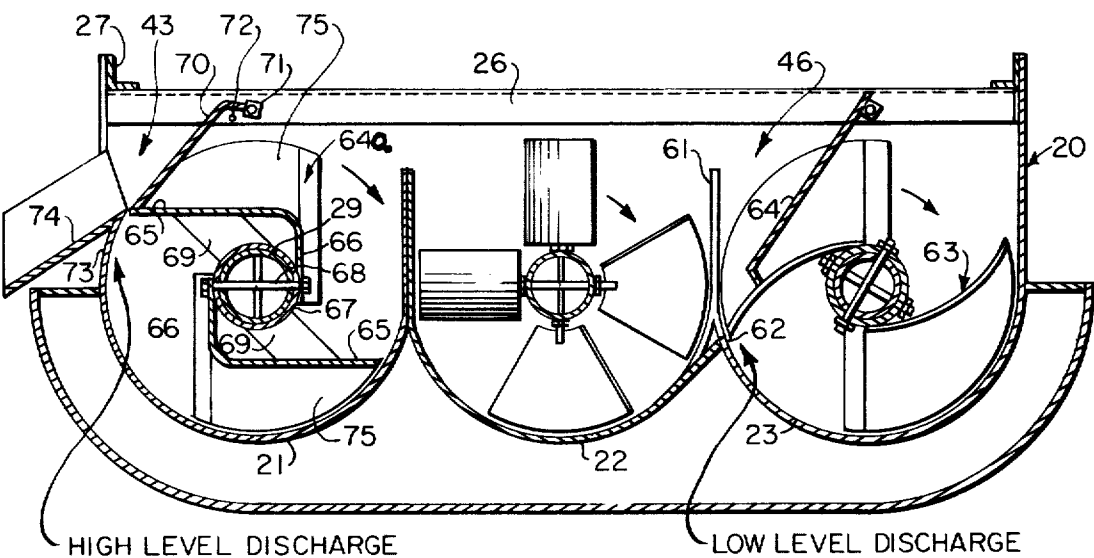


FIG. 8

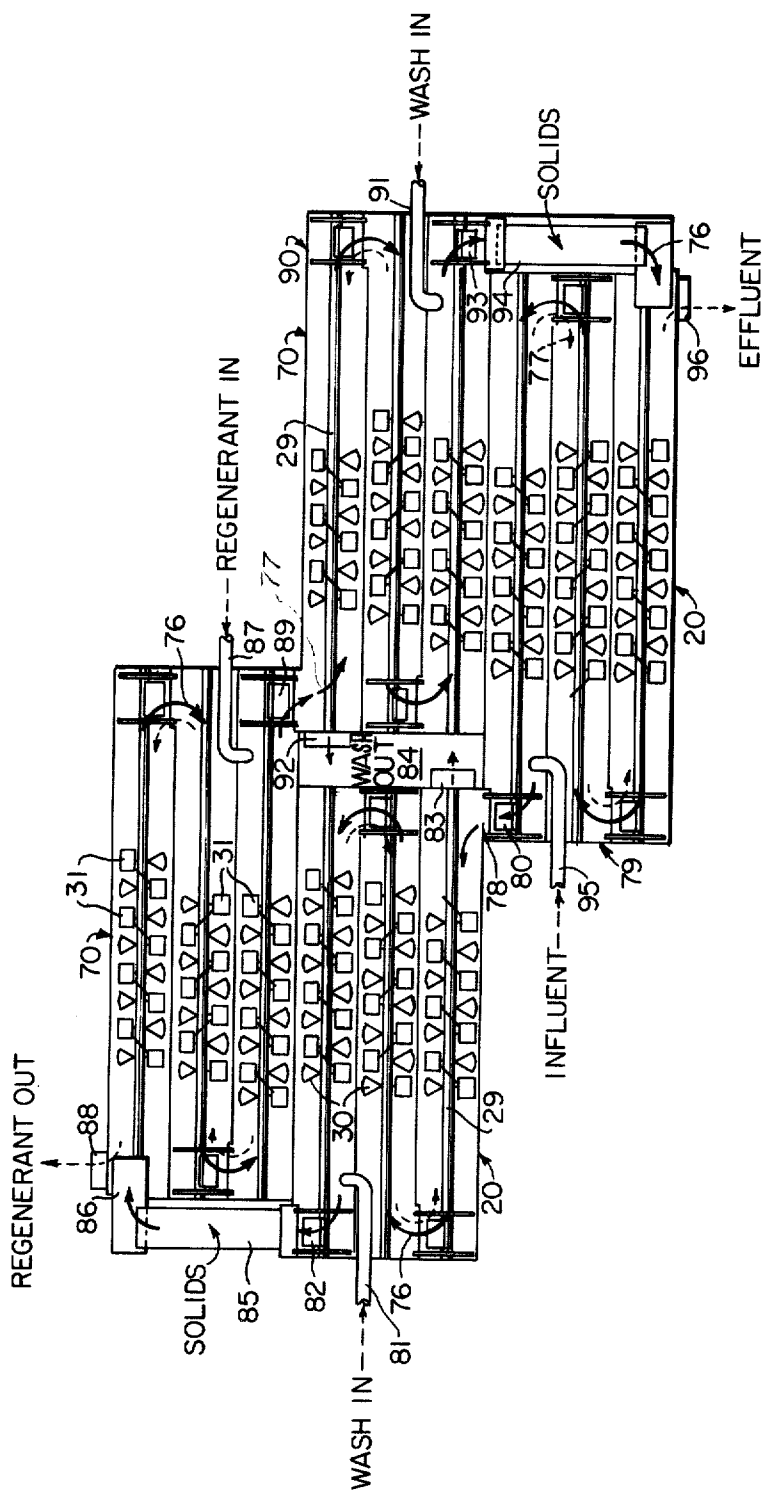


FIG. 9

CONTINUOUS FLOW COUNTER-CURRENT LIQUID AND SOLID CONTACT APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to counter-current liquid and solids continuous contact apparatus, commonly called a counter-current contactor, and, more particularly to a horizontal counter-current contactor which provides continuous, liquid-solid contact for extracting, leaching, ion exchange, decoloring, deodorizing, crystallizing, washing, flotation and the like.

2. The Prior Art

In counter-current contactors, it has been proposed to provide adjustable paddles arranged to form an interrupted helix, the paddles slowly lifting the solid material from a trough, tumbling it gently, and advancing it upstream continuously counter to the direction of liquid flow. The purposes of such a contactor are as follows: it allows continuous operation without down time for repacking columns, flushing, or regenerating; continuous counter-current flow eliminates start-of-run and end-of-run differences and allows controlled uniform effluent; samples or side streams of liquid or solid material or both may be removed or introduced at selected points; gentle "lubricated" tumbling of solids minimizes or eliminates attrition of valuable solids such as ion exchange resin beads; the contactor may be jacketed for heat transfer, if desired; troughs can be rubber-lined, if desired; for certain applications wipers may be added to the paddles to provide a continuous self-cleaning action. In such apparatus difficulties have been encountered in achieving the desired intimate contact between the liquid and solids.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a counter-current liquid and solids continuous contact apparatus characterized by a trough for flowing the liquid in one direction and a helical arrangement of paddles for tumbling and advancing the solids in the opposite direction upstream, the paddles including generally flat vanes for advancing the solids and generally curved scoops for tumbling the solids. It has been found that the coaction between the vanes and the scoops is such as to provide greatly enhanced large area contact between the liquid and the solids. The apparatus of the present invention has been found particularly efficacious in ion exchange reactions.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the apparatus, its components and their interrelationships, as illustrated in the present disclosure, the scope of which will be indicated in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the present invention, reference is made to the following detailed description, taken in connection with the accompanying drawings, wherein:

FIG. 1 is a side view, with portions broken away, of a portion of an apparatus embodying the present invention;

FIG. 2 is an end view of the portion of FIG. 1;

FIG. 3 is a top plan view of the entire apparatus of FIG. 1;

FIG. 4 is an end view, with portions broken away, of the entire apparatus of FIG. 3;

FIG. 5 is a perspective view of one of the components of FIG. 1;

FIG. 6 is a perspective view of one of the components of FIG. 3;

FIG. 7 is a schematic diagram illustrating certain of the principles of operation of the apparatus of FIG. 3;

FIG. 8 is an end view, with portions broken away, of the entire apparatus of FIG. 3; and

FIG. 9 is a top plan view, with portions omitted, of another apparatus embodying the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

In the drawings, the numeral 20 designates a single independent unit of a counter-current contactor embodying the present invention. Unit 20 is supported at a desired elevation on a suitable supporting framework or leg structure (not shown).

Unit 20 includes three (or more) parallel elongated U-shaped troughs 21, 22 and 23, which are of equal length and which extend substantially for the entire length of the unit 20. The vertical side walls 24 of the three troughs are all of the same height and the two outermost troughs 21 and 23 have outer side walls 25 which extend above the tops of side walls 24. The outermost side walls 25 are strengthened by a series of crossbraces 26 interconnected with longitudinal bars or braces 27. Any alternate structure may be employed to render the shell of unit 20 sufficiently rigid, the shell being formed of sheet metal. Unit 20 also may embody an underlying casing or housing 28 below the bottoms of troughs 21, 22 and 23.

Within each trough 21, 22 and 23 and extending lengthwise and centrally therein for the entire length thereof is a rotary hollow shaft 29, having secured thereto adjustably a plurality of radially extending paddles 30 and scoops 31, which collectively are disposed along an interrupted helix. As will be explained, paddles 30 advance solids along the trough and scoops 31 lift solids from the bottom of the trough, tumble it gently, and advance it upstream counter to the flow of liquid through the trough. The liquid moves by hydraulic gradient, not requiring a pressure feed.

Each paddle 30 is a flat plate element having outwardly diverging side edges and a circularly curved outer peripheral edge. Each scoop has a cylindrically curved catch portion that is semi-circular in cross section and a flat inner face, defining a region with open top and open outer end. Each paddle and scoop pair are rigidly anchored to an adjusting rod 33 which in turn is connected to rotary shaft 29 by means of adjustable screw-threaded parts 34 or the like. Other forms of connections between the paddle and scoop pairs and shaft 29 may be employed. In any event, each paddle and each scoop may have its pitch or angle changed with reference to shaft 29. This adjustability enables accurate setting to lift various solids from the bottom of the trough and to advance them along. Some solids behave differently from others and the adjustability feature is therefore necessary. Paddles 30 also are set to overlap longitudinally of shaft 29 so that the solids are gently tumbled by the scoops in maximum contact with the counter flowing liquid. The arrangement of the several pairs of paddles and scoops basic in allowing the liquid to flow by gravity reversely to the advancement of the solids through the liquid stream. Intimate

contact of the solids with the liquid is obtained without restricting liquid flow.

The end portions of the three shafts 29 are supported exteriorly of the end walls 35 and 36 of the multiple trough structure by means of sturdy bearings 37 which may be bracketed to the end walls or suitably tied in to the underlying supporting frame structure, not shown. This outboard arrangements of bearings relieves the sheet metal trough structure from the direct support of shafts 29.

As shown in FIG. 3, the three shafts are geared together at 38 and 39 to turn in unison and in the same direction. One shaft may be powered by suitable gearing 40, driven by an underlying variable speed drive (not shown). Unit 20 may be of any practical length.

The diagram in FIG. 7 shows the essential paths of solids and liquids through the basic unit 20 of the apparatus. The path of the solids is indicated by solid line 41 and the path of the liquid by broken line 42, the diagram illustrating the counter flow of the liquid and solids through the three troughs 21, 22 and 23. With continued reference to FIG. 7, there is shown diagrammatically a solids outlet 43 at one end of trough 21. At the remote end of trough 23 is a liquid outlet 44. Solids are introduced into the system slightly upstream from the outlet 44. There are two additional points in unit 20, indicated at 45, 46, where solids are transferred from one trough to the next without interfering with the counter flow of liquid. The structures shown particularly in FIGS. 1, 4 and 6 provide for these transfers of solids and/or liquid from trough to trough.

FIG. 4 shows the three troughs 21, 22 and 23 and associated elements in cross section adjacent liquid outlet 44. At liquid outlet 44, a discharge receptacle 47 or the like is provided upon the outer side of trough 23 at one end thereof. A vertically adjustable weir 48 is provided to regulate the outflow of liquid from the trough 23 into the receptacle 47, and this weir also controls the liquid level in the entire system, i.e. in the three troughs of unit 20. It may be observed in FIG. 3 that paddles 30 in each trough 21, 22 and 23 are properly pitched to cause advancing of the solids in the direction of flow, as indicated in FIG. 7 by the solid line, when the several shafts 29 are turning in the direction indicated in FIG. 4. The liquid in the system of course flows in the opposite direction as previously explained.

The previously mentioned transfer point 45 for solids and liquids between troughs 21 and 22 also is shown in FIG. 4. Means are provided at this point to transfer solids from the trough 22 to the trough 21, without interrupting the counter flow of liquid from the trough 21 to the trough 22. This means comprises a scoop 49 having a tubular hub 50 cross-bolted rigidly to shaft 29 as at 51. Scoop 49 therefore turns with shaft 29 in trough 22. Scoop 49 comprises diametrically opposed reversely curved blades 52, whose tips 53 pass close to the wall of trough 22. The scoop also has side wall portions 54 integral therewith, in turn having outwardly flared terminal straight edge portions 55 for close contact with a coacting scavenger plate or scraper 56. Scavenger plate 56 has its upper end pivoted at 57 between a pair of the transverse braces 26 and has a bottom transverse lip 58 which rests upon the scoop blades 52 to scrape and transfer solids therefrom into the trough 21 during rotation of the shaft 29 in the trough 22. Scavenger plate 56 is freely suspended under the

influence of gravity and merely rises and falls by the camming influence of rotating blades 52.

To effect the actual transfer of solids and liquid between troughs 22 and 21, the adjacent side walls 24 are notched as at 59. This forms a horizontal edge 60 of reduced height over which the liquid can flow readily from trough 21 to trough 22 and this edge is well below the top edge of the liquid outlet weir 48. Rotating scoop 49, coacting with scavenger plate 56, elevates and smoothly transfers solids from the trough 22 to the trough 21 and over edge 60 in the reverse direction to liquid flow. Scavenger plate 56 with lip 58 continuously scrapes the solids from the two sections of the scoop and forces them through the notch between the two troughs and into trough 21.

With reference to FIG. 8, the previously mentioned transfer point 46 for solids and liquids is shown. Solids must be transferred from the trough 23 into trough 22 while liquids flow freely in the reverse direction from the trough 22 into trough 23. The adjacent trough side walls are again notched at 61, FIG. 8, to provide a horizontal lip 62 identical to the previously described lip or edge 60. The rotating scoop 63 for solids at transfer point 46 and the coacting scavenger plate 64 are identical in construction and operation to the previously described elements 49 and 56. This arrangement, FIG. 8, enables the counter passage of solids from the trough 23 to the trough 22 and liquid from the trough 22 to the trough 23 exactly as described previously in connection with transfer point 45.

FIG. 8 also depicts a somewhat modified scoop and scavenger plate for use at the solids outlet 43. Outlet 43 must discharge the solids from trough 21 at a higher elevation than transfer points 45 and 46 because at outlet 43, no liquid is discharged from unit 20. This feature becomes particularly important where multiple units 20 are employed in a more elaborate system employing multiple liquids, such as the system of FIG. 9 to be described hereinafter. In FIG. 8, a scoop 64a is shown including essentially flat parallel opposed scoop blades 65 whose tips operate close to the curved wall of trough 21. Blades 65 are connected by right angular extensions 66 to a hub 67 which is cross-bolted at 68 to an adjacent rotary shaft 29. Scoop blades 65 may be braced by diagonal braces 69 as shown. A somewhat modified scavenger plate or scraper 70 is pivotally suspended as at 71 from brace bars 26 and a stop element 72 is provided on bar 26 to limit downward swinging of scavenger plate 70. The outer side wall portion 73 of trough 21 is somewhat elevated relative to the edges of 61 and 62 to assure that no liquid will be discharged at solids outlet 43. There is therefore a relatively high elevation discharge of solids from unit 20 as is desirable. A suitable chute 74 or conveyor means or receptacle is provided at the solids outlet of unit 20. The general operation of the modified scoop device 64, 64a is similar to that of scoop device 49. Scoop blades 65 and their side wall portions 75 scoop and elevate the solids from trough 21 and coacting scavenger plate 70 scrapes the solid material from the two sections of the scoop and transfers it to outlet chute 74 without allowing any liquid outlet at this point. The basic feature in the apparatus at this point is the elevation of outlet 43. The scoop has been modified for this purpose. In other respects, the apparatus is essentially the same as previously described.

An ion exchange system, embodying the present invention, in which solids circulate continuously through the troughs and never leave, is shown in FIG. 9.

The several units 70 in FIG. 9 are basically the same as the unit described in detail previously and need not be further described in detail. The system shown in FIG. 9 provides for example an arrangement whereby several distinct liquids may be caused to contact a given solid, without any intermingling of the liquids and while the solids are transferred from unit-to-unit of the apparatus containing the various treatment liquids. In one form, there is an ion exchange treatment in the unit 70 at the bottom of FIG. 9 followed by a first washing of the solids, a regenerative treatment at the top of FIG. 9 and a second washing, as shown.

In FIG. 9 the continuous path of solids from unit 70 to unit 70 of the system is shown by the solid line arrows 76. The counter flow of the particular liquid in each unit 70 is designated by broken line arrows 77. From an inspection of these full line and broken line arrows in FIG. 9, it is readily apparent that the particular liquid in each unit 70 remains in that unit and is not transferred to a next adjacent unit 70 and therefore does not commingle or mix with any other treatment liquid in the entire system. The solids, on the other hand indicated by the full line arrows, are transferred from unit-to-unit through the entire system to receive a separate treatment by a separate liquid flowing counter thereto in each unit 70. Various like systems can be devised with the basic unit 70.

More particularly in FIG. 9, solids enter a first wash unit 70 at 78 from an ion exchange unit of the system indicated at 79. There is a solids transfer means 80 at this point having one of the high level transfer scoops 75 and associated elements, previously described. The first wash liquid enters the first wash unit 70 as at 81 and flows counter to the solids in this particular unit. The solids are transferred at 82 to the next unit 70 at the top of FIG. 9 by another one of the previously described typical high level transfer means which prevents the transfer of liquid while effecting the transfer of solids. The first wash liquid discharges at 83 to a common sump 84 or the like, centrally located in the system.

The solids transferred at 82 discharge onto a short solids conveyor 85 carrying the same into a regenerative unit 70 at 86. Regenerant liquid flowing oppositely to the solids enters at 87 and is discharged at 88 in FIG. 9. The solids are again transferred by transfer means 89 to a second wash unit 70 of the apparatus designated 90 in FIG. 9. The second wash liquid enters this unit at 91 and is discharged at 92 to the common sump 84 after flowing counter to the solids in the three troughs of the particular unit. After the second wash of the solids, they are transferred at 93 to a conveyor 94 which carries the solids to the ion exchange unit 79. The ion exchange liquid enters this unit 95 and discharges therefrom at 96. Each discharged liquid at a particular unit 70 of the system is controlled by one of the weirs 78 previously described, FIG. 2. Each unit 20 has within it the previously described low level transfer points to allow transfer in the opposite direction of both solids and liquid within a particular unit 70 of the total system shown in FIG. 9. As stated, the several liquids of the entire system cannot and do not mix because of the high level transfer means for solids only between the several units 70.

OPERATION

In operation, blades 30 and scoops 31 cooperate to advance solids and to ensure their intimate contact with the counter-current liquid. The diametrically opposed positioning of the blade and scoop of any pair ensure that the most highly compacted regions of the solids dispersion as produced by the scoops are contacted by the blades. It will be observed that, longitudinally of shaft 29, the dimension of scoop 31 is larger than the dimension of blade 30 and that, radially of shaft 29, the dimension of scoop 31 and the dimension of blade 30 are approximately the same. It has been found that this apparatus multiplies the efficiency of ion exchange reactions by at least an order of magnitude with respect to prior ion exchange apparatus.

Since certain changes may be made in the foregoing disclosure without departing from the invention hereof, it is intended that all matter shown in the accompanying drawings or contained in the foregoing drawings be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. A liquid and solids continuous contact counter flow apparatus comprising a body portion defining at least a trough, a rotary shaft extending longitudinally through said trough, a plurality of spaced generally radial paddles on said shaft collectively forming an interrupted helical distribution on said shaft, said paddles including substantially flat and substantially curved scoops, said paddles being arranged as pairs of oppositely radially directed scoops and blades, said scoops, longitudinally of said shaft, being of greater dimension than said blades, said scoops and said blades, radially of said shaft, being of approximately equal dimension, each of said scoops being approximately hemispherical in cross section with an open top and an open end.

2. A counter-current contactor for liquid and solids comprising a plurality of side-by-side elongated generally U-shaped substantially level troughs, a plurality of shafts, one each of said shaft extending rotatably and lengthwise through one each of said troughs, a plurality of adjustable pitch paddles on each of certain of said shafts collectively forming an interrupted helix on said each of said certain of said shafts, means to drive said shafts in unison and in the same direction, lower level transfer rotary scoops connected with certain of said shafts and driven thereby to transfer solids from one of said troughs to others of said troughs in said contactor and permitting counter flow of liquid in and between said troughs, a higher level solids discharge rotary scoop connected to certain of said shafts and driven thereby to lift and discharge solids from said contactor and retaining liquid therein, and a vertically adjustable weir to regulate the level of liquid in all of said troughs of said contactor, said paddles including a plurality of scoops and a plurality of blades, each of said scoops having inner face portions defining a partially enclosed region for tumbling said solids and said liquid, each of said blades having a single forward face portion for advancing said solids in one direction while permitting counter-flow of said liquid, said scoops and said blades being mechanically related in a geometrical pattern, said paddles being arranged as pairs of oppositely radially directed scoops and blades.

3. The apparatus of claim 1 wherein longitudinally of said shaft, said scoops are of greater dimension than said blades.

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4. The apparatus of claim 1 wherein radially of said shaft said scoops and said blades are of approximately equal dimension.

5. The apparatus of claim 1 wherein each as said scoops is approximately hemispherical in cross section with an open top and an open end.

6. The apparatus of claim 1 wherein said scoops and said blades are adjustably connected to said shafts by cross shafts to which said scoops and said blades are fixed by lock nuts.

7. A counter-current contactor for liquid and solids comprising a plurality of side-by-side elongated generally U-shaped, substantially level troughs, each of said troughs being substantially equal in length and extending the entire length of said contactor, vertical side walls of said troughs being the same height, the two outermost troughs of said plurality extending above said side walls, a plurality of shafts, one each of said shafts extending rotatably and lengthwise through one each of said troughs, said one each of said shafts being hollow, a plurality of adjustable pitch paddles on said one each of said shafts collectively forming an interrupted helix thereon, said paddles including a plurality of blades and a plurality of scoops, one each of said blades having a flat plate element having outwardly diverging side edges and circularly curved outer peripheral edge, one each of said scoops having a cylindrically curved catch portion that is semicircular in cross-section with a flat inner face, each of said blades and said scoops rigidly anchored to an adjusting rod, adjustable screw threaded parts connecting said paddles and said rotary shaft, lower level transfer rotary scoops including diametrically opposed reversely curved blades connected to certain of said shafts and driven thereby

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to transfer solids from one of said troughs to another of said troughs and permitting counter flow of liquid between said troughs, a higher level solids discharge scoop including diametrically opposed reversely curved blades connected to certain of said shafts and driven thereby to lift and discharge solids from said contactor and retaining liquid therein, a vertically adjustable weir to regulate the level of liquid in all of said troughs of said contactor, said one each of said scoops having inner face portions defining a partially enclosed region for tumbling said solids and said liquid, said one each of said blades having a single forward face portion for advancing said solids in one direction while permitting counter-flow of said liquid, said scoops and said blades being mechanically related in a geometrical pattern, said one each of said scoops being of greater dimension than said one of said blades in a direction longitudinally of said shafts, said one each of said scoops and said one each of said blades being of approximately equal dimension in a direction radially of said shafts, said one each of said scoops being approximately hemispherical in cross-section with an open top and an open end, said paddles being arranged as pairs of oppositely radially directed scoops and blades.

8. A liquid and solids continuous contact counter flow apparatus comprising a body portion defining at least a trough, a rotary shaft extending longitudinally through said trough, a plurality of spaced generally radial paddles on said shaft collectively forming an interrupted helical distribution on said shaft, said paddles including relatively flat blades and relatively curved scoops, said paddles being arranged as pairs of oppositely radially directed scoops and blades.

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