

Jan. 29, 1957

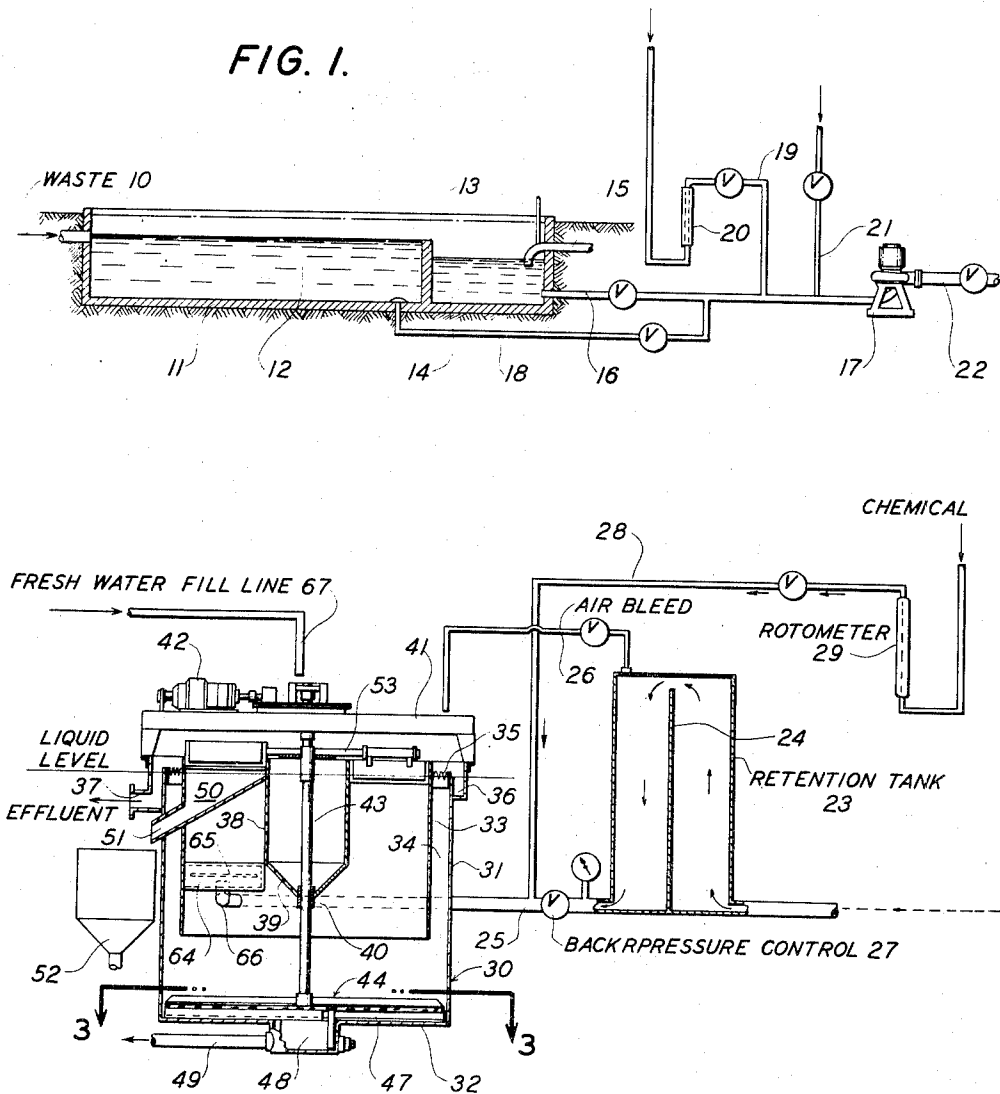
E. M. KELLY ET AL
PRESSURE FLOTATION

2,779,731

Filed June 11, 1953

2 Sheets-Sheet 1

FIG. 1.



EARL M. KELLY
ARTHUR M. KIVARI
LAWRENCE S. FARRELL
INVENTORS.

BY

James B. Christie

ATTORNEY

Jan. 29, 1957

E. M. KELLY ET AL
PRESSURE FLOTATION

2,779,731

Filed June 11, 1953

2 Sheets-Sheet 2

FIG. 2.

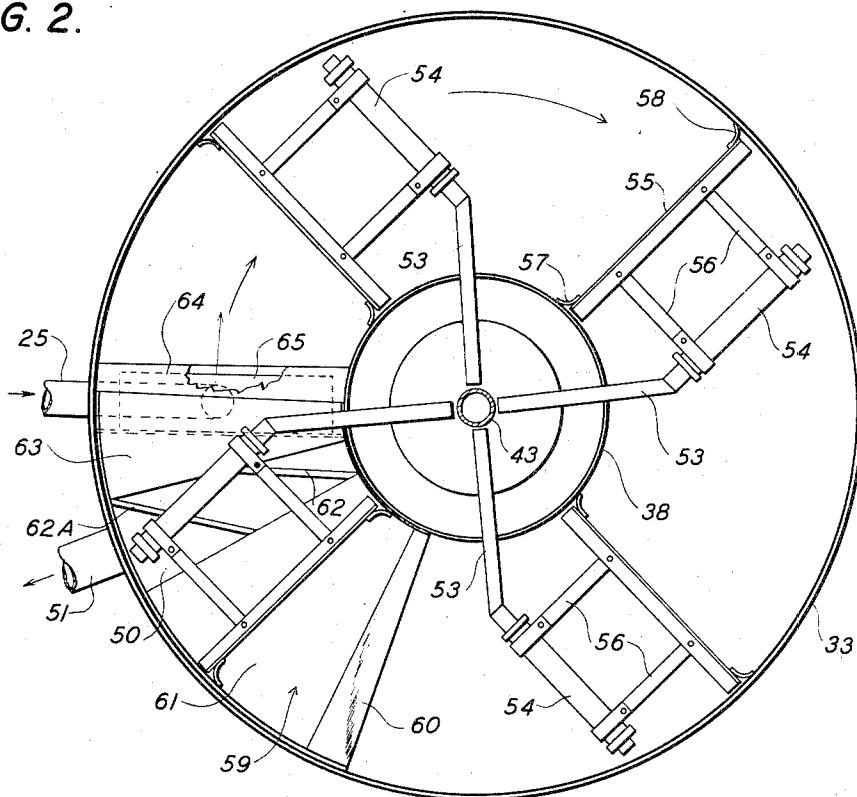
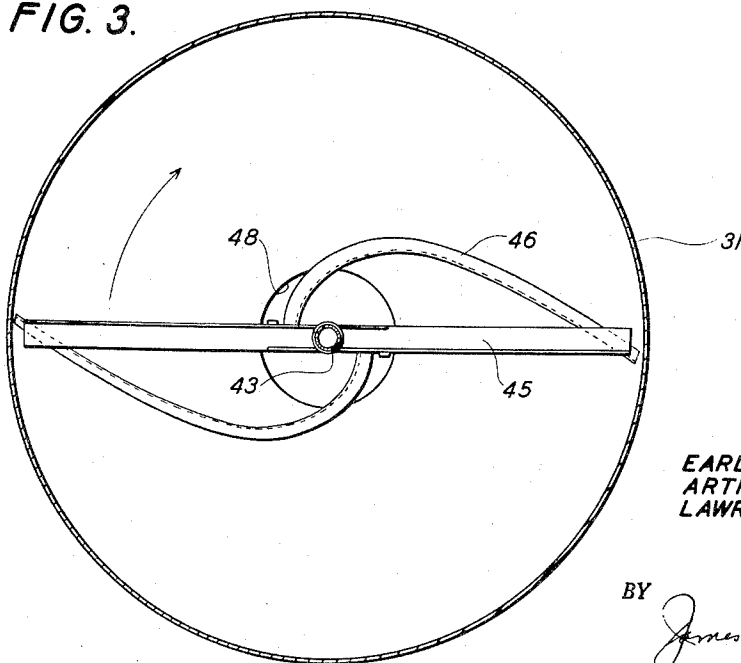


FIG. 3.



EARL M. KELLY
ARTHUR M. KIVARI
LAWRENCE S. FARRELL
INVENTORS.

BY

James B. Christie

ATTORNEY

1

2,779,731

PRESSURE FLOTATION

Earl M. Kelly, Hillsborough, Arthur M. Kivari, Los Angeles, and Lawrence S. Farrell, Azusa, Calif., assignors to Process Engineers Incorporated, San Francisco, Calif., a corporation of California

Application June 11, 1953, Serial No. 360,886

2 Claims. (Cl. 210—3)

This invention is concerned with flotation of suspended solids from liquid and provides improvements in both methods and apparatus for pressure flotation.

Pressure flotation is employed to separate a variety of suspended solids from liquid. The liquid suspension is charged with gas, usually at superatmospheric pressures, and the charged mixture is then introduced into a pool maintained at lower pressure. In consequence of the decrease in pressure, the solubility of the gas in the liquid is decreased and the excess gas comes out of solution as fine bubbles in the pool. These become attached to suspended particles and buoy them upward to the surface of the pool where they form a scum and may be removed by skimming.

Pressure flotation usually is carried out in an elongated rectangular tank. The charged suspension from which solids are to be removed as a scum flows into the pool in the tank over a weir at one end, and the scum floated to the surface of the pool is raked from the surface toward the other end of the tank and up a ramp to discharge.

Pressure flotation has also been conducted in round tanks, the charged suspension being introduced into the pool at a central point in the tank. Round tanks cost less than rectangular tanks and apparatus employing them is preferred for this reason, but in some instances, particularly when the scum is delicate and easily broken, the degree of solids removal obtainable by pressure flotation in round tanks has left something to be desired.

We have discovered that by causing the pool in which pressure flotation is conducted to swirl or circulate gently around a vertical axis, skimming the surface of the pool in the direction of the circulation, i. e. by a concurrent rotary motion around the axis, and admitting the charged suspension to the pool concurrently to the direction of swirl at a level below its surface, separation is greatly improved. In the preferred practice of our invention the surface of the pool is confined in an annulus, the admission is tangential to the flow lines in the pool, and the solids being buoyed up pursue an ascending spiral path.

The operation just described is preferably conducted in a round tank and in terms of apparatus, the invention contemplates a tank for holding the pool of the liquid, a trough for receiving scum disposed approximately radially in the tank adjacent the surface of the pool, skimming means disposed at the surface of the pool, and rotatable about a vertical axis in the tank to move the scum in approximately circular paths along the surface of the pool to the trough and also to set up a gentle circulation in the pool around the axis, and a distributor disposed approximately radially in the pool below the liquid level for discharging into the pool a gas-charged stream of the liquid containing the suspended solids, this discharge being accomplished at a plurality of points extending approximately radially in the tank and concurrently to the gentle circulation maintained in the pool around the vertical axis. This circulation is aided by the direction of discharge of the feed into the pool. If desired, it may also be aided by one or more impellers

2

mounted in the pool below the liquid level and rotating slowly around the vertical axis.

In apparatus of the type described the distributor which discharges the suspension into the pool preferably is located almost directly under the scum trough so that the solids will rotate almost one complete revolution in the ascending spiral from the distributor to the scum trough.

These and other aspects of the invention will be understood completely in the light of the following detailed description which is illustrated by the accompanying figures in which:

Fig. 1 is a diagram, partly in vertical section, showing a preferred form of the apparatus of our invention applied to the treatment of packing plant wastes.

Fig. 2 is a plan view, partly in section, of the flotation device of Fig. 1, particularly illustrating the scum trough and skimming means.

Fig. 3 is a horizontal section taken along the line 3—3 of Fig. 1 and showing the impeller employed in the bottom of the apparatus to move settled solids to a central discharge and at the same time aid in establishing the desired gentle rotary circulation in the flotation apparatus.

Referring now to Fig. 1, the waste 10 to be treated, say slaughter house effluent containing suspended or emulsified protein and fat, flows into a conventional catch basin 11. Considerable solids settle out in the catch basin and the waste flows are blended therein. A pool 12 in which settlement occurs is maintained in the catch basin and liquid containing fine suspended or emulsified solids overflows out of the pool over a weir or end wall 13 into a sump 14 having an emergency overflow pipe 15 near its top. From the sump the suspension of fine solids in liquid flows through a valved line 16 to the inlet or suction side of a vertical centrifugal pump 17. A valved drain line 18 connects the bottom of the catch basin to the pump inlet so that solids settled in the tank may be removed periodically, say during cleanout periods when the tank is flushed or hosed out. Another valved line 19 is connected to the suction side of the pump and contains a metering device 20. Flotation reagents, say alum, to aid in coagulation are added in controlled amounts through this line and meter. Air is added to the flow on the suction side of the pump through a valved line 21.

The pressure side of the pump is connected through a valved line 22 to the bottom of an upright cylindrical retention tank 23 provided with an upright baffle 24 over which the charged mixture from the pump must pass to an outlet line 25. The retention tank is closed at the top and maintained under pressure by the pump, but is provided with a valved air bleeder line 26 through which undissolved air may be bled off. A conventional back pressure control valve 27 is disposed in the outlet line from the retention tank and immediately in front of it another valved reagent feed line 28 is connected. This line, like the other reagent line ahead of the pump is provided with a metering device 29 so that the quantity of chemicals added to the pressurized suspension may be accurately controlled.

The charged pressurized suspension from which the undissolved air, if any, has been bled is fed continuously to a flotation machine 30. This machine comprises an upright cylindrical tank 31 having a flat bottom 32. A cylindrical baffle 33 is disposed concentrically in the tank and extends from above the level of a pool of liquid in the tank to a point more than half way toward the bottom. Between the baffle and the tank wall there is a relatively narrow annular space 34. The top of the tank wall proper is provided with a notched weir 35 over which clarified liquid flows from the annular space into a peripheral launder 36, the overflow being withdrawn through an outlet pipe 37.

A cup 38 is disposed within the annular baffle. The

3

upper portion of this cup is cylindrical and it extends above the liquid level in the tank, this level being established by the weir. The lower portion of the cup is an inverted cone 39 which is joined to the upper or cylindrical portion and terminates in a central bearing 40. This bearing is above the bottom of the first or annular baffle. The cup is surrounded by the pool, the upper surface of which is confined in an annulus between the baffle and the cup.

A bridge or superstructure 41 extends diametrically across the top of the tank and rests on the outside edge of the peripheral launder. This bridge carries a conventional motor drive 42 which slowly turns a vertical shaft 43. This shaft extends downwardly on the axis of the tank and terminates in an impeller structure 44 which extends clear across the tank just above the bottom. As shown in Fig. 3, the impeller consists of a straight arm 45 which extends diametrically across the tank and two curved blades 46 which carry resilient squeegees 47. The blades with the squeegees, which scrape across the bottom of the tank, are so shaped that when turned clockwise as viewed from above (see Fig. 3) they tend to move settled solids into a central well or pit 48 from which the settled solids may be withdrawn intermittently or continuously through a pipeline 49.

A scum trough 50 with its top just above the liquid level in the tank extends approximately radially from the cup to the annular baffle. The bottom of the scum trough slopes to the outside and terminates in a chute 51 which discharges into a hopper 52. The central shaft carries four radial arms 53 which extend horizontally above the level of the pool in the tank (see Fig. 2). Each radial arm has an extension 54 from which is hinged a skimming blade 55. This skimming blade is carried by a pair of arms 56 which pivot about the extension and swing in vertical planes. Stops, not shown, prevent the skimming blades from dropping down into the tank below the liquid level. Each skimming blade carries an inside wiper 57 and an outside wiper 58 which bear respectively against the cup and the annular baffle. As shown in Fig. 2, the shaft rotates clockwise and carries the four skimming blades around the pool surface to a ramp 59. The first portion 60 of the ramp slopes upward sharply, the second portion of the ramp 61 having a more gentle slope to a level above that of the liquid in the pool. The upper edge of the second ramp portion terminates at the scum trough proper. The skimming blades are prevented from dropping into the scum trough by slanted bars 62, 62A, which extend across the top of the trough and after passing across the top of the trough, the skimming blades descend a second ramp 63 until their bottom portions are again below the liquid level in the pool.

If reference is now made to Figs. 1 and 2, it will be observed that a distributor 64 is disposed almost directly underneath the second or rear ramp of the scum trough. This distributor consists of a box closed at its ends and on top and bottom and on its upstream side but open on the downstream side, i. e. in the direction in which rotation takes place in the tank. The distributor box is disposed radially between the cup and the outer baffle, the top of the box being level with the top of the conical portion of the cup. The box contains a horizontal distributor plate 65 which is fastened to the upstream wall. A nipple 66 projects into the bottom of the box at the central point and is fed by the pipe 25 which extends through the tank wall and the first or outer baffle.

A water-filling pipe 67 is provided for filling the tank from the top at the start of operations.

An example of the operation of the apparatus just described is as follows: The material treated is a liquid waste from a packing plant. This is fed into the catch basin which is large enough to give a detention time of at least thirty minutes at peak flows. The coarser suspended solids drop in the catch basin, but finer solids, including fats and a large proportion of suspended or

4

emulsified proteins, are carried over the weir into the sump. From this point this liquid suspension goes to the suction side of the pump, alum being added in small quantities continuously as a coagulant, together with compressed air. The amount of air added is controlled, an effort being made to add the amount of air which will just saturate the suspension at the pressure prevailing on the outlet side of the pump. At sea level and at a temperature of 70° F. water will dissolve approximately 2% of air by volume. At 15 pounds gauge pressure the air solubility is approximately 4%, at 30 pounds 6%, etc.

In passing through the pump the air becomes thoroughly churned into the water and this aids in its solution. In this manner the charged mixture is formed, any undissolved air being bled off in the retention tank. This retention tank should be large enough to assure that the suspension is maintained under the pump pressure for at least thirty seconds before being discharged into the flotation device.

After passing through the retention tank, additional reagents may be added if desired and then the charged suspension is introduced into the flotation machine through the distributor. The distributor is so constructed and disposed that the charged liquid flows concurrently with the gentle swirling or circulation brought about in the tank of the flotation machine by the action of the skimmers and the impeller at the bottom. Thus, as shown in Fig. 2, the flow lines of the entering charged suspension are approximately tangential to the flow lines of the circulating body of liquid in the tank. It will also be observed that the inflowing liquid enters across substantially the entire annulus within which the upper portion of the pool is confined.

The surface of the pool is maintained at atmospheric pressure and so the charged liquid entering the pool contains a higher proportion of gas than will remain in solution in the pool. In consequence, this gas comes out of solution as minute bubbles. These bubbles attach themselves to many of the fine particles in the suspension, which then begin to pursue a rising spiral path toward the skimming trough. This path can occupy almost 360° or one complete turn around the tank, since the distributor is almost directly underneath the scum trough. When the rising particles come within reach of the skimming blades, they are gently swept along the surface of the pool, up the ramp and into the scum trough. The upper portion at least of the body of liquid in the tank is swirling gently at slightly less than the rate of rotation of the skimming blades and impeller, so that the contact of the skimming blades with the particles which form the scum is a gentle one, there being little or no tendency for the particles once floated to lose their buoyancy and drop back.

Some of the heavier particles, however, are not floated by the minute air bubbles. These drop into the bottom of the tank to form a sludge which is raked or swept into the well and then withdrawn either continuously or periodically, depending upon the amount which settles.

Tests of an experimental installation of the equipment just described operating upon rendering plant wastes gave the following results.

Scum

	Moisture	Moisture Free Basis	
		Crude Protein	Crude Fat
	Percent	Percent	Percent
Test 1.....	90.75	23.88	59.7
Test 2.....	92.45	19.38	60.8
Test 3.....	89.4	19.38	58.5

5

Efficiency in fat and B. O. D. removal

	Total Fat		Percent Removal
	Influent, p. p. m.	Effluent, p. p. m.	
Test 2.....	3,830	270	93
Test 4.....	4,300	Nil	99+
5-DAY BIO-CHEMICAL OXYGEN DEMAND			
Test 4.....	6,800	470	93

In another operation conducted at a West Coast meat packing plant, the wastes from the killing and cutter operations only were treated. The results of this operation were as follows:

	Influent, p. p. m.	Effluent, p. p. m.	Percent Removal
Grease (ether-soluble).....	4,360	170	96
Suspended Solids.....	6,270	440	93
Biochemical Oxygen Demand— 5-day, 20° C.....	3,250	1,480	54.5

Above analysis indicates a recovery of 35# of grease per 1,000 gallons treated or a total of 1675# per 8-hour day.

In the foregoing operations the temperature of the suspension in the flotation tank was about 100–120° F. The pressure on the charged suspension just prior to its release into the flotation tank was 25–30 pounds per square inch gauge, so that the suspension contained about 6% air by volume. The retention time between the pump and the flotation machine was about one minute and in the flotation machine itself about fifteen minutes. The speed of rotation of the agitator and skimming mechanism was about 1/8 to 3/4 R. P. M. and the linear speed of the skimmer tips varied between 2 and 12 feet per minute. Alum was the only reagent employed. It was used in proportions of about 5 to 20 grains per gallon of liquid treated. Without the alum, removal of suspended solids dropped to about 70%.

It will be observed from the foregoing results that the separation accomplished in the apparatus is extremely good, and in fact superior to those obtained in elongated pressure flotation devices of heretofore customary design. The improved results are believed to be due to several factors, as follows:

1. The entire flow through the flotation machine is

6

concurrent, so that there is no opportunity for turbulence to develop.

2. The charged stream is introduced at a relatively low point in the pool so that there is ample time for the air coming out of solution to attach itself to particles and convey them to the surface in a long, gently ascending spiral path.

3. The skimming speed is only slightly higher than the speed of rotation of the liquid body rotating in the tank so that the skimming blades do not strike the scum particles violently and cause them to lose their buoyancy through loss of air.

We claim:

1. In pressure flotation apparatus in which solids suspended in a liquid pool are buoyed up out of the pool by gas coming out of solution therein to concentrate in the upper portion of the pool adjacent its upper surface, the combination which comprises an upright tank, a baffle disposed in the tank and having bottom and sides, the sides being spaced from the sides of the tank and the bottom being spaced from the bottom of the tank so that the upper portion of the pool is confined in an annulus while the lower portion of the pool underlies the bottom of the baffle, a trough disposed approximately radially from the tank sides to the baffle in the upper portion of the annulus, skimming means disposed across the annulus at approximately the level of the trough for moving floated solids into the trough, means for rotating the skimming means around a vertical axis passing through the baffle, and a distributor disposed approximately radially in the tank at about the level of the bottom of the baffle for admitting a gas-charged liquid stream containing the suspended solids into the pool in the direction of rotation of the skimming means.

2. Apparatus according to claim 1 in which the distributor is disposed substantially directly underneath the trough.

References Cited in the file of this patent

UNITED STATES PATENTS

864,856	Norris	Sept. 3, 1907
1,662,702	Hebden	Mar. 13, 1928
2,263,167	Dorr et al.	Nov. 18, 1941
2,324,400	Kelly et al.	July 13, 1943
2,418,950	Montgomery	Apr. 15, 1947
2,446,655	Lawrason	Aug. 10, 1948

FOREIGN PATENTS

659,978	Great Britain	Oct. 31, 1951
---------	---------------------	---------------