APPARATUS AND METHOD FOR CENTRIFUGAL PURIFICATION OF FATTY OILS

INVENTOR
Benjamin H. Thurman

BY HIS ATTORNEYS
Harris, Kiech, Russell & Kern
My invention relates to the purification of fatty or glyceride oils and more particularly to the removal of dispersed impurities or foots therefrom by steps which include rotating a mass of the impure oil or oil-foots mixture rapidly about an axis, which will be exemplified as horizontal. The invention will be particularly exemplified with relation to processing of a mixture of oil and foots stabilized by soaps or other emulsifying agents to separate the foots. The problem is particularly severe when separating soap-containing foots from fatty oils derived from seeds, beans or nuts, e.g., when removing soapstocks produced in the alkaline refining of such oils. Unless otherwise qualified the term "foots" is herein used in a broad sense and includes the gums to be separated in the degumming of crude glyceride oils by mixing water or dilute reagents therewith, the soapstocks produced and separated in the alkaline refining of crude or degummed glyceride oils, the color and other impurities made available for separation in the re-refining of glyceride oils, and the impurities precipitated or put into form for separation by difference of specific gravity in other known processes for purifying or deriving diverse products from glyceride oils.

There is known a centrifugal extractor in which the rotor turns about a horizontal axis and includes circular perforated bands mounted in concentric relation at different radial distances from the horizontal axis throughout the active internal zone of the machine. The concentric annular spaces between such bands are interconnected at intervals by openings or slots through the bands, these annular spaces and bands forming concentric stages. The lighter liquid is moved inwardly to traverse the slots in sequence. A heavier liquid, usually water or a solvent, flows outwardly from a position near the periphery to traverse the slots in opposite sequence. The liquids alternately mix in the slots and tend to separate by centrifugal force in the spaces between the bands. Such machines have enjoyed considerable success in liquid-liquid extractions. However, attempts to use them as centrifugal separators to remove foots or soap-containing impurities from oils, either by centrifugal action alone or as a result of a washing action combined with the centrifugal action, have not been satisfactory. This is particularly true as to attempts to remove alkali soapstocks stabilized by the soaps or other stabilizing agents therein.

In such band-type centrifugal extractors there is a mixing action at the location of each band, with a tendency to separate in the zones between the bands. Even at relatively low rotational speeds this mixing-separating sequence causes emulsification when processing oils containing normal amounts of soaps or emulsifying agents; also the effluent oil contains undesirably large amounts of residual foots or impurities. For example, attempts to remove alkali soapstocks or gums from high-gum or high-fatty-acid oils in the degumming or refining thereof often leaves 1500 p.p.m. or more of residual foots. To be commercial, the residual soaps must be reduced to a very low value, usually less than about 50–100 p.p.m.

I have found that slippage between the impure oil and such rotating circular bands is of particular significance in producing undesirable emulsions. It is an important object of the present invention to remove dis-persed foots or other impurities from oils by spinning a mass of the oil about an axis while avoiding substantial slippage between the mass and the adjacent surfaces. Another object is to rotate a mass of impure oil rapidly about an axis by pushing against the trailing edge of the mass while confining the mass against spreading in the direction of the axis.

A further object is to purify an oil between surfaces spaced from each other in the direction of the axis of rotation and to confine the liquids therein to turn at the rotational rate without such circular slippage relative to the surfaces as will cause sufficient turbulence to effect emulsification. Slippage can be eliminated by disposing outwardly extending barriers in circular zones between such surfaces and it is often desirable to use a plurality of such barriers in each circular space, dividing same into sectorial zones or spaces respectively containing sectorial masses rotating about the axis in a circular path, the leading edge of each sectorial mass being separated from the trailing edge of the next mass by a barrier.

Typically such circular zones can be formed between baffles or discs extending outwardly from the axis of rotation and spaced from each other in the direction of the axis, the resulting circular zone between each pair of baffles or discs being blocked by one or more outwardly extending caulkts or barriers extending between the spaced baffles or discs. It is a further object to substitute such baffles or discs for some or all of the concentric bands of order equipment to make the liquid within the rotor assume more closely the speed of the latter and thereby reduce the slippage which has heretofore induced emulsification; also to purify glyceride oils in such a structure by removing therefrom foots containing soaps or other troublesome emulsifying agents, the reduction in slippage being in the zones which otherwise would tend to create the troublesome emulsions.

It is a general object of the invention to separate foots from oils by whirling discrete masses of an oil-foots mixture rapidly around an axis in a space of substantial diametric dimension, typically at least 20 inches, said masses following each other in a circular path, and to impose purifying actions on each such mass during the rotation thereof and during continued supply of the oil-foots mixture thereinto. In this connection, it is an object of the invention to introduce the oil-foots mixture or impure oil into the rotating masses at an oil delivery position spaced a substantial radial distance from the axis of rotation, the rate of rotation being sufficient to centrifugally separate some of the impurities, leaving a partially purified oil which advances inward toward the axis through clarifying passages in which circular slippage relative to the bounding surfaces is prevented, thus reducing the tendency to emulsify the residual impurities or water in the partially purified oil. The initially and later centrifuged impurities or foots can be moved outward by centrifugal force to a peripheral zone from which they are removed, the impure oil or oil-foots mixture being delivered under sufficient pressure to cause the centrifugally separated foots to move inwardly toward the axis through the aforesaid clarifying passages, against the action of centrifugal force, to an oil outlet position.

Best results are obtained if the effluent flows of purified oil and impurities are throttled to maintain in the one or more masses a high supertanmospheric pressure.

This is of particular advantage in the processing of certain oils and in preventing liberation of gaseous materials within the masses which would tend to interfere with the desired separation, as by setting up surging. It is an important object of the present invention to supply the impure oil or oil-foots mixture under high supertanmospheric pressure to a series of zones or spaces rotat-
Still further objects lie in the provision of the novel processes and equipment hereinafter exemplified as suitable for practice of the invention and in other novel features that will be apparent to those skilled in the art.

Referring to the drawings, which show features of the process and several arrangements of equipment for practicing same:

FIG. 1 is a flow line diagram showing the principles of the process when employing a washing step; FIG. 2 is a vertical sectional view of a portion of the invention that can be used to create the flow patterns of FIG. 1;

FIG. 3 is a vertical cross-sectional view of the apparatus of FIG. 1, taken along the line 3—3 thereof;

FIGS. 4 and 5 are fragmentary vertical sectional views of a modification of the embodiment of FIGS. 2 and 3, FIG. 5 being taken along the line 5—5 of FIG. 4;

FIG. 6 is a vertical sectional view of alternative equipment and FIG. 7 is a vertical cross-sectional view taken along the lines 7—7 of FIG. 6, FIG. 6 being taken along the lines 6—6 of FIG. 7;

FIG. 8 is a fragmentary vertical sectional view of alternative equipment that can be used to produce substantially the same flows as in FIG. 6;

FIGS. 9 and 10 are fragmentary vertical sectional views of another apparatus for producing substantially the same flows as in the FIG. 6 equipment, FIG. 10 being taken along the line 10—10 of FIG. 9;

FIGS. 11 and 12 are likewise fragmentary vertical sectional views of still another apparatus for producing substantially the same flows as in the FIG. 6 equipment, FIG. 12 being taken along the line 12—12 of FIG. 11;

FIGS. 13, 14 and 15 are fragmentary views of alternative equipment, FIG. 14 being a transverse sectional view taken along the line 14—14 of FIG. 13, FIG. 13 being taken along the line 13—13 of FIG. 14, FIG. 15 being an enlarged fragmentary view showing the structure at the upper portion of FIG. 13; and

FIG. 16 is a generalized flow diagram representing the flows taking place in the embodiments of FIGS. 6—15.

In all of the above views, the apparatus is shown somewhat diagrammatically, often considerably expanded in the direction of the axis of rotation, and often with wall thicknesses increased inordinately to illustrate better the flow paths and the structure producing them. To those skilled in the art of designing the seals, influent and outlet arrangements, etc., of horizontal extractors and in the designing of mountings of internal components of centrifugal machines, the principles of the invention and the somewhat diagrammatic showings of the drawings will be clear and will guide in the design of commercial machines.

The flow diagram of FIG. 1 is illustrative of the invention applied in the refining of glyceride oils to remove fatty acids therefrom. Streams of the fatty oil and an alkali refining agent are respectively drawn from sources 15 and 16 thereof by proportioning pumps 17 and 18 driven at variable volumetric ratios by a device 19. The pumps are desirably of the high pressure type and deliver streams of oil and the refining agent to a junction 20 and thence to a mixer 21. The temperature of the streams can be adjusted by flow through respective heat exchangers 22 and 23 which can be by-passed by valve lines 24 and 25 if desired.

The mixer 21 and the equipment thus far described can be of any suitable type known in the art. The resulting mixture can be conditioned for the forthcoming separation by passing through a coil 28 which may be a part of heat exchanger 29 if further adjustment in temperature is desired and which can serve to condition the mixture by providing a suitable residence time therefor and/or such flow-induced turbulence as will uniformly distribute the solids or otherwise condition the mixture for separation in the manner to be described. In the example under discussion, the solids will be largely dispersed in the oil
and will comprise soaps and other impurities commonly present in alkali soapstocks. The soaps may be the result of reaction between an alkaline refining agent and the free fatty acids of the oil. In other instances the foots may be substances dispersed or dissolved in the oil, such as gums, coloring matter, etc., of the oil or products resulting from the reaction or association of the refining agent with components of the oil other than free fatty acids. The soaps and some of the other impurities are emulsifying agents.

While still at high pressure induced by the pumps 17 and 18, the oil-foot mixture is delivered as a stream through a flow restricting valve 29a to the liquid inlet (LLI) of a separator 30 of the type shown in FIG. 2. It flows outwardly (arrows 31) between surfaces rotating about a horizontal axis to an oil delivery position where upon discharge into a rotating zone the centrifugal force rapidly disperses much of the dispersed foots outwardly (arrow 32) to a peripheral zone to be described, leaving a centrifugally purified oil that is forced toward the rotational axis (arrows 34) to an oil outlet position from whence it flows axially from the rotor of the separator (arrows 35) through the liquid outlet (LOL) of the machine to a valve 36 which throttles the oil flow to maintain a high superatmospheric pressure throughout the centrifugal zones of the separator.

If the centrifugally purified oil (arrows 34) is to be washed as a part of the operation, a wash medium is withdrawn from a source 38 thereof by a high pressure pump 39 (which may be driven proportionally to the pumps 17, 18) and fed to the heavy liquid inlet (HLI) of the separator whence it flows axially (arrows 40) and thence discharged into the centrifugally purified oil at a wash discharge position, flowing outwardly (arrows 41) in counterflowing and washing relation with the centrifugally purified oil to the peripheral zone where it joins and dilutes the foots and moves inwardly therewith toward the axis (arrows 42) and then axially outward from the heavy liquid outlet (HLO) of the separator through a valve 44. The counterflowing of the wash medium through the centrifugally purified oil removes residual foots or impurities. At the same time, the wash medium dilutes or makes more flowable the centrifugally separated foots, facilitating their discharge.

The separator 30 may include a stationary housing 49 (FIG. 1) in which a rotor 50 turns at high speed, being driven through a shaft 51 by a drive 52 (FIG. 1) through any suitable connection 53. The rotor is shown as including two generally conical housing members 54 secured to the shaft and joined base to base by a curved section 55 within which is the peripheral zone, previously mentioned, indicated by the numeral 56. The rotor includes also two baffles or discs 57 and 58 secured to and extending outwardly of the shaft, being spaced from each other in the direction of the shaft axis to form a circular zone 60 therebetween. The discs 57 and 58 are substantially conical in this embodiment but their bases are not of equal diameter and are spaced to define a peripheral throat for the circular zone 60 for purposes to be described. The circular zone 60 may extend inward from such throat to the surface of the shaft 51.

The peripheral zone 60 contains cauls or barriers 61 spaced from each other around the inner periphery of the rotor. These are here substantially triangular members in planes radial to the axis of rotation and serve to prevent circular slippage of the separated foots and to facilitate pumping thereof from the rotor as suggested by the arrows 42.

The outer peripheral portion of the circular zone 60 likewise contains cauls or barriers 62 (FIGS. 2 and 3) forming a series of spaces or sectorial zones 63 arranged in a circular series around the shaft axis. The barriers are here flat radially disposed plates of substantially trap-}

---

The remaining text includes detailed descriptions of various components and their functions, likely related to the design and operation of a centrifugal separator for processing oil-foot mixtures. The text is technical and detailed, discussing the flow dynamics, pressure management, and the separation process. It also mentions the interaction of the oil-foot mixture with a wash medium to improve the separation efficiency. The separator includes a stationary housing with a rotor that rotates at high speeds, and the design involves multiple baffles and barriers to manage the flow and ensure effective separation. The text is a continuation of technical specifications and operational principles, essential for understanding the design and functionality of such separators in the context of processing and refining oil-foot mixtures.
surfaces of the baffles 57 and 58. The barriers 61, 62, 71 and 75 accomplish this result in the embodiment under discussion. A further purification can be effected by countercflowing water or other washing medium through the centrifugally separated oil which is being forced inwardly in the sectorial zone 63 and discharge the openings or slots 67. Here and hereafter this washing medium will be indicated as water for purpose of simplicity of nomenclature although it should be clear that the term comprehends any washing medium which is relatively immiscible with the oil and which is capable of associating with the residual impurities or foams to wash them from the centrifugally purified oil.

In FIG. 2, the water is forced through a pipe 80, as indicated by the arrows 40, and flows radially from a junction 81 through a plurality of radial pipes 82 discharging the water into one or more of the annular spaces 66, preferably a space not too far removed from the periphery of the shaft. In any instance, the water is introduced at a position between the oil delivery position, determined by the lip of the baffle 57, and the oil outlet position, determined by the openings 72. Three and preferably more open-ended pipes 82 are employed to distribute the water at different peripheral positions in one or more of the annular spaces 66. The bands 65 and their slots 67 give an opportunity for the centrifugally purified oil and the water to mingle and flow countercurrently, thus effecting a washing action. It is not always essential, however, to use the bands 65 as will be later evident. In the absence of the bands 65, the water can be introduced into the circular zone 60 between the baffles 57 and 58 at a larger number of positions, the barriers 62 being extended inward to a point beyond the water inlet position.

The water is thrown centrifugally outward as indicated by the arrows 41 and counterflows the inflowing oil, arrows 34, in the sectorial zones 63, exerting a further washing action. The water then reaches the peripheral zone 56 where it dilutes the foams and facilitates forcing of the latter from the machine. The outflow of water through the transition zone 78 is concurrent with the outward movement of the foams therein and is beneficial in aiding the separation taking place therein. If direct dilution of the foams or impurities is desired, one or more of the radial pipes may be extended to discharge water or dilute directly into the peripheral zone 56, see the pipes 82 of FIGS. 2 and 3 which can be used here or in the other structures herein suggested.

FIGS. 4 and 5 show a structure closely related to that shown in FIGS. 2 and 3 but making provision for additional sectorial zones, usually narrower in the direction of the axis of the shaft than in the structure of FIG. 2. In this structure, the conical discs 57 and 58 are supplemented by flat discs 85 in the circular zone 60 therebetween. The flat discs 85 are spaced from each other in the direction of the rotational axis and provide sectorial zones 86 therebetween divided into sectorial spaces 87 by radial caulk or barriers 88 (FIG. 5). In this embodiment the concentric cylindrical bands 65 are disposed farther from the axis than in FIGS. 2 and 3 to occupy all or a part of the aforesaid transition zone 78. Three of such bands are exemplified in FIGS. 4 and 5 and designated as an inner or distributor band 65A bridging the supply passage on and extending forwardly by the discs 57 and 58, an intermediate band 65B extending leftward to traverse the supply passage 70 and guide the oil-fouls mixture into a delivery space between the bands 65A and 65B, and an outer band 65C likewise bridging between the housing member 54 and the baffle 58. Each of these previously described bands has the openings or slots 67 previously described, those of the inner or distributor band 65A opening directly on the circular zones 86 and their component sectorial spaces 87 formed between a central group of the flat discs 85. The circular and sectorial zones to the right and left of such central group receive liquids from and discharge liquids into the zones of the central group through openings 90 in the discs 85. As before, openings 72 in the shaft deliver the purified oil to the interior of the hollow shaft 51. If a water wash is desired, the stream 91 radiates from the pipe 80 into each of the circular zones between the flat discs 85 of the central group. Preferably there should be at least one pipe 91 or water discharge orifice in each sectorial space 87, preferably more.

In the embodiment of FIGS. 4 and 5 the incoming oil-fouls mixture is delivered to the interband spaces for initial separation but otherwise the flow pattern is similar to that in FIGS. 2 and 3. The barriers 61 and 88 prevent circular slippage. If desired the barriers 61 or 88 may be extended radially to traverse and block the interband spaces but the adjacency of the barriers 61 and/or 88 in the position shown is often sufficient to prevent such circular slippage between the liquid and the bands in the interband spaces as would otherwise cause undesirable emulsification.

FIGS. 6 and 7 show a modified flow pattern and arrangement of baffles and barriers better suited to the invention. Here a plurality of flat baffles 108 are mounted on the shaft 51 at positions spaced along the axis of the shaft to provide circular zones 102 therebetween. Substantially impervious caulk or barriers 104 extend outward from the shaft to divide each circular zone into a peripheral series of sectorial zones 106 best shown in FIG. 7. The barrier 104 pressing against the trailing edge of the sectorial zone 106 is the leading edge of the sectorial mass to the rear thereof, as is true also as to the barriers 61, 62 and 88 in the embodiments previously described.

The oil-fouls mixture advances outward through a narrow circular space 107 between the end wall of the rotor housing and a manifold structure 120 to be described, this space having radial-rib baffles 107A as previously described to bring the mixture up to shaft speed and maintain it at such speed as it discharges out a peripheral extension of the manifold into zone 125 at a delivery position spaced a substantial distance from the axis of rotation albeit short of the peripheries of the baffles 108. The mixture thus discharged enters a plurality of closed-ended pipes 109 respectively traversing the sectorial zones parallel to the shaft and providing one or more openings 109 communing with each zone. These openings may face in any direction but I prefer to face them inwardly or dispose them in the inner half of each pipe. The open ends of the pipes 105 can be threaded into the end baffle 106 to open on the zone 125. As before, the rods are rapidly centrifugally separated and are thrown outwardly to a peripheral zone 110 immediately within a cylindrical peripheral wall 111 of the rotor, equipped with the aforesaid barriers 61 to prevent circular slippage. A disc 112 rotating with the shaft provides a peripheral edge 113 disposed close to the peripheral wall 111 of the rotor. The distance between this peripheral edge and such wall 111 is less than the distance between the peripheries of the baffles 108 and the peripheral wall so that the edge 113 extends into the body of the baffles in the peripheral zone 56, forming a seal and determining the position at which the foams are withdrawn therefrom. The edge 113 is covered by or submerged in the annular body of foams to prevent oil spilling over into the stream of foams that is forced inwardly along a space 114 between the end of the rotor housing and the disc 112, reaching the effluent chamber 77 previously described. The space 114 may have radial-rib baffles 115 as previously described to keep the heavy effluent up to rotor speed.

As before, the centrifugally purified oil flows inwardly in each sectorial zone 106. It reaches oil outlet positions determined by the shaft perforations 72 and flows thence to the effluent chamber 73.

Water is likewise delivered to each sectorial zone 106.
at a position between the oil delivery position and the oil outlet position thereof. This is accomplished by a plurality of pipes 116 respectively traversing the sectorial zones at positions radially inwardly of the pipes 108. Each pipe has one or more openings 117 communicating with the corresponding sectorial zone. These openings may face in any direction. The water issuing therefrom counterflows the centrifugally purified oil in the annulus or annular counterflow zone between the pipes 108 and 116 as previously described and reaches the peripheral zone 119 after flowing concurrently with the centrifugally separated solids in the annulus or annular zone between the pipes 108 and the peripheral zone.

The water is supplied to each of the pipes 116 from the manifold structure 120 having a radial passage 121 receiving the water from a passage of the shaft 51. One end of each pipe 116 is threaded into the manifold structure 120, the other end being closed. The oil-fouts mixture may likewise be delivered if desired to each of the pipes 108 through an appropriate manifold equipped with the aforesaid radial-riff baffles. However, it is simpler to conduct it from the supply chamber 69a through a shaft passage and thence outwardly in the rib-baffled space 107 between the manifold structure 120 and the rotor housing to the zone 125.

In the embodiment of FIG. 8, another disc 129 cooperates with the manifold structure 120 to form a passage 130 which conducts the oil-fouts mixture to the zone 125 between radial baffles 131 constructed as previously described. However, in this embodiment the pipes 108 are eliminated, the oil-fouts mixture flowing through the openings 152 of the baffles which previously received the pipes 108 in the embodiment of FIG. 6. The end baffle, indicated by the numeral 109 in FIG. 8, contains no such opening. The water is introduced into the respective sectorial zones 106 as previously described.

FIG. 8 suggests an alternative method of withdrawing the fouts from the peripheral zone 110. Instead of moving them inward to the shaft through a passage between the end baffle 109 and the adjacent rotor housing member 135, this member 135 provides a series of openings 136 at one or more radial positions usually about 1-4 inches from the inner periphery of the wall 111. The fouts moving over the periphery of the end baffle 109 move inward only to these openings, flowing thereafter into the interior of the stationary housing 49 of the machine. The fouts drop therein to a well 139 at the bottom of the housing, either through spaces between the rotor and the housing or along the inner diameter of the housing, being withdrawn through a pipe 140. This method of withdrawing the fouts from the rotor may be employed in the other illustrated embodiments as a substitute for providing a passage conducting them to the shaft at a position within the rotor.

The embodiments of FIGS. 9-12 differ from those previously described in FIGS. 6 and 8 primarily in the method of introducing the oil into the several sectorial zones 106. In the embodiments of FIGS. 9 and 10, radial pipes 148 extend outward in each sectorial zone 106 from the manifold structure 151 with the shaft and forming an annular manifold space 151 around the axis thereof. The annular manifold space 151 opens on the supply chamber 69a. The inner end of each pipe 148 may be threaded into the pipe 150, the outer end being closed, the impure oil being discharged at the oil delivery position just inward of a plurality of orifices 152. If the diameter of each pipe 148 is large, the impure oil is discharged in the baffles 109, the orifices 152 may face outwardly of the pipe 148 in all directions, otherwise the orifices will face in fore and aft directions. The water is suitably supplied to a passage 154 of the shaft and flows outwardly to the manifold structure 120 through nipples 155 traversing the manifold space 151. Similar nipples 157 conduct the purified oil from the inner end of each sectorial zone 106 to a passage 158 of the shaft for restricted discharge as previously defined. Radial-riff baffles 159 are present in the space 160 through which the separated solids move toward the outlet shown and the baffles 61 previously mentioned are disposed in the peripheral zone in which the separated solids collect.

To increase the contact between the water and the centrifugally purified oil in each of the embodiments employing sectorial zones, the water may be delivered to the respective zones at a larger number of positions at the same radius. For example, in the embodiment of FIGS. 9 and 10, the number of pipes 116 may be increased so that more than one pipe traverses each sectorial zone. In addition, the number of the inner ends of each pipe discharging into any particular sectorial zone may be increased to jet additional streams into the rotating sectorial mass of oil.

The embodiment of FIGS. 11 and 12 differs from that of FIGS. 9 and 10 in combining the pipes 148 and the bafflers 110. In this connection, the pipes 148 can be of such external dimension as to bridge and space the baffles 109 in which event these pipes may perform the combined function of supplying one of the influent liquids and dividing the circular zone between adjacent baffles into the aforesaid series of sectorial zones. In FIGS. 11 and 12, the inner ends of the pipes 148 may be threaded into the pipe 150, as before, to communicate with the annular manifold space 151. At the desired delivery position, each pipe 148 may provide openings 165 facing two sectorial zones separated by the pipe. The purified oil can be withdrawn through the nipples 157 previously described. It is even possible to use alternate pipes 148 of any circular series to discharge the oil-fouts mixture and the remaining pipes to withdraw the purified oil if the oil withdrawal ports of the latter are positioned closer to the axis and if the inner ends of said alternate pipes communicate with the annular manifold space 151 and the inner ends of the remaining pipes communicate with the passage 158.

The embodiment of FIGS. 13-15 is related to the embodiment of FIG. 6 but differs primarily in the construction near the periphery of the rotor. The oil-fouts mixture is pressured to flow outwardly in the space 157 between the radial-riff baffles 109a around a peripheral extension of the manifold structure 120 as previously described. However, this peripheral extension here terminates in a peripheral lip 180 disposed only a short distance inside the inner peripheral wall 111 of the rotor. The lip 150 is opposite the delivery space 140. Inner and outer bands 185 and 186, of the type of the bands 65 previously described, having openings or slots 188 and 199 which are preferably out of radial alignment with each other at least to the degree suggested in FIG. 14. These bands form a part of the rotor and can be attached between the disc 112 and the disc-like extension of the manifold structure 120. As shown, the band 185 is thus mounted in a position at the periphery of the baffles 109. The band 186 is shown as extending between the disc 112 and the radial-riff baffles 109a, which may form a part of the manifold structure 120.

Caulks or barriers 184 divide each interdisc circular zone into a peripheral series of sectorial zones 106 as previously described. In addition caulks or barriers 190 desirably though not necessarily traverse the interband space 184 at spaced peripheral positions. These positions may be opposite the ends of the caulks or barriers 104 and in fact may be less than the peripheral position. However, the barriers 190 are attached to one or other of the bands 185, 186, preferably the inner band, and extend parallel to the rotational axis of the rotor. Barriers 61 are disposed in the peripheral zone as previously described. The orifical bands 185, 186 may be closely spaced, typically not more than one inch. For example, in a rotor having a diameter of 34", the outermost band 186 may be spaced inside the wall 111 about.
3,027,390

11

¼", the bands 185, 186 being about 1" apart, the lip 180 being substantially at a midpoint therebetween.

In this embodiment, as in FIGS. 4 and 5, the interband space 184 acts to distribute the incoming oil between the various sectoral zones 156 and to effect an initial separation of the impurities. Thus, the impure oil flowing over the lip 180 enters the delivery space provided by the interband space 184, this space being a sectoral space periodically blocked by the baffles 190 to avoid any emulsification of the impurities due to rotational slipage. As the consequence of the high rotational speed, the impurities start immediately to separate, being thrown outward through the orifices or slots 189 of the outer band 186 as suggested by the arrow 193 of FIG. 15 to the peripheral zone 110 along which they flow in the same direction as the flow of the mixture in the interband delivery space 184. The pressure on the incoming oil forces the thus partially purified oil inwardly through the orifices or slots 185 of the inner band 185 as suggested by the arrows 194, this oil being thus distributed to and further purified in the sectoral zones 166 both by the additional centrifugal action tending to separate residual impurities and by the multiple-port injection and counterflow of water previously described. It is desirable that the water be introduced into the oil at a large number of points to secure better distribution and contact with the oil. As shown in FIG. 14, this result may be accomplished by increasing the number of pipes 116 of distributing the water from the manifold structure 129, two such pipes being shown in each sectorial zone with their openings 117 directed laterally as distinct from inwardly or outwardly. The same arrangement may be used in other embodiments to increase the contact between the wash medium and the oil. The washed oil enters the hollow shaft 51 through the openings 72 as previously described.

In the embodiment of FIGS. 13-15, the peripheral zone 110 lies essentially between the outermost band 186 and the inner peripheral wall 111 of the rotor housing. The peripheral edge 113 of the disc 112 terminates in this peripheral zone 110 as suggested in FIG. 15, the separated footings thereover and into the space 114 equipped with the aforesaid radial-rib baffles 115 which serve to keep the footings up to speed and to facilitate their removal from the rotor through the shaft passage and the effluent chamber 77 as previously described.

The caulked or barriers 62, 68 or 104 of FIGS. 4-15 are preferably quite narrow, being almost always no more than 1" in width and usually of a width of about ¼-½", the width determining the spacing of the baffles between which the barriers extend. It will thus be apparent that the baffle spacing in FIGS. 4, 6, 8, 9, 11, and 13 is considerably exaggerated and that the axial length of the corresponding rotors is quite small, much less than that actually shown, or that the number of baffles will be substantially increased with the axial lengths suggested.

FIG. 16 shows the general flow patterns that take place in the embodiments of FIGS. 4-15. In addition, FIG. 16 shows a valve 205 beyond the pump 39 for the wash medium and illustrates this pump as being driven at a speed proportional to the pumps 17 and 18 through a connection 206 with the device 19, the arrangement being such that the volumetric ratios between the pumps 17, 18 and 39 are variable.

From the above the primary steps of the processes of the invention and the manner of performing them in any of the separators 30 described above or in separators of related design will be readily apparent. Several features should, however, be emphasized and further discussed as follows.

In this connection if the process is performed in separators types disclosed herein, extremely high throughput can be obtained. They can be made to provide relatively open or large inlet and outlet ports within the rotating portion of the machine which avoid restrictions or blockages which tend to form in some commercial centrifuges when processing certain oils such as high-loss vegetable oils. While the invention is not limited to the use of horizontal machines, these currently have the advantage that the size of equipment necessary to perform the process is greatly reduced. They can be permanently closed machines, requiring no disassembly for cleaning as do conventional vertical machines. Cleaning can be effected by backflowing a cleaning fluid through the machine under pressure.

It is desirable that the water or other washing medium be introduced into the oil containing residual footings under turbulent conditions in a mixing zone, and that the introduction be at a plurality of positions 104 to induce a mixing turbulence or to discharge the water or washing medium into an already turbulent oil at a plurality of distributed positions or both. Discharge into narrow channels or between closely spaced surfaces is likewise desirable. At the same time, it is desirable that the pressured oil flow inwardly from the mixing zone toward the rotational axis smoothly and in substantially laminar or non-turbulent flow, typically at a flow having a Reynolds number under about 2000, in an annular clarifying zone inwardly of the outlets of the pipes 82 of FIGS. 2-5 or the outlets of pipes 116 of FIGS. 6-13.

The use of the described caulked or barriers in this inner annular zone is of importance in this connection and in preventing circular slippage of the liquid relative to its bounding surfaces. Also in the mixing zone it is desirable in the preferred practice of the invention to reduce or eliminate turbulence caused by circular slippage of the oil-foot mixture or the oil-foot-water mixture relative to the passage-bounding surfaces which confine such mixture. This can best be accomplished by the caulked or barriers 62, 68, 104 and 190 as described. If the barriers 190 in the embodiment of FIGS. 13-15 are eliminated, the closely adjacent barriers 104 between the baffles 180 will accomplish this purpose in a measure.

This is particularly true if the radial depth of the outer annular zone or transition zone between the body of footings in the peripheral zone and the delivery position of the oil-foot mixture is shallow. Radial depths of the barriers up to about 5 inches or about 1½ of the radius of the peripheral wall 111 have been successfully used in embodiments similar to FIGS. 13-15.

In practicing the processes of the invention the footings collecting in the peripheral zones of any of the described machines is often quite viscous and can be separated from the machine only because of the caulked or barriers 62 or those indicated at 62 or 104 if the barriers 61 are not used. Any of such barriers 61, 62 or 104 act as the vanes of a centrifugal pump to build up or increase the centrifugal pressure that is effective in discharging the separated footings as a stream from the machine. Using the caulked or barriers 62 or 104 it has been shown that the process is successful in discharging viscous footings that could not be discharged in the absence of such caulked or barriers. The use of the barriers 61 in the peripheral zone improve the process further in this respect.

In these connections, the process has successfully separated very viscous soapstocks in the alkali refining of glyceride oils, even without the water washing step. However such introduction of water is further beneficial not only in effecting a washing of the oil and producing an effluent oil that is clear and contains far less impurities but also in reducing the viscosity of the soapstock by dilution thereof. In this latter respect reliance can be placed on the counterflow wash medium or any of the embodiments can be equipped with devices like the pipes 82' for delivering some of the wash medium directly to the peripheral zone containing the separator.

Introduction of water into the partially purified oil also has other far reaching advantages. It will usually be found that the operation is smoother and more stable.
if the water or other washing medium is supplied to the equipment. The quality of the oil will be improved inasmuch as it will contain less foreign matter and usually will be clearer. In the refining of glyceride oils, additional water or other washing medium has made it possible in many instances to use less alkali reagent or alkali solutions of lower concentration. Finally, the invention has made it possible to employ much less water than would be needed or conventionally used in other processes where the water was mixed with an oil from a first centrifugal separation and separated in a separate centrifuge. In such operations it is common to employ 15-30% water while in the present invention the amount of water can be reduced to about 0-15%.

It is a feature of the invention that the processes performed in the machine can be effected in the presence of high supratmospheric pressures throughout the internal flow pattern. Thus, when pressures of 50-150 p.s.i. or more can be used with efficient pressures, created by the throttling action of the valves 36 and 44, of 10-150 p.s.i. to keep all of the materials in the liquid phase and in a condition facilitating separation. This is of particular importance in refining oils with volatile alkalis such as ammonia or with low excesses of soda ash with or without small amounts of caustic where CO₂ may tend to be released. Internal pressures of about 75-150 p.s.i. are desirable in such instances. High internal pressures also aid in maintaining the uniform efficient flows of which the invention is capable and which are to be distinguished from the surging or uneven flows that have been encountered in some other processes.

The high internal pressures discussed above are minimum pressures and are over and above the centrifugally induced pressures. In machines of a rotor diameter of about 30 to 48 inches driven at speeds of about 800 to 3000 r.p.m., values of g will be about 1100 to 3500. It is desirable that the invention employ rotors of a diameter of at least 20 inches, preferably more, as this diameter is usually required to give sufficient radial depth to the annular counterflow zone and to position it in the outer half of the radius as is usually desirable.

Dimensional relationships are to various extents critical in the practice of the invention. Thus it is desirable to employ equipment of sufficiently large diameter to provide adequate room for distinct flow patterns of the type outlined. The equipment should have sufficient internal radial dimensions to establish distinct zones for the operations performed and to maintain therein distinct bodies or strata of the materials undergoing treatment. Generally, it is desirable to employ a rotor of a diameter of at least 20", although rotors up to 60" diameter are feasible. Bowls of conventional vertical centrifuges do not exceed about 15" diameter. The larger diameters here contemplated not only permit use of lower speeds to obtain the same g but, more importantly, give sufficient radial space to form distinct annular zones. Such zones include the aforesaid peripheral zone (in which the centrifugally separated solid is collected), the transition or outer annular zone immediately inside the peripheral zone and extending inward to the oil-feet delivery position (in which zone most of the feet separate centrifugally from the oil and in which the wash waters concurrently with the feet), the annular wash or counterflow zone extending inward from the oil-feet delivery position to the wash medium-discharge position (in which zone the wash medium-counters the oil parts purified by centrifugal action), and the annular clarifying zone extending inward from the wash medium-discharge position toward or to the oil-feet outlet (in which clarifying zone the residual feet and wash medium are centrifugally separated while there is no circular slippage relative to the confining surfaces). The radial depth of the peripheral zone is usually of the order of an inch or less, typically about 2-6% of the rotor radius but may be more. The radial depth of the transition or outer annular zone is not unduly critical but is usually about 1-6", typically about 4-20% of the rotor radius. The radial depth of the annular wash zone is likewise not critical and may vary from a major part of the rotor radius to a small but significant fraction thereof, being most commonly in the range of about 5-70% thereof or about 1-15 inches. In somewhat similar manner the radial depth of the annular clarification zone can range from a major part of the radius to a relatively small but significant fraction thereof, ranging usually about 10-70% thereof or about 2-15 inches. These ranges are, however, merely exemplary of best practice and it should be clear that under some circumstances the methods of the invention can be successfully practiced with deviations from such ranges, which are given as guides in which the best operating conditions will be found.

As concerns the alkali refining of glyceride oils, the invention has solved the problem of separating the viscous soapstocks often produced. It has also made possible the washing of the oil as it is being centrifugally separated from the soapstock in the rotating machine. If the invention is operated in accordance with the principles herein taught the soapstock is separated cleanly from the oil, mainly in the aforesaid transitional zone at or near the oil-soapstock-delivery position which zone should be kept near the periphery of the rotor. Washing of the partially purified oil takes place in the aforesaid annular wash zone. It is a feature of the invention that these zones are maintained in their relative positions and conditions, resulting in a stable operation heretofore impossible. In one of the zones the separation of soapstock from the oil takes place directly. In the other of the zones the separated oil is effectively washed for a significant period without emulsification. In this respect, there is no emulsification of the oil with the separated soapstock or vice versa in the transitional zone nor is there any emulsification of the water with the oil in the wash zone.

The success of separating the soapstock from the oil and washing of the oil in the same rotating zone is dependent upon having stable conditions whereby the zones are maintained without emulsification. Attempts to perform these operations in band-type horizontal machines equipped with the baffles and the caulk or barriers used in the invention have not been successful because of emulsions that resulted from the over-mixing of the oil with the countercurrent wash water, and from the emulsification of oil with the soapstock near the oil-feet delivery position when no countercurrent water was used. The construction herein described eliminates this emulsification and induce stable conditions whereby the aforesaid zones are maintained without emulsification.

From a theoretical and practical standpoint, the conditions best suited for separation of feet from oil would not be the same as the conditions best suited for a water washing operation. Nevertheless, by use of the principles herein outlined it has been found possible for the first time successfully to combine these operations in a single rotational unit, thus greatly simplifying the processes and the equipment needed for handling the streams. The process conditions are ideal for expelling the foot continuously and producing an oil of clarity and purity not heretofore obtainable from any centrifugal machine. The following is an example of the invention employed in the ammonia refining of a crude non-degummed soya oil containing 0.6% free fatty acids and which was normally to be refined by use of a 14% solution of ammonia in accordance with prior practice. The equipment included a separator with a 17 inch radius rotor equipped with the baffles and baffles of the invention, rotating at about 2200 r.p.m. The oil was continuously mixed with a 10% aqueous solution of ammonia by proportioning the mixing equipment suggested in FIG. 1, items 17-20 inclusive, the oil temperature being about 146-158° F. The mixer 21 was a vertical paddle-type mixer and the ammonia
was used in amount about five times that theoretically required to neutralize the free fatty acids. The temperature was increased to about 161-168° F. in the coil-type heat exchanger 29 and discharged through the valve 36 at about 150-154° F. The influent oil pressure was about 115-125 p.s.i., and the effluent oil pressure about 100-110 p.s.i. all when no water was supplied by the pump 39. The heavy liquid effluent or soapstock was dark brown and quite viscous but flowable and discharged continuously from the equipment. The oil was normally clear. Under these conditions about 5% by weight of the oil of fresh heat water was then pumped into the process by the pump 39. The oil effluent became clearer, the soapstock thinned out and the operation became generally smoother. The influent oil pressure was about 87 p.s.i. and the effluent oil pressure about 73 p.s.i. The free oil, dry basis, in the soapstock was about the same as when no water was added, evidencing the lack of emulsification of the water and soapstock in the machine. When the water was being added, the oil effluent contained about 60% less ammonia, free and combined, than when no water was added and had about .088% free fatty acids as compared with about .11%. Conditions best suited for the ammonia refining or degumming of glyceride oils will be as follows.

Solution strength will normally be about 7-14%. Amount of solution will be up to about five to seven times the amount that would be required theoretically to react the free fatty acids of the oil. In an ammonia degumming operation the amount of ammonia can range from a small amount, e.g. about 1.5 to 3.0% of 0.5% ammonia by weight, representing only about 1-5 times that corresponding to the free fatty acids of the oil, up to an amount of ammonia equal to that corresponding to such acids.

The temperature of mixing will usually be about 90 to 160° F. but lower temperatures can be used. Influent temperatures to the separator will normally be about 130 to 190° F. Influent and effluent pressures will be within the ranges previously set forth. The ammonia soap content of the separated oil will be some 60-90% less than when no water was used. The amount of water pumped into the separator will normally be about 3-10%.

The invention is excellently suited to the refining of glyceride oils containing relatively small amounts of gums or soaps. For example, it is excellently suited to the refining of vegetable oils resulting from commercial processes in which nonsaponifying alkalins (soda ash, ammonia, etc.) have been employed in the primary refining step, these oils still containing residual soaps and color impurities that are desirably removed in a re refining step. Such refining involves a treatment with caustic to remove color impurities, residual phosphorus-containing compounds, etc.

By way of example, a soda ash refined cottonseed oil, cooled to 90-100° F., may be mixed with 1.5% of 24° Bé. caustic, put through a suitable mixer and advanced through a coil where the mixture is heated to about 140-180° F. flowing then into one of the machines hereinbefore described. About 12% of water is injected counter current from a system having a large number, typically at least 25 and preferably more, small holes spaced equally around the circumference. In the example being considered, the water discharged at points 39° F. closer to the shaft than the positions from which the oil-foots mixture is displaced. The water temperature was 155° F. The operation was smooth and the soap content of the washed oil was reduced to 40 p.p.m. The operation was successful even without the use of a flush in which water is introduced directly into the feet in the peripheral zone, as through the pipes 39 as previously mentioned. The phosphoric content of the resulting oil was 2.0 p.p.m. and in some in some instances processes of this type can reduce the phosphoric content to less than 1.0 p.p.m. These results indicate the production of a high quality oil that is at least equal to that obtainable in commercial refining employing concentrated caustic and utilizing a single or double water-washing step employed as a separate operation. In the example under discussion, the feet displaced as a clear liquid with no trace of emulsified oil.

The refining loss was only 0.4%.

As another example of such refining by use of the present invention, the soya oil produced in the first example mentioned above was processed by the invention by mixing therewith about 1.5% of 20° Bé. caustic solution at a temperature of about 112-116° F., the mixture being delivered to the separator 30 at a temperature of about 150-189° F., discharging from the equipment at a temperature of about 160-168° F. after equilibrium was reached. The influent oil pressure was about 72 p.s.i. and the effluent oil pressure about 78-86 p.s.i. About 10% of water was pumped into the equipment and served to counterflow the oil from which some of the feet had been removed, this water reaching the peripheral zone to dilute the feet-containing caustic solution forming the heavy effluent, tending to prevent graining out of the soap and other undesirable actions taking place in the absence of the water.

The heavy effluent liquid discharged smoothly from the machine. The treated oil contained only 80 p.p.m. of residual soaps. Attempts to process this oil in an extractor-type machine equipped exclusively with perforated concentric beds produced emulsification of the water and the oil to such an extent that the operation was not practical because of the presence of too much feet in the separated oil and too much emulsified oil in the effluent feet.

The invention is also well suited to the caustic refining of degummed oils, of which the following is an example. A degummed crude soya oil was mixed with 20° Bé. caustic soda solution in the usual excess and introduced into a 34-inch diameter machine at a position about 16° from the axis. About 10-17% of water was introduced into the machine at a large number of points spaced slightly over 12" from the axis. The temperature of the influent mixture was about 160-180° and the purified oil effluent about 134-144° F., respective pressures being 79-82 p.s.i. and approximately 62 p.s.i. The operation was very stable and no emulsions were formed. The purified oil had a residual soap content of approximately 3 p.p.m., and it was found that the residual soap decreased substantially with an increase in the number of water outlets.

The above results were obtained with the machine rotating at 2100 r.p.m. Other runs in which the speed was raised stepwise from 1200 r.p.m. to 2100 r.p.m. gave similarly good results.

The invention is generally applicable to the degumming or refining of high free fatty acids oils and high gum oils as well as low free fatty acid and low gum crude oils. The presence of large amounts of free fatty acids and/or gums does not defeat satisfactory operation in accordance with the present invention because of the decrease in emulsifying tendencies in the presence of soaps or emulsifying agents.

In a related field, the invention is also applicable to the countercurrent washing of acidulated soapstock. It has heretofore been the practice to acidulate separated soapstock from prior processes by mixing therewith large amounts of sulfuric acid and allowing the mass to settle. Such settling produces an intermediate layer which is usually discarded along with the lower layer of acid water.

According to the invention, soapstock is continuously mixed with the acid and, without intervening settling, pumped into the separator 30 to which water is fed by the pump 39. This water washes out the residual mineral acid and other water soluble impurities while chemically producing an unusually good separation of the products. The process also removes materials preferentially water washable, e.g., glycerides and meal particles which are removed as a part of the heavy phase effluent.

Various changes and modifications can be made without
departing from the spirit of the invention as defined in the appended claims.

I claim as my invention:

1. A process for removing feet from a mixture of glyceride oil and feet containing emulsifying agents, which process includes the steps of: delivering a stream of the mixture of glyceride oil and feet to a space at a delivery position spaced radially from an axis while rotating said space about said axis at an angular rate sufficient to throw said feet outwardly leaving a partially purified glyceride oil, said feet being moved outwardly by centrifugal force toward a peripheral zone, the said mixture being delivered to said space under sufficient pressure to force said partially purified oil toward said axis; and continuously withdrawing a stream of the centrifugally purified oil and a stream of feet from said peripheral zone at such rates as to maintain a body of feet in said peripheral zone while throttling each of such withdrawn streams to maintain superatmospheric pressure throughout said rotating space.

2. A process as defined in claim 1 in which said stream of said mixture is delivered to said rotating space at said delivery position by first delivering such stream under pressure to one side of said rotating space at a position near said axis and, and conforming the material of such stream to flow outward to said delivery position as an axially-narrow outwardly-diverging stream surrounding said axis while conforming such axially-narrow stream to move at said angular rate during such outward flow.

3. In the process for separating feet from a mixture of glyceride oil and feet subjected to emulsion formation subject to substantial turbulent forces the steps of: delivering a stream of the mixture of glyceride oil and feet to a space and discharging the same into such a space at a delivery position spaced radially from an axis while rotating said space about said axis at an angular rate sufficient to throw the said feet outwardly to a radially-narrow peripheral zone spaced at least about 10 inches from said axis and producing a partially purified oil, the stream of oil-feet mixture being delivered to said space under sufficient pressure to force said partially purified oil toward said axis; causing said partially purified oil in the direction of said axis through a plurality of narrow substantially-radial passages disposed side by side in the direction of said axis having inner effluent portions relatively close to said axis and outer portions terminating in an annular zone between said peripheral zone and a central axis having a radius slightly less than that of said delivery position while blocking circular slippage of the partially purified oil in such passages, the partially purified oil being further centrifugally purified during flow through said passages; continuously withdrawing the further centrifugally purified oil from said effluent portions of said passages; and continuously withdrawing a stream of said feet from said peripheral zone at such rate as to maintain the body of feet therein of substantially constant depth from time to time, such depth being measured radially of said axis.

4. A process for producing from a mixture of glyceride oil and feet in a single operation a centrifugally purified and washed glyceride oil by use of a circular zone closed pressurally from the atmosphere bounded by a peripheral wall concentric with an axis and of a diameter at least about 20 inches, which process includes the steps of: delivering said mixture of glyceride oil and feet to said circular zone at a plurality of mixture-delivery positions disposed in a circle having a radius less than said peripheral wall, said circle being at a first radial distance from said axis; rotating said circular zone about said axis at an angular velocity sufficient to throw said feet centrifugally outwardly through an annular zone between said mixture-delivery positions and said peripheral wall into a peripheral zone immediately inside said peripheral wall leaving a partially purified glyceride oil; supplying said mixture of glyceride oil and feet to said mixture-delivery positions under sufficient pressure to force said partially purified oil to flow inwardly past a plurality of circumferentially spaced positions disposed at a second position that is a second radial distance from said axis less than said first radial distance and to an effluent position disposed a third and relatively small radial distance from said axis; discharging streams of a washing medium respectively at said plurality of circumferentially spaced positions into contact with the partially purified oil moving inwardly past said circumferentially spaced positions the washing medium being immiscible with and of greater density than said oil; moving the washing medium outwardly from its discharge positions to first countercurrently said partially purified oil in the annulus between such circumferentially spaced positions and said mixture-delivery positions and then countercurrently with the feet in said annular zone to said peripheral zone to form a body of diluted feet in the latter zone; forming the partially purified oil in its inward flow between said second and said third effluent position to flow substantially radially inward as separate streams disposed side-by-side along said axis and driving the partially purified oil of such separate streams to maintain same at said angular velocity and prevent circular slippage thereof; continuously withdrawing a stream of centrifugally purified washed oil from said effluent position; and continuously withdrawing an effluent stream of diluted feet from said body thereof.

5. A process as defined in claim 4 including the steps of: forming the partially purified oil of at least some of such streams in their inward flow between said second and third positions to flow as separate segments, the segments of such separate stream being arranged in a circular pattern about said axis and including the step of individually driving such separate segments to maintain same at said angular velocity until they reach said effluent position.

6. A method of purifying a glyceride oil containing impurities capable of being taken up by a purifying agent to produce feet in the oil, which process includes the steps of: mixing with the glyceride oil a controlled amount of said purifying agent to form an oil-feet mixture; delivering the oil-feet mixture continuously and continuously discharging such mixture as separate streams at a plurality of circumferentially spaced delivery positions in each of a plurality of circular spaces between axially spaced surfaces extending outward from an axis and disposed thereabout; rotating said circular spaces about said axis at a sufficient regular rate to move said feet outwardly along said circular spaces from the mixture delivery positions by centrifugal force to a peripheral zone disposed outwardly of said circularly spaced delivery positions leaving a partially purified oil, said delivery of said mixture being under sufficient pressure to force the partly purified oil inwardly along said circular spaces toward said axis through an annulus disposed inwardly of said circularly spaced delivery positions; introducing a washing medium into said annulus at a plurality of circularly spaced discharge positions in each of said circular spaces at positions closer to said axis than said circularly spaced delivery positions and moving same outward first to countercurrently the partially purified oil flowing inwardly of said circular spaces through said annulus from said delivery positions to produce a washed purified oil and then outwardly past said mixture delivery positions to flow countercurrently with said feet to said peripheral zone to form a body of diluted feet in the latter zone; driving the liquids in said circular spaces at said angular rate by blocking each circular space along at least one line extending outwardly therefrom said axis; continuously withdrawing a stream of the washed purified oil from said circular spaces; continuously withdrawing a stream of the diluted feet from
said body thereof; and throttling each of the withdrawn streams to maintain superatmospheric pressure throughout said circular spaces.

A process for separating mixtures of glyceride oils containing separable dispersed material of higher specific gravity by use of a rotor turning about an axis and equipped with a plurality of concentric radially spaced apertured bands two of which provide a radially narrow delivery space, which process includes the steps of: flowing the mixture into one end of said radially narrow delivery space and thence along such space in a direction parallel to said axis; rotating said delivery space and the mixture about said axis at a rate sufficient to move the dispersed material outwardly in said delivery space; progressively removing said dispersed material outwardly from said delivery space through the apertures of the outer of said two bands during flow of said mixture along such space in said direction parallel to said axis and collecting the thus-removed dispersed material in a peripheral zone around and paralleling said delivery space; progressively withdrawing partially purified oil inwardly from said delivery space through the apertures of the inner of said two bands during such flow of said mixture along such delivery space; maintaining the mixture introduced into said one end of said delivery space under sufficient pressure to force said withdrawn partially purified oil inwardly to an effluent position close to said axis; continuously withdrawing oil from said effluent position; and continuously withdrawing the collected dispersed material from said peripheral zone.

8. A process for producing from a mixture of glyceride oil and feet in a single operation centrifugally purified and washed oil by use of a rotor having a circular zone concentric with an axis and bounded outwardly by a peripheral wall, the rotor having a diameter of at least about 20", which process includes the steps of: delivering said mixture under pressure to said circular zone and releasing same at a delivery position forming the inner boundary of a transition zone and the outer boundary of a counterflow zone, there being a clarifying zone immediately within said counterflow zone; producing a partially purified oil by centrifugally separating the oil from said mixture in said transition zone; moving the oil outwardly from said transition zone and collecting same in an adjacent peripheral zone immediately within said peripheral wall; withdrawing a stream of the collected feet continuously from said peripheral zone; moving the partially purified oil through said counterflow zone by delivering a wash medium into said circular zone at the common boundary of said counterflow and clarifying zones and moving same through the partially purified oil in counterflow relationship and thence through the transition zone to the peripheral zone to dilute the oil and collect thereof; moving the oil washed by said wash medium inwardly through said clarifying zone immediately within said counterflow zone to an effluent position closed to said axis; confining said washed oil to move through said clarifying zone to said effluent position as separate segments in each of a plurality of narrow substantially radial passages; delivering a stream of the washed and clarified oil from said circular zone at said effluent position; and throttling the withdrawn streams of oil and feet to maintain superatmospheric pressure throughout said circular zone and to maintain the radially depth of the collected diluted oil in said peripheral zone about 2-6% of the rotor radius.

9. A process for the separation and washing of mixtures containing soaps Directorate from the alkali treatment of glyceride oils, which process includes the steps of: introducing said mixture under pressure into a rotating zone at a mixture-delivery position disposed at a radius near the outermost portion of said zone and there subjecting such mixture to centrifugal force while positioned between closely spaced surfaces rotating about an axis to produce a heavier component moving outwardly from said mixture-delivery position away from said axis to said outermost portion of said zone and a partially purified lighter component moving inwardly of said mixture-delivery position toward said axis; introducing a wash medium into said rotating zone at a plurality of wash-medium-delivery positions substantially inward of said mixture-delivery position and flowing such wash medium countercurrent to the inwardly moving partially-purified lighter component in the zone between said mixture-delivery position and said wash-medium-delivery positions to wash same and then concurrently with said outward-moving heavier component to said outermost portion of said rotating zone; moving the washed lighter component inwardly of said wash-medium-delivery positions to a discharge position through at least some of said circular zones between axially spaced surfaces while confining same against axial spreading and against circular slippage relative to such surfaces; continuously separating withdrawing streams of effluent materials from said discharge position and from said outermost portion of said rotating zone; throttling each of said effluent streams; and adjusting the throttling of said streams to maintain in said outermost portion of said rotating zone a body of said heavier material diluted by said wash medium, said adjustment being such as to maintain superatmospheric pressure throughout said rotating zone and said effluent streams ahead of the positions at which such streams are respectively throttled.

10. A centrifugal separator for the separation of mixtures produced in the processing of glyceride oils, including in combination: a stationary housing; a rotor in said housing mounted on a shaft journalled to turn about an axis, the interior of said rotor forming a rotor space closed from the atmosphere and bounded outwardly by a peripheral wall of a diameter of at least 20 inches, the outermost portion of said rotor space immediately adjacent said peripheral wall being an annular peripheral zone; a plurality of baffles extending substantially radially inwardly of said axis in at least the inner portion of said rotor space, said baffles being spaced from each other in the direction of said axis to provide circular zones therebetween; means for impeding relative movement between the liquid in each circular zone and the baffles bounding same, said last-named means including at least one ball; delivering each circular zone and extending substantially radially outwardly in said annular peripheral zone; and a mixture-delivery means for delivering the mixture to be separated to said rotor space at a mixture-delivery position radially inward of said peripheral wall and its adjacent peripheral zone while said rotor is turning rapidly about said axis to separate the mixture by introducing into the specified outer peripheral zone at centrifugal action, the heavier component moving outward to said annular peripheral zone, said mixture-delivery means including a mixture-supply pump means delivering the mixture to said mixture-delivery position under pressure sufficient to force the lighter component inwardly along said circular zone to an inner discharge position; a first passage means extending from said inner discharge position along said shaft to a position outside said housing for removing a stream of said lighter component from said discharge position; a second passage means extending from said annular peripheral zone inwardly of said rotor to a position outside said housing for removing a stream of the separated heavier component from such peripheral zone; and a discharge means for maintaining a body of said separated heavier component in said peripheral zone and for maintaining superatmospheric pressure throughout said rotor space, said throat discharge means including an adjustable valve in each passage means for adjusting said valves at respective positions outside said rotor for adjustable throttling said streams removed through the respective passage means.

11. A centrifugal separator as defined in claim 10 including a plurality of pipes providing a plurality of discharge orifices opening on at least some of said circular zones at radial positions inward of said mixture-delivery...
position and on said lighter component moving inwardly along the corresponding circular zone; and wash-medium pump means delivering a washing medium to said plurality of pipes under pressure to discharge streams of said washing medium into said inwardly-moving lighter component to counterflow same in the radial zone between said discharge orifices and said mixture-delivery position.

12. A centrifugal separator as defined in claim 11 including a manifold connected to the discharge of said wash-medium pump means, and means for connecting said plurality of pipes to said manifold, said centrifugal separator including a passage means communicating with said manifold extending outwardly to said peripheral zone and opening thereon at a position radially outward of said mixture-delivery position.

13. A centrifugal separator for processing mixtures of oils containing separable dispersed material of higher specific gravity, said separator including: a stationary housing; a shaft traversing said housing journalled to turn about an axis; a rotor in said housing attached to said shaft having a rotor space therearound comprising an annular peripheral zone bounded by an internal peripheral wall extending substantially axially and of a diameter of at least 20 inches, there being an annular transition zone immediately within said annular peripheral zone and an annular clarifying zone between said transition zone and said shaft; a plurality of axially spaced baffles extending outwardly of said shaft in said annular clarifying zone of said rotor space, said baffles having circular peripheries adjacent the outer end of said clarifying zone, said baffles forming axially-narrow side-by-side circular zones there-between; means for blocking liquid in each such circular zone against slippage relative to the surfaces of the baffles bounding such circular zone, said last-named means including at least one outwardly-extending barrier in each circular zone spacing the baffles bounding such circular zone; a circular distributor band surrounding said circular peripheries of said baffles and providing perforations therethrough opening on the outermost portions of each circular zone at circumferentially spaced positions to supply liquid thereto from said annular clarifying zone; mixture-supply means for supplying the mixture to said transition zone under sufficient pressure to force centrifugally-purified oil inwardly through said perforations and said circular passages to a discharge position near the innermost portion of said annular clarifying zone; oil outlet means opening on said annular clarifying zone at said discharge position; and means for removing separated dispersed material from said annular peripheral zone.

14. A centrifugal separator as defined in claim 13 including a second circular band and means for mounting same in said transition zone around but spaced from said distributor band to form an interband delivery space, said mixture-supply means including passage means opening on said interband delivery space at a plurality of circumferential positions and pump means supplying said mixture to said passage means under said pressure sufficient to force said centrifugally-purified oil inwardly through said perforations, said second circular band providing perforations conducting centrifugally-separated dispersed material outwardly therethrough toward said annular peripheral zone.

15. A centrifugal separator as defined in claim 13 including a second circular band of larger diameter than said distributor band and means for mounting same in said transition zone around but spaced from said distributor band to form an interband delivery space with ends respectively positioned on opposite sides of the radial midplane of said rotor space, means for closing one of said ends of said interband delivery space, said mixture-supply means including outlet means discharging into the other end of said interband delivery space to advance said mixture therealong toward said closed end thereof.

16. A centrifugal separator as defined in claim 15 in which said outlet means of said mixture supply means comprises a manifold space within said rotor space opposite said other end of said interband delivery space and opening sidewardly thereon, and in which said mixture supply means includes a mixture-supply pump means and a passage means interconnecting said mixture-supply pump means and said manifold space.

17. A centrifugal separator as defined in claim 16 in which said mounting means for said second circular band includes a wall bounding said manifold space and to which said second circular band is attached.

References Cited in the file of this patent

UNITED STATES PATENTS

2,301,109 Clayton Nov. 3, 1942
2,301,110 Clayton Nov. 3, 1942
2,313,541 Flowers Mar. 9, 1943
2,670,132 Posbielniak Feb. 23, 1954
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,027,390
March 27, 1962

Benjamin H. Thurman

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 17, for "bardiers" read -- barriers --;
Column 18, line 52, for "regular" read -- angular --.

Signed and sealed this 31st day of July 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents