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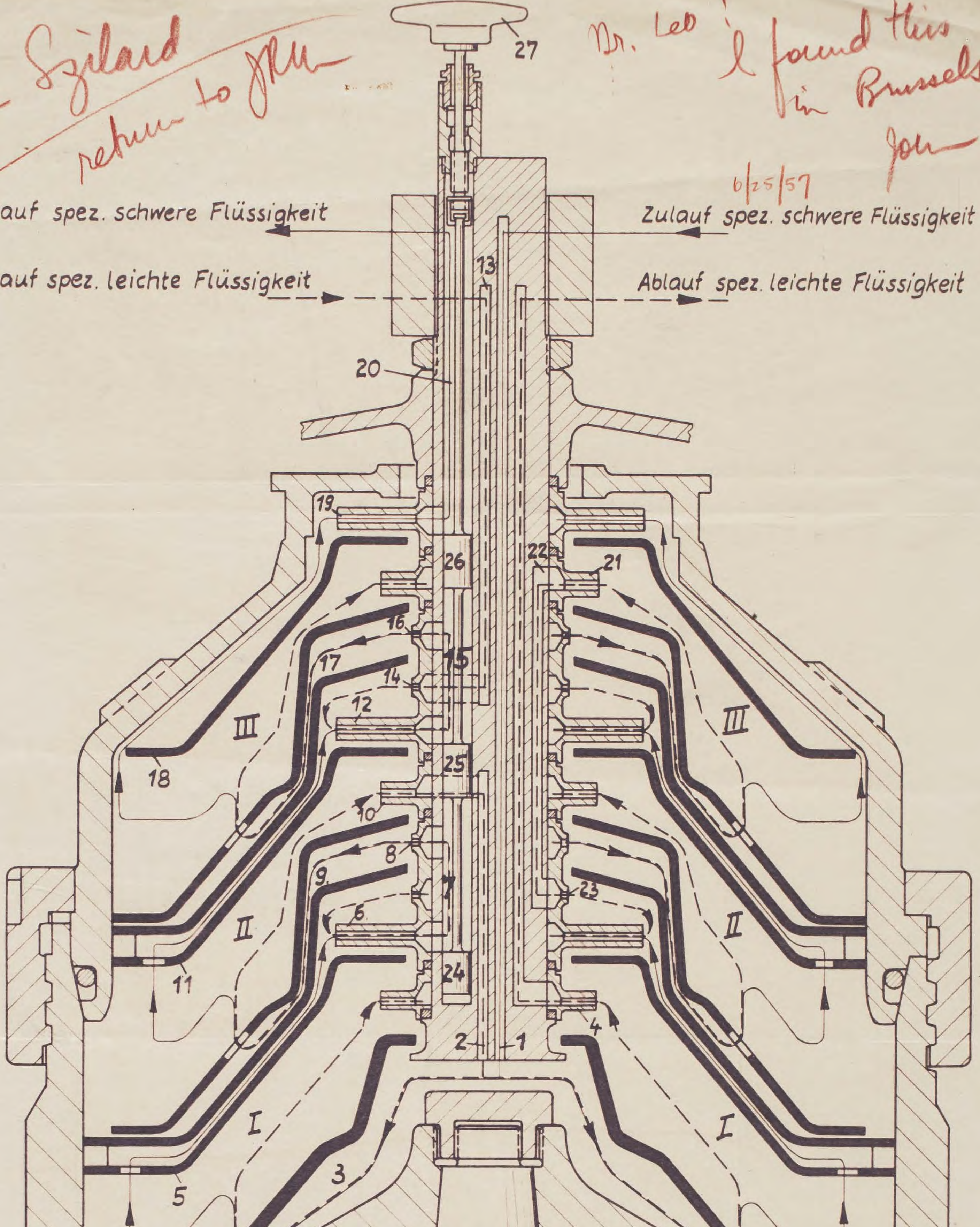

Strömungsplan des LUWESTA-Extraktors EG 2006

a German machine

W.S. AG., Oelde, den 8.1.1953

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Dagtekening 16 Juni 1949.

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665.54 : 665.1.03 : 622

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NEDERLAND

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N.V. DE BATAAFSCHE PETROLEUM MAATSCHAPPIJ,
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Werkwijze voor het met elkaar in aanraking brengen van twee of meer stoffen.

Aanvrage No. 159 Cur., ingediend 20 December 1945, 11 uur 10 min (herleide tijd 16 uur 47 min); openbaar gemaakt 15 Februari 1949, voorrang van 21 Juni 1945 af, (Ver. St. v. Am.).

De uitvinding heeft betrekking op een werkwijze voor het met elkaar in aanraking brengen van twee of meer stoffen, die, met elkaar in contact zijnde, ten minste twee fasen vormen, waarvan ten minste één een fluïdum is.

Een in de techniek veel voorkomende bewerking is het met elkaar in aanraking brengen van twee of meer niet of niet volledig mengbare stoffen, ten einde de uitwisseling van opgeloste bestanddelen of het optreden van een chemische reactie tussen deze stoffen te bevorderen. Wil een goed contact tijdens en een gemakkelijke scheiding na de uitwisseling of chemische reactie tot stand gebracht kunnen worden, dan is het noodzakelijk, dat ten minste één van de stoffen een fluïdum is, d.w.z. een gas of een vloeistof, waaronder mede colloïdale oplossingen, emulsies en suspensies worden verstaan. Is een van de andere stoffen vast, dan moet zij in een toestand verkeren, die het mogelijk maakt, dat zij in fijne toestand in de fluïde-fase wordt verdeeld: zij moet dus poedervormig of fijnkorrelig zijn.

Men streeft er in het algemeen naar, bij contactprocessen de beoogde uitwisseling van bestanddelen of de chemische reactie zo snel en volledig mogelijk te laten verlopen. Te dien einde moet in korte tijd een innig contact tussen de stoffen tot stand worden gebracht en wel liefst met een eenvoudig en niet zeer groot apparaat.

Bovendien moet het met elkaar in aanraking brengen van de stoffen op een zodanige wijze geschieden, dat na afloop van het contactproces de stoffen gemakkelijk van elkander te scheiden zijn. Het rendement van het contactproces moet hoog zijn en het mag slechts in geringe mate afhankelijk zijn van de hoeveelheden en van de chemische en physische eigenschappen van de bedoelde stoffen.

De uitvinding beoogt nu een werkwijze voor het met elkaar in aanraking brengen van twee of meer stoffen, waarbij in hoge mate aan de hierboven gestelde eisen wordt voldaan.

Volgens de uitvinding leidt men de genoemde fasen gelijktijdig door een ringvormige ruimte, die begrensd wordt door twee in elkaar gelegen en elkaar niet rakende omwentelingsoppervlakken, waarvan het ene met een zodanige hoeksnelheid ten opzichte van het andere om zijn as draait, dat één van de fasen gedispergeerd wordt gehouden in de andere continue fase en dat de verdeling van de ene fase in de andere regelmatig is.

Iedere fase kan verschillende stoffen bevatten, zoals oplosmiddelen met verschillend oplossend vermogen of verschillende selectiviteit, stoffen om de viscositeit, de oppervlaktespanning of de dichtheid te veranderen, zuur- of basisch reagerende verbindingen, zouten, reductiemiddelen, halogenerende stoffen, physisch of chemisch werkende absorbentia, adsorbentia, oxydatiemiddelen, kationen- of anionenuitwisselende harsen of stoffen, die gewoonlijk bij de raffinage, scheiding, extractie, concentratie of zuivering van fluïde mengsels worden gebruikt.

De fasen worden bij voorkeur in tegenstroom door de ringvormige contactzone

Verkrijgbaar bij het Bureau voor de Industriële Eigendom, te 's-Gravenhage.
Prijs per ex. f 1.—.

1,6 cm, een glazen stator met een diameter van 2,08 cm en een effectieve hoogte van 66 cm. De rotor had een toerental van 2200 omw./minuut en de hoeveelheid doorstromend gas bedroeg 120 g/uur. Het uitstromende gas bevatte 34,1 vol.% H_2, 0,6 vol.% zure en 0,0% in zuren oplosbare bestanddelen.

Men kon een duidelijk visgraatpatroon van de kooldeeltjes waarnemen.

TABEL D.

Afmetingen van de kolom in cm			Concentratie van azijnzuur in grammol per liter in de voeding	Concentratie van azijnzuur in grammol per liter in het		Totale hoeveelheid doorstromende vloeistof in cm^3/cm^2 sec.	Verhouding tussen de hoeveelheid toegevoerde continue en disperse fase	Omtreksnelheid van de rotor in m/sec.	Rendement in aantal theoretische schotels per m
statordiameter in cm	rotordiameter in cm	hoogte in cm		raffinaat	extract				
21,6	15,9	50,8	0,526	0,091	0,576	0,64	1,32 : 1	3,12	4,62
21,6	15,9	50,8	0,466	0,084	0,518	1,32	1,36 : 1	2,49	4,56

Conclusies.

1. Werkwijze voor het met elkaar in aanraking brengen van twee of meer stoffen, die, met elkaar in contact zijnde, ten minste twee fasen vormen, waarvan ten minste één een fluïdum is, met het kenmerk, dat men de genoemde fasen gelijktijdig door een ringvormige ruimte leidt, die begrensd is door twee in elkaar gelegen en elkaar niet rakende omwentelingsoppervlakken, waarvan het ene met een zodanige hoeksnelheid ten opzichte van het andere om zijn as draait, dat één van de fasen gedispergeerd wordt gehouden in de andere continue fase en dat de verdeling van de ene fase in de andere regelmatig is.

2. Werkwijze volgens conclusie 1, met het kenmerk, dat de verdeling van de ene fase in de andere zodanig is, dat er een visgraatpatroon wordt gevormd.

3. Werkwijze volgens conclusie 1 of 2, waarbij het verschil in soortelijk gewicht tussen de fasen ten minste 0,02 g/cm^3 bedraagt, met het kenmerk, dat de fasen in tegenstroom door de ringvormige ruimte worden geleid.

4. Werkwijze volgens conclusie 1, 2 of 3, met het kenmerk, dat men werkt met een toestel, waarbij de verhouding tussen de breedte van de ringvormige ruimte en de diameter van het binnenste omwentelingsoppervlak tussen 5 en 0,02 ligt en dat het oppervlak van de dwarsdoorsnede van de ringvormige ruimte ten minste 10 cm^2 bedraagt.

5. Werkwijze volgens een van de voorafgaande conclusies bij een kinematische viscositeit van het fluïde mengsel van ongeveer die van water, met het kenmerk, dat de omwentelingssnelheid van een van de omwentelingsoppervlakken ten opzichte van het andere groter is dan 0,75 m/seconde, maar niet zo groot, dat de stroming overal turbulent wordt en/of dat er stuwing in de contactzone optreedt.

6. Werkwijze volgens een van de voorafgaande conclusies, met het kenmerk, dat in iedere doorsnede van de contactzone de verhouding tussen de hoeksnelheden van het binnenste en het buitenste oppervlak groter is dan het kwadraat van de verhouding tussen de stralen van het buitenste en het binnenste oppervlak, maar niet zo groot, dat er turbulentie of stuwing optreedt.

7. Werkwijze volgens een van de voorafgaande conclusies, waarbij het binnenste oppervlak met een bepaalde omtreksnelheid om zijn as draait, met het kenmerk, dat deze snelheid zo groot is, dat in ieder punt van de contactzone het product van deze omtreksnelheid en de afstand tussen de de contactzone begrenzende oppervlakken gedeeld door de kinematische viscositeit van het fluïde mengsel groter dan 2500 is.

Aanvrage No. 159 Cur.

Hierbij 1 blad tekeningen.

63629 Plate 3

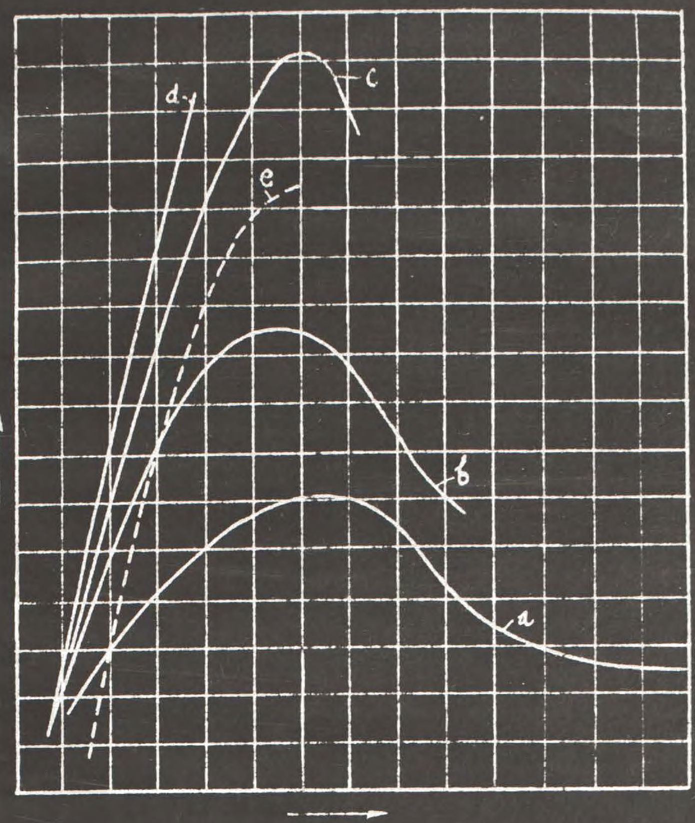

FIG. 10

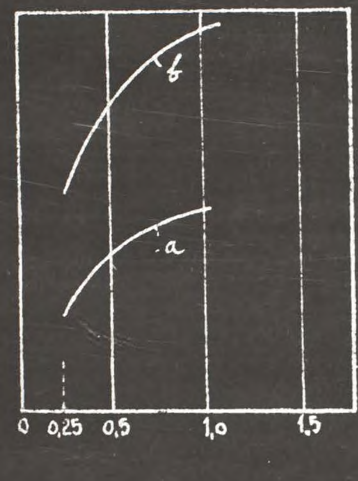

FIG. 11

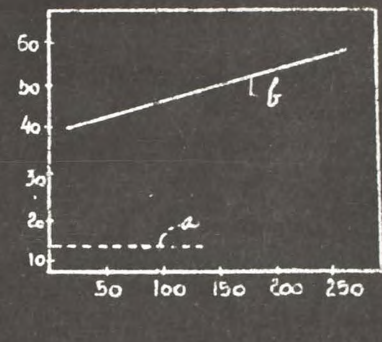

FIG. 12

159 Curv-3

geleid. Hiervoor is het noodzakelijk, dat de soortelijke gewichten van de fasen ten minste 0,02 g/cm³ verschillen en dat het ene einde van de contactzone hoger is gelegen dan het andere.

In de fig. 1a—1n zijn de verticale doorsneden van enige vormen van contactzones weergegeven. Hieruit blijkt onder andere, dat de omwentelingsoppervlakken, die de contactzone begrenzen, niet coaxiaal behoeven te zijn (zie fig. 1c) en dat verschillende contactzones in elkander kunnen worden gebouwd (zie fig. 1b).

Laat men bijvoorbeeld het binnenste en het op één na buitenste omwentelingsoppervlak van het in fig. 1b afgebeelde apparaat om hun as wentelen, dan verkrijgt men met slechts twee roterende oppervlakken drie in elkaar gebouwde contactzones. De te behandelen stoffen kunnen nu bijvoorbeeld eerst door de binnenste contactzone worden geleid, vervolgens eventueel tezamen met andere stoffen door de tweede zone, enz. Door deze compacte bouwwijze wordt een aanmerkelijke ruimtebesparing verkregen.

Tijdens het contactproces kunnen één of meer eigenschappen van de met elkaar in aanraking zijnde fasen, zoals het volume, het soortelijk gewicht, de viscositeit of de oppervlaktespanning, ten gevolge van het toevoegen of onttrekken van stof op een of meer punten van de contactzone of door het optreden van chemische of physische reacties, veranderen en daar de doorstromende stoffen steeds met beide omwentelingsoppervlakken in aanraking zijn, is het daardoor soms wenselijk de doorsnede van de contactzone op verschillende hoogten te laten verschillen (zie fig. 1d—1n). Men draagt er in de regel zorg voor, dat de omwentelingsoppervlakken geen discontinuïteit vertonen.

In het algemeen past men een contactzone toe, die begrensd wordt door twee coaxiale cylinderoppervlakken, waarvan het buitenste stil staat en het binnenste om zijn as draait (zie fig. 1a).

Aan de uiteinden van de zone treden stromingen op, die het rendement van het contactproces ongunstig beïnvloeden („eindeffect"); haar invloed wordt relatief groter bij kortere zones. Daarom past men bij voorkeur zones toe, wier lengte minstens tweemaal zo groot is als de diameter van het buitenste cylinderoppervlak.

De verhouding van de breedte van de ringvormige ruimte en de diameter van het binnenste omwentelingsoppervlak wordt bij voorkeur tussen 5 en 0,02 en meer in het bijzonder tussen 2 en 0,1 gekozen.

In fig. 2 is een apparaat weergegeven, waarin het beschreven contactproces kan worden uitgevoerd. Hierin zijn pompen en andere hulpapparaten, die voor het begrijpen van de werking niet van essentieel belang zijn, weggelaten.

De contactzone wordt begrensd door twee coaxiale cylindervlakken 1 en 2. Het buitenste vlak (de stator) 1 staat stil en het binnenste (de rotor) 2 draait om zijn as; de rotor is aan de bovenzijde 3 en onderzijde 4 gelagerd en wordt door een motor 5 aangedreven. De zware en lichte stoffen (bijvoorbeeld vloeistoffen), die respectievelijk de disperse en de continue fase vormen, worden respectievelijk door de leidingen 6 en 7 toegevoerd en komen in de contactzone in tegenstroom met elkaar in aanraking.

De gevormde dispersie komt via een leiding 14 in een bezinkruimte 8, waar de lichte fase wordt afgescheiden; deze wordt via een leiding 10 afgevoerd, terwijl de resterende vloeistof door een leiding 12 naar de contactzone wordt teruggeleid.

De zware fase doorstroomt de contactzone van boven naar beneden, wordt gedispergeerd in de lichte fase en komt via een leiding 15 in een bezinkruimte 9. Daar worden kleine hoeveelheden lichte fase afgescheiden en via een leiding 13 naar de contactzone teruggeleid. De zware fase wordt via een leiding 11 afgevoerd.

Het contactapparaat werkt onder zodanige omstandigheden, dat zich in de contactzone een scheidingsvlak vormt, dat zo is gelegen, dat de disperse fase er naar toe stroomt.

In de bezinkruimten 8 en 9 zijn niveauregelaars 38 en 39 aangebracht, die de hoogte van dit scheidingsvlak tussen de fasen kunnen regelen. Gewoonlijk stelt men de niveauregelaar in werking, die zich in de bezinkruimte bevindt, waaruit de disperse fase wordt afgetapt, i.c. dus de regelaar 39. Deze regelt de hoogte van het scheidingsvlak tussen de fasen in de contactzone door variatie van de stand van een afsluiter 40.

Vele variaties van de geschetste uitvoeringsvorm zijn mogelijk: zo kan de contactzone tussen de toevoerleidingen van een of meer leidingen worden voorzien, waardoor stoffen worden toe- of afgevoerd; de leidingen 6 en 7 kunnen respectievelijk met de retourleidingen 12 en 13 worden gecombineerd, het contactproces kan onder verhoogde of verlaagde druk, bij hoge

of lage temperatuur, onder instraling of onder invloed van uitwendige krachtvelden of electrische of magnetische velden plaats vinden, enz.

Aangezien de disperse fase het apparaat gemeenlijk het snelst doorloopt, verdient het, als een van de stoffen niet stabiel is, aanbeveling deze de disperse fase te laten vormen. Bij een contactapparaat, zoals in fig. 2 is aangegeven, wordt in de continue fase een schuifspanning opgewekt. Deze heeft het ontstaan van wervels ten gevolge, die de vorm van een torus hebben. In elke wervel stroomt het fluïdum horizontaal om de rotor en bovendien vertoont de vloeistof in elke wervel een roterende beweging om de hartlijn van de wervel. Bij iedere wervel heeft deze laatste stroming juist een andere richting dan bij de beide aangrenzende wervels (zie fig. 3). Bij sommige contactapparaten vertoont de stroming in de contactzone een ietwat ander beeld: de rechtsdraaiende wervels verenigen zich tot een spiraalvormige band en evenzo de linksdraaiende, zodat de stroming nu plaatsvindt in twee tegengesteld draaiende, zich om de rotor windende spiralen (zie fig. 4).

Brengt men een tweede, met de eerste niet mengbare, fase in de contactzone, dan wordt deze tweede fase in de eerste continue fase gedispergeerd. De grootte van de gevormde deeltjes loopt betrekkelijk weinig uiteen en hangt af van de grootte van de schuifspanning in de continue fase en van verschillende physische en chemische eigenschappen van de fasen. Zo zullen de relatieve hoeksnelheid tussen en de diameters van de omwentelingsoppervlakken, de doorstromende hoeveelheden en de viscositeit van en de oppervlaktespanning tussen de fasen en nog vele andere factoren de graad van dispersie en dus ook de mate van contact tussen de fasen bepalen.

Is de disperse fase een gas of een vloeistof, dan zal deze in vele kleine deeltjes worden verdeeld. De verdeling van deze deeltjes naar de grootte is zodanig, dat ongeveer 90% er van een bezinksnelheid bezit, die niet groter dan viermaal en niet geringer dan een kwart van de gemiddelde bezinksnelheid van deze deeltjes is, met andere woorden, de gevormde deeltjes verschillen onderling slechts weinig in grootte.

Door het ontstaan van deeltjes van ongeveer gelijke grootte worden emulsie- en/of schuimvorming voorkomen, daar deze verschijnselen meestal het gevolg zijn van de vorming van zeer kleine deeltjes. Daarom is het contactproces volgens de uitvinding speciaal geschikt voor het in contact brengen van fluïde systemen, die bij andere contactprocessen neiging tot schuim- en of emulsievorming vertonen.

Het dispergeren van een fase in de andere vindt gemakkelijker plaats, naarmate de oppervlaktespanning tussen de beide fasen geringer is. Deze kan worden verminderd door toevoeging aan één of aan beide fasen van oppervlakte-actieve stoffen, zoals kation- of anion-actieve stoffen, of organische verbindingen, zoals normale of zure sulfaten, sulfonaten, phosphaten, phosphonaten of carboxylaten of stoffen, die een van de volgende radicalen bevatten: hydroxyl-, sulfhydryl-, carbonyl-, formyl-, aether- of estergroepen, primaire, secundaire of tertiaire amino- of quaternaire ammonium- en andere oniumradicalen; halogeen-, cyaan-, thiocyaan- of nitrogroepen.

Deze de oppervlaktespanning verlagende stoffen kunnen ook worden toegevoegd om emulsievorming tegen te gaan, bijvoorbeeld bij de extractie van penicilline uit waterige oplossingen.

Bij een grotere omwentelingssnelheid van de rotor worden de deeltjes van de gedispergeerde fase kleiner en gelijkmatiger van afmeting en volgen ze meer de wervelstroming van de continue fase.

In tabel A zijn de verschillende stromingsgebieden, die achtereenvolgens doorlopen worden bij toenemende snelheid van de rotor en de daarbij optredende verschijnselen vermeld (zie ook de fig. 5—9).

Het blijkt nu, dat het rendement van het contactproces het grootste is in de stromingsgebieden D en E, dus als de deeltjes van de disperse fase klein en gelijkmatig van grootte zijn en de verdeling van deze deeltjes in de continue fase regelmatig is, vooral wanneer deze deeltjes een visgraatpatroon vormen (zie fig. 8 en 9). Dit patroon ontstaat, doordat de deeltjes van de disperse fase door de stroming in de torus- of spiraalvormige wervels om de rotor worden meegesleurd.

Bij zeer snelle rotatie van de rotor treedt turbulentie in de contactzone op. De verdeling van de disperse fase wordt dan ongeordend en het visgraatpatroon verdwijnt. Bovendien kan de door het verschil in dichtheid veroorzaakte stroming van de fasen ophouden, zodat geen ontmenging van de fasen meer optreedt en door elk van de uitlaten beide fasen worden afgevoerd. Men noemt dit verschijnsel stuwing.

TABEL A.

Stromingsgebied	Vorm en afmeting van de deeltjes van de disperse fase	Aard van de verdeling van de deeltjes van de disperse fase in de continue	Stroming van de deeltjes door de contactzone	Patroon gevormd door de deeltjes in de contactzone	Zie figuur	Rendement van het contactproces
A	slierten en grote deeltjes	onregelmatig	in een spiraal om de rotor	onregelmatig	5	slecht
B	kleinere deeltjes van meer gelijkmatige afmeting	regelmatig	in een weinig hellende of horizontale richting om de rotor	strepen	6	matig
C	kleine deeltjes van onderling gelijke grootte	regelmatig	horizontaal om de rotor; deeltjes zijn in wervels geconcentreerd	optreden van smalle heldere en brede troebele banden; visgraatpatroon begint te verschijnen	7	goed
D	kleine deeltjes van onderling gelijke grootte	regelmatig	in wervels om de rotor en om de omtrek van de wervels	duidelijk visgraatpatroon	8 en 9	uitmuntend
E	kleine deeltjes van onderling gelijke grootte	regelmatig	in wervels om de rotor en om de omtrek van de wervels	duidelijk visgraatpatroon, eventueel optreden van heldere en troebele banden	—	uitmuntend
F	kleine deeltjes	turbulentie	ongeordend	geen patroon	—	geen geregelde stroom door de contactzone

Men kan op de volgende wijze vaststellen, wanneer stuwing in een contactapparaat zal optreden: zet voor gegeven hoeveelheden van de doorstromende vloeistoffen in eenzelfde grafiek uit de verhouding tussen de door de disperse en de continue fasen ingenomen volumina van de contactzone (1) en de verhouding tussen de lineaire snelheid, waarmede de disperse en de continue fase door de contactzone stromen (2) als functies van de omtreksnelheid van de rotor. Het punt, waar deze lijnen (1) en (2) elkaar snijden, geeft aan, wanneer stuwing zal optreden. Dit geschiedt als voldaan is aan de betrekking:

$$H = \frac{1}{\left(\frac{F_c}{F_d}\right)^{1/2} + 1}$$

H stelt hierin het deel van de contactzone voor, dat door de disperse fase wordt ingenomen; F_c respectievelijk F_d zijn de per oppervlakte-eenheid van de doorsnede der contactzone en per tijdseenheid doorstromende hoeveelheden der continue, respectievelijk der disperse fase.

Men kan de in de bovenstaande tabel weergegeven stromingsgebieden aanduiden door bepaalde waarden van het getal van Reynolds R_e. Dit kengetal stelt het dimensieloze quotiënt

$$\frac{(R_2 - R_1)\ V\rho}{\mu}$$

voor, waarin R_1 de diameter van het binnenste en R_2 de diameter van het buitenste omwentelingsoppervlak, ρ de dichtheid en μ de absolute viscositeit van het fluïde mengsel in de contactzone voorstelt.

Indien de absolute hoeksnelheden van de omwentelingslichamen respectievelijk ω_1 en ω_2 bedragen, dan is $V = R_1\,\omega_1$ als $\omega_2 = 0$; $V = R_2\,\omega_2$ als $\omega_1 = 0$ en

$$V = \frac{(R_2 + R_1)}{2} \cdot (\omega_2 - \omega_1) \text{ als } \omega_1 \neq 0 \text{ en } \omega_2 \neq 0.$$

Nu is gebleken, dat er, indien alleen

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het binnenste omwentelingsoppervlak roteert, een stroming optreedt, die correspondeert met die van de stromingsgebieden D of E (zie tabel A), als in elke doorsnede van de contactzone R_e groter dan 2500 en bij voorkeur zelfs groter dan 3000 is. Staat echter het binnenste oppervlak stil en roteert het buitenste, dan verkrijgt men dezelfde soort stroming en het daarbij behorende hoge rendement van het contactproces reeds als R_e groter is dan 2000. Indien het buitenste oppervlak roteert, worden wervels gevormd, die over een groter gebied stabiel zijn; hierdoor treedt bij lagere waarden van R_e nog een gunstige stroming op.

Is de kinematische viscositeit $\left(\frac{\mu}{\rho}\right)$ van een fluïde mengsel ongeveer gelijk aan die van water en gebruikt men een contactapparaat van in het fig. 2 weergegeven type, dan wordt een goed contact verkregen, als de omtreksnelheid van de rotor meer dan 0,75 m/seconde bedraagt.

Met een contactapparaat, waarin de beide omwentelingsoppervlakken roteren, verkrijgt men goede resultaten, als in iedere doorsnede van de contactzone is voldaan aan de ongelijkheid:

$$\frac{\omega_1}{\omega_2} > \left(\frac{R_2}{R_1}\right)^2$$

Het spreekt wel vanzelf, dat de rotatiesnelheid nooit de waarde, waarbij stuwing of turbulentie optreedt, mag overschrijden.

Het verband tussen het rendement en de relatieve omtreksnelheid van de rotor bij een apparaat volgens fig. 2 is weergegeven in fig. 10. De krommen hebben betrekking op een extractieproces tussen twee vloeistoffen. Het rendement is uitgedrukt in theoretische schotels per meter (zie hiervoor Hunter and Nash, Journal of the Society of Chemical Industry, Vol. 51, p. 285 T (1932)). De krommen *a*, *b*, *c* en *d* gelden voor een totale hoeveelheid doorstromende vloeistoffen van respectievelijk 0,226, 0,376, 0,650 en 1,32 cm^3/cm^2.seconden. Uit de grafiek blijkt, dat bij grotere hoeveelheden het rendement toeneemt, als de rotorsnelheid constant blijft. De krommen eindigen bij het punt, waar stuwing optreedt. De gestippelde kromme *e* is opgenomen bij dezelfde hoeveelheid doorstromende vloeistoffen als kromme *c* (0,650 cm^3/cm^2.seconde), maar de disperse en continue fase zijn verwisseld. Dit heeft kennelijk geen grote invloed op het rendement.

Alle krommen vertonen een maximum bij ongeveer dezelfde rotorsnelheid. De grenzen, waartussen de hoeveelheid doorstromende vloeistoffen kan variëren, liggen blijkbaar ver uiteen en het rendement van het contactproces is zeer wel te beïnvloeden door verandering van de rotorsnelheid. Het wijzigen van de rotorsnelheid is te vergelijken met het veranderen van de grootte of het type van de vulling of de grootte van de openingen in de schotels of zeefplaten van torens. Snelheidsveranderingen van de rotor zijn echter veel gemakkelijker te bewerkstelligen dan het verwisselen van vulmateriaal en dergelijke, wat wel een opmerkelijk voordeel van het bovenbeschreven contactapparaat betekent. Bovendien kan men op eenvoudige wijze de duur van het contact van de fasen regelen.

In fig. 11 zijn de resultaten weergegeven van proeven met twee contactapparaten van verschillende afmeting. In beide apparaten liet men een extractieproces in tegenstroom tussen twee vloeistoffen plaats vinden, die een verschil in dichtheid van meer dan 0,2 g/cm^3 en een grensvlakspanning van meer dan 10 dynes/cm bezaten. De viscositeit van de continue niet-waterige fase bedroeg ongeveer 1 centipoise. Men bepaalde bij elke doorstromende hoeveelheid vloeistof het maximale rendement en tekende vervolgens voor elk contactapparaat een kromme, die het verband tussen die maximaal bereikbare rendementen en de doorstromende hoeveelheden aangaf. Kromme *a* behoort bij het grote, kromme *b* bij het kleine contactapparaat.

Het blijkt, dat een goed rendement wordt verkregen, als de doorstromende hoeveelheid vloeistof meer dan 0,25 en bij voorkeur meer dan 0,5 cm^3/cm^2.seconde bedraagt.

Tussen 0,5 en 1,0 cm^3/cm^2.seconde varieert het maximale rendement minder dan 20%; het rendement is dus binnen wijde grenzen weinig afhankelijk van de belasting.

Men neemt gewoonlijk aan, dat het rendement van de meeste contactapparaten, zoals gevulde torens of torens met zeefplaten, omgekeerd evenredig is met de wortel uit het oppervlak van de loodrechte doorsnede door de contactzone. Zet men dus bij dergelijke apparaten het product van het rendement en de wortel uit het oppervlak van de doorsnede uit als functie van het oppervlak van de doorsnede, dan verkrijgt men een horizontale rechte (zie fig. 12, lijn *a*). Doet men nu echter hetzelfde bij een roterend contactapparaat, dan blijkt men een stijgende lijn te verkrijgen (zie fig. 12, lijn *b*), waaruit dus volgt, dat het rendement van een roterend contactapparaat bij toeneming van de doorsnede minder snel afneemt dan dat van gevulde torens en dergelijke. Bovendien blijkt uit het feit, dat lijn *b* veel hoger ligt dan lijn *a*, dat ook bij roterende apparaten met een betrekkelijk kleine doorsnede het rendement hoger is dan bij een toren met dezelfde doorsnede; bij doorsneden van meer dan 10 cm² geven roterende contactapparaten altijd betere resultaten dan de tot nu toe gebruikelijke apparaten.

Hieronder volgt een opsomming van enige doeleinden, waarvoor de bovenbeschreven werkwijze kan worden gebruikt. Deze opsomming is ingedeeld naar de aard van de in aanraking te brengen fasen en wordt door enige uitvoeringsvoorbeelden gevolgd. De eerstgenoemde fase is steeds de continue fase.

1. Gas-vloeistof en vloeistof-gas systemen.

Het reinigen van gassen; het verwijderen van sommige gasvormige bestanddelen uit gassen, zoals bijvoorbeeld geschiedt door de refluxvloeistof bij gewone of extractieve destillatie; gasabsorptie en het drogen of bevochtigen van gas.

2. Gas-vaste stof (in poedervorm) systemen.

Adsorptie van gasvormige bestanddelen, zoals het scheiden van methaan en andere lichte gassen van aethaan en aethyleen door adsorptie aan kool; adsorptie aan silicagel en andere poedervormige adsorbentia; het fractionneren van poeders door uitspoelen of gasflotatie; chemische adsorptie, zoals de adsorptie van olefinen, diolefinen en acetylenen door cuprozouten.

3. Vloeistof-vloeistof systemen.

Extractieprocessen voor het splitsen van vloeibare mengsels van organische en/of anorganische componenten met verschillende graad van verzadiging of polariteit of moleculaire configuratie, zoals het scheiden van olefinen, diolefinen, acetylenen, naphthenen, aromaten, alkylphenolen, thiophenolen, stikstofhoudende basen en dergelijke van petroleum- of koolteerolie-fracties of synthetisch bereide mengsels met behulp van een of meer selectieve oplosmiddelen zoals zwaveldioxyde, furfural, phenolen, sulfolanen, oplossingen die koper bevatten, aldehyden, ketonen, aethers, esters, aminen, nitriten, nitrokoolwaterstoffen; het zuiveren en raffineren van vetzuren, vette oliën, dierlijke, plantaardige en vluchtige oliën, zoals Chinese houtolie, lijnolie, soyaolie, citroenolie, harsolie, tallolie, katoenolie en dergelijke met geschikte oplosmiddelen als aethanolamine, furfural en sulfolanen; het zuiveren van een dialkylamine, zoals diisopropylamine, door afscheiden van het overeenkomstige monoalkylamine en andere verontreinigende bestanddelen met een koolwaterstof als oplosmiddel; de extractie, concentratie en zuivering van antibiotica, zoals penicilline, met selectieve oplosmiddelen; de scheiding van polymeren met behulp van oplosmiddelen; de scheiding van epi- en dichloorhydrienen van water met diïsopropylaether of een soortgelijk oplosmiddel; andere extractieprocessen, en wel in het bijzonder die, waarbij ten gevolge van de geringe selectiviteit van het oplosmiddel een groot aantal trappen is vereist. Verder het neutraliseren van stoffen, zoals het behandelen met sterk basische vloeistoffen, bijvoorbeeld het neutraliseren van koolwaterstofoliën die zwavelwaterstof, mercaptanen, thiophenolen, alkylphenolen, naphtheenzuren of sulfonzuren bevatten met sterk basische waterige vloeistoffen zoals oplossingen van stoffen die het in oplossing gaan van andere stoffen bevorderen (solutizer); de scheiding van alkylphenolen van thiophenolen en het splitsen van mengsels van alkylphenolen of thiophenolen in hun componenten; het splitsen en zuiveren van mengsels van sulfonzuren en naphtheenzuren. Zuurbehandeling, zoals de behandeling van minerale olie met zwavelzuur om de gomvormende bestanddelen en andere verontreinigingen te verwijderen.

4. Vloeistof-vaste stof systemen.

Uitlogingsprocessen, zoals het activeren van klei met zuur, het uitwassen van neerslagen, het wassen van paraffine met oplosmiddelen ter verwijdering van olie, het regenereren van adsorbentia, het verwijderen van olie uit adsorbentia, het extraheren van olie uit leisteen of asfalt, de extractie van vette oliën uit gemalen of gebroken substanties met behulp van organische oplosmiddelen, zoals het winnen van olie uit katoenzaad of gebroken soya-

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bonen. Verder de scheiding van proteïne, zoals antigenen, allergene eiwitten en andere bestanddelen van het bloed, van hormonen, vitaminen en antibiotica door adsorbtie op vaste stoffen. Het scheiden van stoffen met verschillende graad van polariteit of verzadiging, zoals phenolen en koolwaterstoffen, aromaten, en niet-aromaten, door middel van absorptie aan een vaste stof, zoals silicagel. Verder processen waarbij ionenuitwisseling optreedt, zoals die, waarbij inonenuitwisselende harsen en stoffen van het permutiettype worden gebruikt.

5. Vloeistof-gas-vaste-stof systemen.

Werkwijze voor het scheiden van minerale bestanddelen, zoals het schuim-flotatieproces.

6. Vloeistof-vloeistof-vaste stof systemen.

Het scheiden van proteïnen, zoals antigenen, afweerstoffen, allergene eiwitten en andere bestanddelen van het bloed en van hormonen, vitaminen en antibiotica door de deze stoffen bevattende mengsels in een continue fase op te lossen en daarin adsorberende vaste deeltjes en een niet mengbare vloeibare fase te dispergeren, zodat de vaste deeltjes worden geconcentreerd op het scheidingsvlak van de beide vloeibare fasen.

7. Vloeistof-vloeistof-vloeistof systemen.

Het transport van een in een oplosmiddel opgeloste stof naar een ander oplosmiddel door deze oplosmiddelen in tegenstroom door een dispergerend medium te leiden, zoals het extraheren van phenolen uit een hoogkokende koolwaterstof met behulp van een laagkokend zwaarder oplosmiddel, door deze stoffen in tegenstroom door een dispergerende waterige alkalioplossing te leiden.

Uitvoeringsvoorbeeld I.

Benzinemonsters (A.S.T.M. 5% kookpunt bij 57° C en 90% kookpunt bij 170° C) met verschillend gehalte aan tertiair butylmercaptaan werden in tegenstroom in contact gebracht met een waterige 3 N oplossing van KOH, en wel in twee contactapparaten van het in fig. 2 geschetste type.

Het apparaat, waarmede de proeven 1 en 2 werden gedaan, bezat een effectieve lengte van 63,5 cm, een statordiameter van 3,33 cm en een rotor-diameter van 2,54 cm. Het apparaat, waarmee de proeven 3 en 4 werden verricht, had eveneens een effectieve lengte van 63,5 cm, een statordiameter van 5,50 cm en een rotordiameter van 3,75 cm.

In tabel B zijn de resultaten van deze proeven vermeld. Uit de proeven 1 en 2 blijkt, dat een vergroting van de omtreksnelheid tot boven 0,75 m/seconde een meer dan evenredige toeneming van het rendement ten gevolge heeft, terwijl uit de proeven 3 en 4 volgt, dat een vergroting van de hoeveelheid doorstromende vloeistoffen met 50% een verhoging van het rendement met 100% veroorzaakt.

Bij alle proeven werd een duidelijk visgraatpatroon gevormd, behalve bij proef 1, waar de rotorsnelheid te laag was.

TABEL B.

Proef No.	Hoeveelheid KOH-oplossing in cm³/cm².sec.	Hoeveelheid benzine cm³/cm².sec.	Percentage tert. butyl mercaptaan in voeding	Percentage tert. butyl mercaptaan in raffinaat	Omtreksnelheid v.d. rotor in m/sec.	Verdelingscoëfficiënt tussen KOH en benzine	Temperatuur in °C	Rendement in theoretische schotels per m
1	0,039	0,191	0,046	0,0216	0,653	6,44	23,3	1,38
2	0,038	0,094	0,470	0,000432	1,01	6,53	23,0	18,4
3	0,011	0,053	0,0479	0,00817	1,42	6,36	23,8	5,48
4	0,018	0,086	0,0500	0,00169	1,42	6,53	23,0	11,3

Uitvoeringsvoorbeeld II.

Door het verrichten van een acetylatieproef bleek, dat een nauwkokende fractie van petroleumalkylphenolen (beginkookpunt 195,5° C, eindkookpunt 206,5° C, 5% destillatietemperatuur van 197° C, 50% destillatietemperatuur 199° C, 95% destillatietemperatuur 205° C) overeenkwam met een mengsel van 57% xylenolen en aethylphenolen (voor een groot deel O-aethylphenol, 2.6-, 2.4- en 2.5-xylenolen) en 43% cresolen (aanzienlijke hoeveelheden van alle drie cresolen). Men loste dit mengsel op in een 50—50 vol.% mengsel van iso-octaan en benzeen, zodat een oplossing werd verkregen, die 200 g alkylphenolen per liter bevatte. Deze oplossing extraheerde men in tegenstroom met een 2 N waterige NaOH-oplossing in een contactapparaat van het in fig. 2 weergegeven type. De effectieve lengte van dit apparaat bedroeg 63,5 cm, de rotordiameter 3,75 cm en de statordiameter 5,575 cm. De hoeveelheid doorstromende alkylphenolen-oplossing bedroeg 0,1100 cm³/cm².seconde en die van de NaOH-oplossing, welke de continue fase vormde, 0,052cm³/cm².seconde. De omwentelingssnelheid van de rotor varieerde tussen 0,982 en 1,11 m/seconde en men kon een duidelijk visgraatpatroon waarnemen.

Het gehalte aan xylenol en aethylphenol van het raffinaat bedroeg 96% en van het extract 7,9%.

Uitvoeringsvoorbeeld III.

Verscheidene waterige penicilline-oplossingen werden met verschillende soorten oplosmiddelen geëxtraheerd in een contactapparaat van het in fig. 2 geschetste type. De effectieve lengte van dit apparaat bedroeg 104 cm, de statordiameter 5,08 cm en de rotordiameter 3,30 cm. De proeven werden verricht bij een temperatuur van 0 à 3° C, om ontleding van de penicilline in de oplossing tegen te gaan. Steeds verkreeg men een duidelijk visgraatpatroon in de kolom. De laatste twee proeven toonden aan, dat, indien de fasen een betrekkelijk groot verschil in soortelijk gewicht bezitten (chloroform 1,5, water 1,0), de keuze van de disperse en continue fase weinig invloed op het rendement van het contactproces heeft. De bij de proeven verkregen resultaten zijn in tabel C weergegeven.

TABEL C.

Zuiverheid van de in de waterige voeding aanwezige penicilline in Oxford-eenheden per mg vaste stof [1])	Oplosmiddel	Continue fase	Verhouding tussen de hoeveelheid toegevoerde continue en disperse fase	Omtreksnelheid van de rotor in m/sec.	Percentage van de penicilline in extract	Zuiverheid van de penicilline in Oxford-eenheden per mg vaste stof	
						in raffinaat	in extract
175	MIBK [2])	MIBK	1 : 1	1,73	97,5	35	810
71	MIBK	waterige voeding	1 : 1	1,12	92,1	71	1043
	50—50% $CH\ Cl_3$—MIBK	$CH\ Cl_3$—MIBK	0,67 : 1	1,73	99,5		
	$CH\ Cl_3$	$CH\ Cl_3$	0,67 : 1	1,89	95		
	$CH\ Cl_3$	waterige voeding	0,67 : 1	0,95	96		

[1]) Zie Florey en Jennings, British Journal of Experimental Pathology, Vol. 23, pag. 120, June 1942.

[2]) Methylisobutylketon.

Uitvoeringsvoorbeeld IV.

Twee oplossingen van azijnzuur in methylisobutylketon werden in een glazen contactapparaat bij kamertemperatuur met water in aanraking gebracht. Men bepaalde de invloed van de omwentelingssnelheid van de rotor en de hoeveelheden doorstromende vloeistoffen op het rendement.

De resultaten van deze proeven zijn weergegeven in tabel D. Zij tonen aan, dat men bij verandering van de hoeveelheid doorstromende vloeistof het rendement toch constant kan houden door de rotorsnelheid te variëren. Ook bij deze

proeven kon men steeds een duidelijk visgraatpatroon waarnemen.

Uitvoeringsvoorbeeld V.

Twee verschillende monsters niet-gezuiverde smeerolie, waarvan de viscositeitsindex kleiner dan —50 is, werden in een glazen contactapparaat van het in fig. 2 geschetste type in aanraking gebracht met furfural. De effectieve lengte van het apparaat bedroeg 51 cm, de statordiameter 9,52 cm en de rotordiameter 5,44 cm. Het toerental van de rotor werd constant gehouden en wel op 300 omw./minuut. De voorverwarmde furfural werd bovenin de kolom ingevoerd, de te zuiveren smeerolie onderin. De laatste vormde de disperse fase. Nadat de raffinaatfase van furfural was bevrijd, werd de viscositeitsindex (V.I.) er van bepaald. Bij deze proeven werd steeds een duidelijk visgraatpatroon gevormd. De resultaten waren als volgt:

Viscositeit van de olie in de voeding in S.U. seconde bij 99° C	Doorstromende hoeveelheid in cm³/minuut		Temperatuur van het apparaat in ° C		Raffinaat	
	Smeerolie	Furfural	bij de top	bij de bodem	V.I.	Opbrengst in %
200	640	700	88	79	55	50
60	650	1.075	96	69	44	41

Uitvoeringsvoorbeeld VI.

Een gasmengsel van 27,1 vol % H_2S en 72,9 vol.% stikstof werd bij atmosferische druk en kamertemperatuur in tegenstroom in aanraking gebracht met een waterige oplossing van 15,1 gew.% di-aethanolamine. Men gebruikte hiervoor een glazen contactapparaat van het in fig. 2 afgebeelde type met een effectieve lengte van 71 cm, een rotordiameter van 1.4 cm en een statordiameter van 1,9 cm. De rotor had een constant toerental van 1395 omwentelingen per minuut. Het oplosmiddel werd bovenin het apparaat ingevoerd en wel 0,078 cm³/seconde. Het gasmengsel trad bij de bodem in het apparaat met een snelheid van 3,32 cm³/seconde. Al de aanwezige H_2S werd opgelost.

Men nam vervolgens vergelijkende proeven met hetzelfde gasmengsel, maar met een 6 gew.% oplossing van di-aethanolamine en een apparaat, dat een glazen stator met een diameter van 2,2 cm en een metalen rotor met een diameter van 1,6 cm bezat.

De volgende resultaten werden verkregen:

Snelheid rotor in omw./min	Hoogte vloeistofkolom in cm	Hoeveelheid gas in cm³/sec.	Hoeveelheid oplosmiddel in cm³/sec.	H_2S-concentratie in voeding in %	Percentage verwijderd H_2S
1240	83,7	3,13	0,041	24,5	72,5
0	81,3	3,13	0,037	29,7	56,5

Bij rotorsnelheden, variërende van 1240 tot 1395 omw./minuut, werd een patroon waargenomen, dat overeenkwam met het in fig. 6 afgebeelde.

Uitvoeringsvoorbeeld VII.

Een licht koolwaterstofkraakgas, dat lager kookt dan de butaan-butyleenfractie en dat 2,8 vol.% zure bestanddelen, 25,2 vol.% H_2 en 10 vol.% in 98%-ig zwavelzuur (met 3% Ag_2SO_4) oplosbare bestanddelen bevatte, werd in tegenstroom bij atmosferische druk en kamertemperatuur in aanraking gebracht met poedervormig lampzwart. Men gebruikte hiervoor een contactapparaat met een roestvrij stalen rotor met een diameter van

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Plate 2

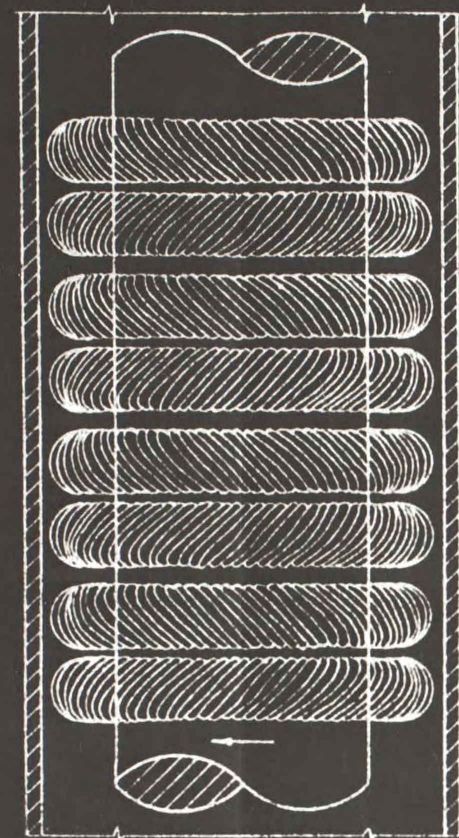

Fig. 3

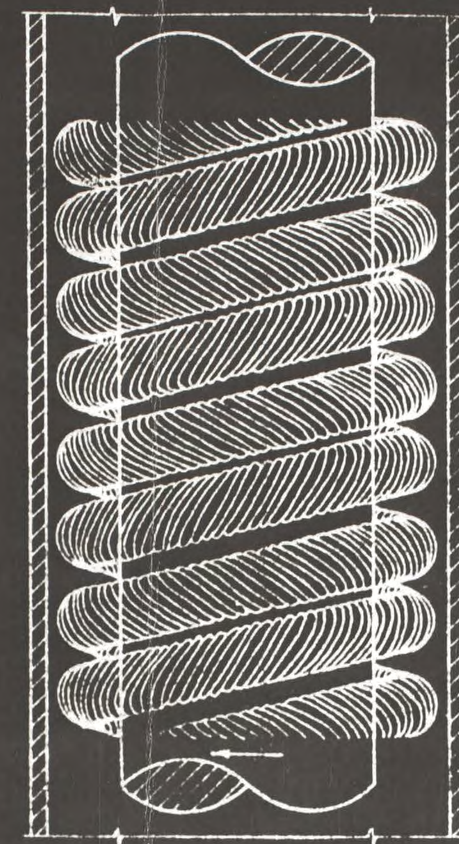

Fig. 4

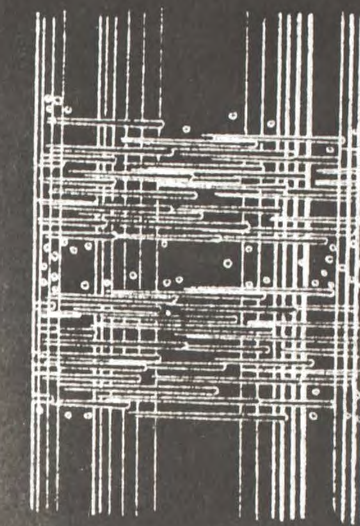

Fig. 7

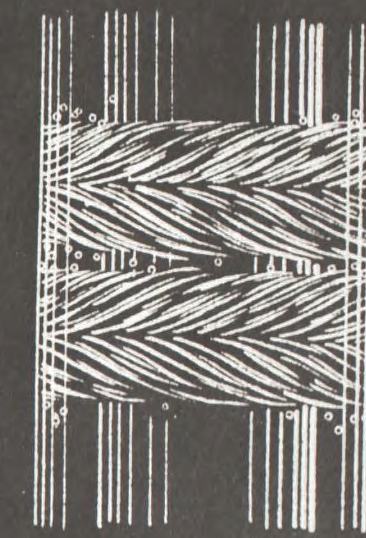

Fig. 8

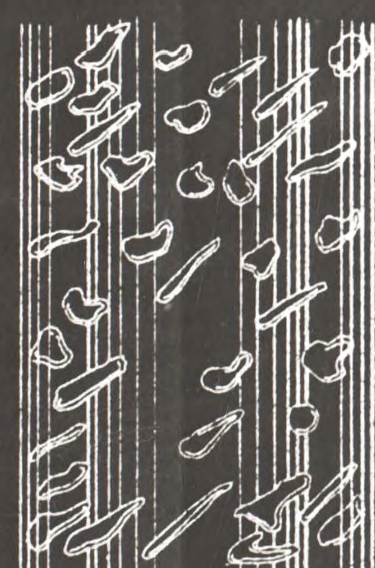

Fig. 5

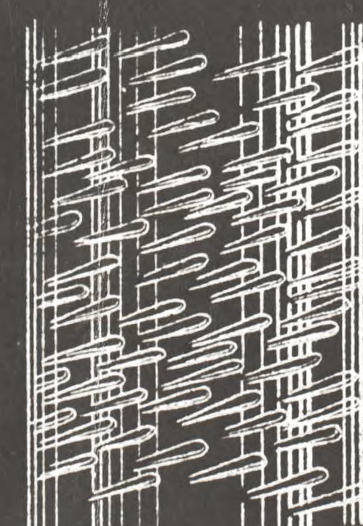

Fig. 6

Fig. 9

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Fig. 1a

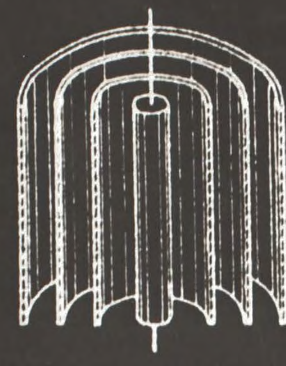
Fig. 1b

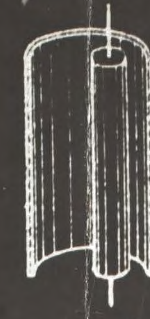
Fig. 1c


Fig. 1d


Fig. 1e


Fig. 1f


Fig. 1g


Fig. 1h


Fig. 1i


Fig. 1j


Fig. 1k


Fig. 1l


Fig. 1m


Fig. 1n

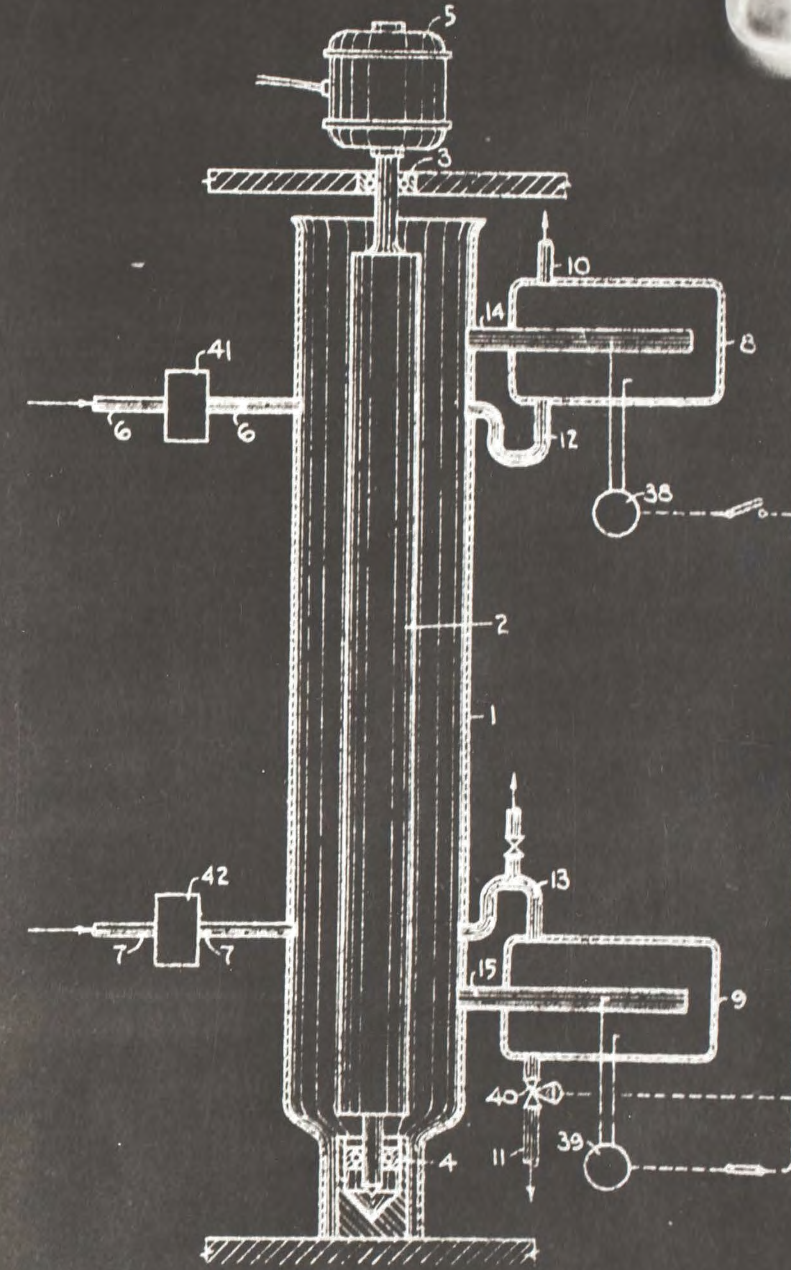

Fig. 2

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f.4/19/40, g.6/30/44, publ.10/2/44, f.Fr.5/1/39

Apparatus for the conversion of nuclear energy into another form of energy.

Centre National de la Recherche Scientifique.

It is known that the neutron is a particle having a mass very close to that of the proton and that the number of neutrons contained in the nucleus of any atom is equal to the difference between the atomic weight and atomic number of the particular atom. It becomes immediately clear that all atoms, except light hydrogen, contain one or several neutrons.

The neutrons are knocked out of the atomic nuclei by bombarding the latter with particles of diverse nature. Thus, for example, a mixture of radon, i.e. the emanation of radium, with powdered beryllium emits the so-called fast neutrons. The neutrons are absorbed by the atoms of the substance which they traverse. This absorption releases energy and it is more or less powerful depending on the nature of the absorbing substance and on the velocity of the neutrons. The fast neutrons (i.e. those having a velocity equal to or higher than 10,000 meters per second) are absorbed only little; the very slow neutrons (i.e. those having a velocity of the order of 2,500 meters per second at most) are absorbed most extensively. The velocity of very slow neutrons being of the order of that imparted to hydrogen atoms by thermal agitation, such neutrons are termed also thermal neutrons.

Certain elements absorb largely neutrons whose velocities range within narrow limits, these limits depending furthermore on the absorbing element. The neutrons so absorbed are termed absorbed by resonance.

The present invention is based on the following discovery:

The fast and the thermal neutrons, upon their absorption in uranium, may cause a rupture of the uranium nucleus into large fragments with concomitant release of energy of 0.00032 erg. This rupture is accompanied by the emission of an average of about three neutrons (now two neutrons, now four, now one, etc.).

It is particularly the last-mentioned phenomenon, namely the emission of an average of three neutrons at each rupture of the uranium atom due to absorption of a thermal neutron, which constitutes the basis of the invention. It must be noted that the thermal neutrons are much more effective than the fast neutrons in causing such ruptures. The "resonance" neutrons do not cause any rupture.

The new neutrons produced at each rupture are fast neutrons. Consequently they are less effective for causing, in turn, new ruptures and very likely will leave the mass of uranium (its dimensions being necessarily limited) without being absorbed.

The authors of the present invention have found that by introducing into the uranium mass a substance containing very light atoms (hydrogen, for example) or light atoms (water, paraffin or, still better, heavy water, i.e. water which contains deuterium, or carbon) which absorb the neutrons only very little, it is possible to reduce the velocity of the fast neutrons (produced upon each rupture) and therefore to increase considerably the chances of obtaining new ruptures with the aid of neutrons that were slowed down. This slowing down of fast neutrons is due to impacts between the latter and the nuclei of light or very light elements introduced into the uranium mass.

The object of the present invention is an apparatus for the conversion of nuclear energy into another form of energy, which is characterized in that it comprises a base material capable of giving, under the action of neutrons, an emission of electrons in chains, containing in its body a neutron-retarding element intended to slow down at least a portion of the latter, in approximate thermal equilibrium with the medium so as to substantially stabilize the development of chains and permit liberation of energy furnished by the transmutations of the base material with a view to its utilization.

The appended drawings represent, by way of an example, an embodiment of the apparatus according to the invention.

Fig.1 shows the entire layout in elevation.
Fig.2 shows the plan corresponding to Fig.1.
Fig.3 shows the end view corresponding to Fig.1.
Fig.4 shows the section on line IV-IV of Fig.2.
Fig.5 shows an enlarged section on line V-V of Fig.2.
Fig.6 shows an enlarged section on line VI-VI of Fig.1.
Figs.7 through 11 show the details.
Figs.12 and 13 are explanatory diagrams.

Prior to describing the embodiment of the apparatus represented in the drawings, some explanations will be given to enable a better understanding of the theoretical considerations which underlie the working of this apparatus.

Let us consider, for example, a mass of uranium in which is distributed a light substance such as for example, heavy water and into the body of which there may be introduced, for example, sectors of cadmium-coated metal plate mounted on discs and serving to absorb a fraction of the thermal neutrons and whose coefficient of absorption becomes progressively greater than that of uranium as the temperature increases. Let us suppose also that an auxiliary source of neutrons is placed, for example, in the center of the apparatus.

A neutron emitted by the auxiliary source causes, by simple absorption, the rupture of a uranium nucleus. This rupture results in an emission of three fast neutrons, for example, each of the latter being able to follow one of the following processes, with otherwise different chances:

1. In diffusing through the uranium mass, each neutron may leave the apparatus without being absorbed, and become lost in space;

2. In traversing the light substance wherein it is slowed down, each neutron may after a certain number of impacts be absorbed by the light atoms;

3. In traversing the uranium mass, each neutron may be absorbed without causing a rupture;

4. If it leaves the light substance with a critical, so-called "resonance", velocity, each neutron is quite liable to be absorbed without causing a rupture;

5. In traversing the cadmium-coated metal plate, each neutron may be absorbed by the latter;

6. In traversing the uranium mass, each neutron may be absorbed and cause a rupture with release of a large amount of energy and emission of three new neutrons.

Two cases may then occur:

Case A. It is easily understood that, if the proportion of the sum total of the first five aforementioned processes (all of which lead to losses of neutrons without creation of new neutrons) is greater than that of the process 6, then the reactions giving rise to ruptures cannot multiply or, more exactly, cannot branch out a great deal.

The diagram in Fig.12 indicates how the reactions of four neutrons branch out when each of the neutrons causes a rupture (the solid circles represent ruptures, the production of new fast neutrons being shown by diverging lines, and the hollow circles represent any one of the aforementioned courses 1 to 5).

It is seen that the four initial ruptures have been followed by the production of only eight ruptures from a total emission of 36 neutrons. The chains are arrested quite rapidly since each of the neutrons at the end of the chains pursues one of the wasteful courses 1 to 5 mentioned above. We would use the term "convergent" chains therefor.

On the average, the successive rupture reactions grow only little and stop after a few reactions. The energy released per second is insignificant and can not be utilized.

Case B. If the proportion of the process 6 is sufficient as compared to the sum total of the processes 1 to 5, then the chain growth will multiply and keep on increasing.

Using the same symbols as in Case A, we will have, for example, the diagram in Fig.13 appended herewith. The first four ruptures are then followed by a substantial number of new ruptures developed with time and the energy released is substantially greater. We would say we are dealing here with "divergent chains".

If, for example, for one neutron causing a rupture, only 1.007 neutrons (on the average) out of the three produced will cause new ruptures, then the number of ruptures will increase with time in geometric progression by the common ratio 1.007, i.e. a divergent progression tending to infinity. To be sure, the system will be broken up by an explosion.

By introducing into the uranium mass a light or very light element (a moderator of fast neutrons emitted at each rupture) and, contingently, an element which absorbs said slowed-down neutrons, it is thus possible to bring into being a divergent rupture chain (case B) with the release of substantial energy.

The chances of obtaining this divergent chain may be increased by trying to alter the relative proportion of the different processes 1 to 6.

The conditions required therefor and which may serve as a basis for effecting the embodiments of the apparatus according to the invention are, among others, as follows:

a) To reduce losses due to escape of neutrons into the space outside of the uranium mass (process 1 mentioned above), the dimensions of the mass of the apparatus may be enlarged; also there may be placed on the outside of the latter a layer of material such as iron, which is non-absorbing and which reflects the escaping neutrons back into the interior of the uranium mass.

The neutrons slowed down behave like a gas which has been generated in a sphere of compressed fine sand. The pressure of the gas or the number of gas molecules per cm^3 is greater in the sand than on the outside due to the multiple impacts of the gas against the sand grains. Besides, the time of residence of each molecule in the sand is substantially increased by increasing the dimensions of the sphere. In the case of neutrons, the chances that they would be absorbed by the uranium are substantially increased by slightly increasing the dimensions of the uranium mass. It is also preferable to use materials very high in uranium, such as the metallic uranium which leads to readily acceptable dimensions for the apparatus.

b) To reduce losses due to absorption of neutrons by the light substance introduced into the uranium (process 2 mentioned above), the preferred choice would be a light substance which absorbs a very little amount of neutrons. The lighter this substance, the better it will retard the neutrons. If we compare: ordinary water, heavy water, carbon, we shall see that the efficiency of retardation for the same quantity of material traversed will be in the following order: ordinary water, heavy water, carbon. But the absorption power will range in the inverse order.

Thus it will be preferable to select heavy water as the moderator because carbon (weak moderator) would occupy in the apparatus a much larger volume, necessitating much larger dimensions for the latter.

c) Utilizing natural uranium, it is possible to reduce losses due to absorption of neutrons by the uranium (process 3 mentioned above), because the absorption of thermal neutrons in the uranium, without rupture, is proportional to that which causes the rupture.

d) To reduce losses due to absorption of resonance neutrons, care should be taken to decrease the proportion of the slowed-down neutrons having the critical velocity termed "resonance". This proportion depends on the choice of the moderator element introduced and on its distribution. Therefore, ordinary water is preferable over heavy water and especially carbon. On the other hand, the proportion of resonance neutrons decreases if the light moderator substance is distributed in discontinuous fashion within the uranium mass. Considering what has already been stated on the subject of the process 2, it seems preferable to select heavy water as the moderator and distribute a small volume thereof within the uranium mass.

e) Losses of neutrons due to absorption in the cadmium-coated plate may be increased or decreased at will by introducing the plate or plates to a greater or lesser depth into the uranium mass.

f) As to process 6, i.e. absorption of neutrons by the uranium with rupture, this factor can not be varied when using natural uranium.

To the extent that the aforementioned conditions have been more or less realized, as a whole or in part, there will be more or less chances of expecting the case B (divergent chain) to materialize.

Thus all that seems to be necessary is simply the introduction of a light or very light element (heavy water or hydrogen, for example) into the uranium mass in order to permit obtaining the divergent chains of ruptures with substantial release of energy.

But this divergent chain of ruptures presents the hazard of incurring an explosive release of energy (which precludes industrial utilization of the apparatus for the purpose of supplying a central heat station, for example).

This is where comes in, ultimately, the introduction of cadmium (or other similar element absorbing thermal neutrons) into the uranium mass. This absorbing element makes it possible indeed to put on the brake - if necessary - on the development of the rupture reactions. As a result of the introduction of cadmium, for example, (in the form of sectors of cadmium-coated metal plate) into the uranium mass, it becomes possible to control the operating conditions of the apparatus in a manner such that the proportion of the rupture process 6 exceeds by a very small quantity the sum total of the processes 1 to 5.

As a matter of fact, the processes 1 to 5 include the waste process 5 whose proportion may be made as large as desired.

The reaction will still be explosive, because the case B is being realized. The chains of the rupture reaction are branching out, the energy released increases and the temperature of the apparatus, i.e. of the uranium and of the moderating light substance, rises. But the effectiveness of the moderation, for a given substance, decreases with rise in its temperature (as the square root of absolute temperature). In proportion to the rise in temperature of the apparatus, the neutrons will be slowed up to a lesser extent and therefore become less effective for causing ruptures.

In fact, the proportion of processes 6 and 3 diminishes while that of processes 1, 2, 4, 5 remains substantially constant. As a result, at any given instant, the conditions of case A will be automatically established, provided that they were initially very close thereto due to introduction of sectors of the cadmium-plated sheets. Then the machine will stop, the chains having become convergent. But when the calories generated in the apparatus are then evacuated, the temperature will drop and the case B will prevail again; with the chains becoming divergent again and the temperature rising again, we have thus an operation of the apparatus between two temperatures. The maximum temperature will be the higher, the more closely the case B had been realized at the start, i.e. the farther the cadmium-coated plate sectors were drawn out from the uranium mass. This temperature is controllable by the position of the cadmium-coated plate sectors.

It should be mentioned that, besides the elements termed here as moderators, the elements designated by the term absorbents have a section effective for the absorption of neutrons. However, the designation "absorbing elements" is justified by the following considerations:

As far as the moderating elements are concerned, their absorbing power is low. These moderating elements are, as already stated and as will be shown further hereinbelow, are light or very light elements. In contrast, for the elements designated by the term absorbents and which are heavy elements, the absorbing power is very high and - an important fact - increases with temperature. The classification of these elements is based on data given in "Tables annuelles de constantes et données numériques pour la physique nucléaire", chapter entitled Neutrons - Coefficients of diffusion (publ.by Hermann & Cie., No.26, 1938, pages 44/89 and 44/95.).

Now a description will be given of the embodiment of the apparatus according to the invention, represented on Figs.1 to 11.

This apparatus comprises an outer shell of refractory brick 1, forming the thermal insulation, and disposed around an inner shell 2 constituted by bricks of a material such as iron for example, non-absorbing and reflecting the neutrons. The thickness of this shell 2 may be several dozen of centimeters.

In the interior of the shell 2 there is arranged an iron casing 3 containing 36 elements in the shape of parallelepipeds 4. Each of the latter contains six cubical elements 5 of nickel-iron alloy about 15 cm, on each side. Between the cubes 5 and the elements 4 there are placed plates 5a of metallic uranium (fabricated as known in the art from uranium hydride) or other material rich in uranium. The cube containing the 36 elements 4 is about 1.10 m. on each side.

Within the 216 small cubes 5 there is circulated a moderating liquid for fast neutrons (preferably pure heavy water of 99.6% deuterium content - such as produced, for example, in Norway by the Norskhydroelektrik). For this purpose the cubes 5 of each element 4 are connected with each other by small conduits arranged alternately near the top and near the bottom (Figs.5 and 10).

The moderating liquid contained in the apparatus is maintained in continuous circulation by two high-pressure rotary pumps, 29-30 which force it through tubes 15-16 into two headers 10 each provided with eighteen valves 27 to control the admission of the liquid into tubes 26 which supply the moderating liquid to cubes 5 in the three upper and lower rows, respectively, of the parallelepipedal elements 4. The moderating liquid flows through the 108 cubes of each of the three lower and upper rows, respectively, of the elements 4, leaves via pipes 19 to pass into collectors 17,18 and thence via pipes 15,16 to the rotary pumps 29,30. The circulation of the moderating liquid is thus uninterrupted.

A reservoir 12 is provided to permit, by means of valves 13 and 14, the evacuation and the storage of the moderating liquid. Control valves 27 are operated electrically by any suitable control device 11.

The moderating liquid thus circulating within the cubes 5 serves as a vehicle for the calories generated in the apparatus. For this purpose the tubes 19 protruding from shell 1 are surrounded by concentric tubes 20 (Fig.11) wherein circulates ordinary water to which the moderating liquid transmits its calories. This cold water, under high pressure, enters the tubes 20 via tubes 22 and leaves as hot water, still under high pressure, via tubes 21, for example at a temperature sufficient for the operation of high-pressure turbines. The assembly of tubes 19 and 20 is enclosed in an insulating shell 23 which is a continuation of shell 1 (Figs.1 and 2). In the interior of the latter, the tubes 19 and 26 for admission and withdrawal of the moderating liquid are provided with insulating wrappers 24,25 (Fig.5). The volume of moderating liquid (heavy water) used may be, for example, 725 liters.

Sheet metal discs 7 serve to carry the sectors 7a made of cadmium-coated metal plate (Figs.7 to 9). These discs are mounted on shafts 6, the rotation of which is effected by suitable electric means 28 (motors, for example) to permit placing the discs 7 into such predetermined positions as are desired. The discs 7 penetrate through slots 8 (Figs.7 to 9) in the walls of elements 4. Tubes 9 serve for the admission and discharge of inert gas (CO_2, for example) into the apparatus, the presence of such gas being intended to prevent oxidation of uranium. Finally, in the center of the apparatus there is disposed the source of neutrons comprising, for example, a small tube 31 which contains a few milligrams of radium mixed with beryllium powder.

The operation of the apparatus is as follows:

The aforesaid state B having been established, the apparatus is regulated with the aid of discs 7 inserted to a greater or lesser extent into elements 4 until the maximum temperature in the apparatus reaches 320°C., for example. And the conditions of case A or case B are attained automatically and alternately when the position of the discs has been regulated, as described herein above.

The vapor pressure of heavy water being about 90 atmospheres at 320°C., and when it is circulated at the rate of 200 liters per second so as to be cooled, for example, to 20°C. in the heat exchanger 23, the amount of heat removed per second will be:

$$200 \times 1000 \times 1.15 \times 300 = 6.9 \times 10^7$$

small calories grams per second (1.15 being the average specific heat of heavy water at these temperatures).

The corresponding capacity of the boiler thus constituted by the apparatus will be:

$$6.9 \times 10^7 \times 4.18 \text{ joule/seconds} = 2.9 \times 10^5$$

kilowatts, or roughly 300,000 kilowatts.

The uranium consumption, using a total mass of 11.75 tons, would be about 3 milligrams per second, or one ton every 10 years.

It is clear from the preceding that the apparatus described permits governing the release of energy by preventing it from becoming explosive, namely:

1. First of all by reducing the velocity of liberated neutrons, so that they become slow neutrons, approximately in thermal equilibrium with the medium. This is effected due to the presence of deuterium combined in the form of heavy water. As already shown, there could be utilized also another very light element, hydrogen in free or combined form, or light elements such as beryllium, carbon, oxygen, for example, in free or combined form. A special merit of very light moderators is that they reduce the quantity of neutrons which are absorbed by resonance in uranium and which might thus become lost for the chain reaction. The resultant decrease in velocity of neutrons provides already one stabilization means, because of the fact that the probability that a neutron would escape the apparatus before being absorbed increases with temperature. It permits, on the other hand, to establish conditions in which a temperature rise leads rapidly to a change in concentrations or distributions of the constituents of the apparatus, thus arresting the growth of the chains.

2. By introducing the sectors of cadmium-coated plate into the uranium mass, to absorb the slowed-down neutrons, in a proportion which is the greater, with respect to absorption by uranium, the higher the temperature.

By the use of these two means, the chains can grow until a sufficiently large energy has been liberated, and can be again automatically interrupted or limited, thereby avoiding explosive development of the nuclear reaction. In this way it is possible to liberate from the uranium mass under discussion, for the purpose of its industrial utilization and commensurate with the requirements, the energy which it is capable of furnishing by transmutation.

In the variations of the apparatus described, it is possible to use, instead of uranium, thorium or a mixture of these two radioactive bodies, or even compounds or mixtures of compounds of these two bodies.

The moderating element or elements may be introduced in the form of a liquid (heavy water, for example), a gas or a solid (powder, for example). They may be more or less intimately mixed with the uranium and the mixture may be obtained by any known procedure. It is feasible, for example, to mix with a compound of uranium or thorium in powder form a hydrogen-bearing compound in solid, liquid or gaseous form; this hydrogen-bearing compound may be, for example, a hydrocarbon, water, water vapor, a hydrogen-bearing gas, a metal hydride or hydroxide.

If the light or very light element introduced into the uranium mass is a gas (hydrogen, helium, etc.) or a vapor (water vapor), it may be introduced if necessary under pressure, particularly so as to maintain the desired concentration of the light or very light element despite the rise in temperature. Instead of introducing into the mass of uranium or uranium compound a light or very light element, this mass may be constituted by a hydrogen compound of uranium or by a mixture of uranium with a non-hydrogen compound of uranium and a hydrogen compound of uranium. As to the proportion of the light or very light element, it should not be too large so as to prevent unlimited branching of the chains. Further below there will be given an approximate formula which makes it possible to estimate this proportion.

To effect a decrease, when the temperature rises, in the proportion of slowed-down neutrons causing the fission of uranium atoms, it has been already shown that there must be introduced into the uranium mass an absorbing element whose absorption coefficient (or the effective section) becomes greater with respect to that of uranium as the temperature rises. In the example shown, this absorbing element is cadmium used in the form of cadmium-coated plate.

In the variations of the apparatus, instead of cadmium, there may be used a compound, a hydrogen compound for example, of cadmium. The introduction of this absorbent may be effected by impregnation with solutions, by a mixture of powders, by insertion of metallic cadmium foil at different points of the uranium mass, or by any other means.

The maximum amounts, not to be exceeded, of the moderating element (hydrogen or other) and of the absorbing element (cadmium or other) introduced into the apparatus may be approximately estimated as follows:

Let P be the product $F_{uf} \times N_u$, wherein

F_{uf} is the effective section of thermal neutrons for producing the rupture of uranium nuclei,

N_u is the number per cm^3 of uranium nuclei in the medium (uranium concentration).

F_{uf} is relative to the mixture of uranium isotopes, although it is known that only the isotope 235 undergoes fission under the action of thermal neutrons. Instead of $F_{uf} \times N_u$, it could just as well be expressed as $F_{u235} \times N_{u235}$ which is a product equal to the preceding.

Let A be the sum total of the products analogous to all bodies which absorb thermal neutrons in accordance with the law $\frac{1}{u}$, i.e. for all bodies present in the apparatus and whose effective absorption surface for thermal neutrons varies approximately as the reciprocal of their velocity u (uranium, hydrogen or others):

$$A = F_R N_R + F_i N_i + F_{usf} Nu + F_{uf} Nu, \text{ wherein:}$$

F_R is the effective absorption section of thermal neutrons for the nuclei of the retarder,

N_R is the number, per cm^3, of nuclei of the retarder in the medium,

$F_i N_i$ is the product of the effective absorption section of thermal neutrons for all of the present nuclei introduced other than those of uranium and retarder, times their respective concentration in the medium,

$F_{usf} N_u$ is the product of the effective absorption section of thermal neutrons for uranium nuclei without producing fissions, times the concentration of uranium in the medium.

Let C be the product (P) for the absorbent element (cadmium or other).

Let: $C = F_c . N_c$, wherein

F_c is the effective section for thermal neutrons in the substance absorbing the neutrons in accordance with a different law, $\frac{1}{u}$ (F_c varies little with u),

N_c is the concentration of the absorbing substance in question (cadmium for example) in the medium.

Let now n be the average number of neutrons produced from one fission of uranium. Among these n neutrons, let n' be the number of those which are capable, for sure, to produce in the apparatus another fission of uranium.

$\frac{n'}{n}$ is the probability that one neutron, produced by one fission and absorbed in the apparatus, would produce another fission.

We have:

$$\frac{n'}{n} = \frac{P}{A + C}$$

In fact, if n neutrons produced by a fission are absorbed in the uraniferous medium, there will be n' of them absorbed by the uranium and each producing a fission while n" will be absorbed by the moderator, the absorbents, etc. without producing fission (n = n' + n").

$$\frac{n''}{n} = (A - P + C)_u$$

wherein u is the velocity of the neutron.

$(A - P + C)_u$ represents the probability of absorption per unit of time, of a neutron having a velocity u which does not produce fission.

$\frac{n'}{n} = P \times u$ = probability, per unit of time, of the absorption of a neutron by uranium and producing a fission.

$$\frac{n'}{n''} = \frac{P}{A - P + C} \quad \text{and}$$

$$\frac{n'}{n' + n''} = \frac{n'}{n} = \frac{P}{A + C}$$

if all of the n neutrons have been, as assumed above, absorbed in the apparatus, some producing and others not producing fissions.

In order that the fissions take place successively in geometrical progression, it is necessary that more than one neutron out of the n neutrons produced at one fission be capable of producing new fissions, i.e. that $n' > 1$, therefrom the equation:

$$n' = n \frac{P}{A + C} > 1 \qquad (1)$$

It has been admitted that n neutrons are absorbed in the apparatus. Or, the latter having finite dimensions, a certain number of neutrons may actually escape from it without being absorbed. The above condition (1) is thus insufficient; it is necessary and we must first satisfy this condition (1) in order that the realization of the apparatus be possible.

We have then:

$$n' = (n' + n'') \frac{P}{A + C} > 1$$

$$n' + n'' < n$$

The ratio $\frac{n' + n''}{n}$ will approach 1 if the dimensions of the uranium-bearing mass (or of the apparatus) are progressively increased, or if it is encased into materials, such as iron, which reflect the neutrons into the uranium-bearing medium.

Therefore, in order to enable the realization of the apparatus, it is necessary that:

$$n' = n \frac{P}{A + C} > 1$$

and it is necessary that the ratio $\frac{n' + n''}{n}$ be as close as possible to unity, due to the use of one of the aforesaid means.

The formula

$$n' = n \frac{P}{A + C} > 1$$

may thus indicate the limits, not to be exceeded, of the concentrations of the bodies introduced into the mixture (here supposed to be homogeneous).

It is clear that the rise in temperature diminishes n' and may cause this quantity to change from a value greater than unity to a smaller value.

In practice, for the realization of the apparatus, we could start with concentrations higher than those indicated in the above formula (for one or several of the bodies) and decrease progressively these concentrations until the desired performance is obtained.

Since the absorbent - as well as the moderating element - may be distributed in heterogeneous fashion within the mass, the latter could consist, for example, of zones of pure uranium (or uranium compound), zones of uranium (or uranium compound) and retarding element mixed together, and finally zones of uranium (or uranium compound) and absorbent mixed together.

The quantity of absorbing element introduced will depend on the temperature of stabilization to be established.

Finally, with respect to the operation of the apparatus represented in the drawings and its possible modifications, we will add the following:

The starting up of the reaction (or its re-starting which may be necessary if its temperature falls below the stabilization temperature) takes place by the action of the source of neutrons 31 as specified in the description of the apparatus. This starting up or re-starting may be effected in the modifications of the present apparatus solely by the action of cosmic radiation, or by some of the neutrons remaining in the apparatus (in case of re-starting), or by introducing into the uranium mass an element, such as beryllium, capable of emitting neutrons in response to the radiation of uranium, or else by neutrons emitted with delay by the substances formed in previous transmutations.

The energy released during the operation of the apparatus may be extracted, for industrial purposes, in the form of heat by conductivity (by contact between the mass and water, for example, to which the heat of the mass will be transmitted), by convection (circulation of water or gas, for example, through the apparatus), by radiation or by effecting endothermic chemical reactions, for example, within the body of the mass.

The agent, if any, used for thermal extraction of the energy of the apparatus may act, as a whole or in part, in the capacity of moderator and/or absorbent. It may also serve as a vehicle for introducing some or all of the substances required in the operation of the apparatus, particularly the cadmium, hydrogen, etc. A certain quantity of energy may be produced supplementarily and utilized by absorbing all or part of the radiations emitted by the apparatus (neutrons, electrons, X-rays, γ-rays, etc.) in suitably chosen bodies and particularly in the bodies constituting the shell. Such extraction means are not otherwise indicated by way of limitation.

The apparatus enables also obtaining very high temperatures susceptible of numerous applications. But the apparatus affords also other applications. The extraction of energy causes, in fact, a strong emission of rays (for example, X-rays, γ-rays or neutrons). Though dangerous and necessitating a protection (water screens) around the whole or part of the apparatus, such rays may on the other hand be suitable for quite interesting applications, particularly for medical purposes.

When the quantity of energy released in the apparatus is in excess of the quantity of energy extracted, the temperature of the mass increases until it reaches or exceeds the predetermined temperature of stabilization. At once, the branching of the chains is limited and the temperature decreases to reach again the temperature of stabilization and drops slightly below this temperature. The branching of chains becomes again unlimited, and so on. Stabilization of reaction is thus effected automatically and without danger of an explosion.

The operation of the apparatus may be arrested: by displacement of the uranium mass (in the case where it consists, for example, of two hemispheres which are then separated and spread apart from each other), or by increasing the quantity of moderator element introduced, or by suppressing the latter. Indeed, when the proportion of moderator element is increased, this means activating the slow-down of electrons but also increasing the probability of their absorption in the atoms of the moderator.

Referring to the explanation of the formula $n' = n \frac{P}{A + C'}$, it is clear that by increasing the proportion of the moderator R we increase N_R and, consequently, $F_R \times N_R$ and A. Therefore, n' decreases and the latter may become less than unity; then the chains no longer diverge.

When the quantity of moderator is reduced, the neutrons produced stay rapid and their effective section of capture in the uranium with production of fissions becomes very small and the condition $n' > 1$ is no longer satisfied.

When A + C greatly decreases, the chances of a neutron escaping from the apparatus are then much greater.

(n' + n") becomes very much smaller than n, and the condition

$$n' = (n' + n'') \frac{P}{A + C} > 1$$ is no longer satisfied.

The stopping of the operation may be also effected by increasing the quantity of absorbing element introduced (insertion of new strips of cadmium, for example, into the mass); or by introducing into the mass, or disposing around the mass, elements which absorb neutrons (insertion of water screens into the mass or the arrangement of a layer of water around the mass); or by drawing away from the mass the exterior diffusing elements, which will be discussed hereinbelow; or by removing the neutron sources previously indicated.

It must be pointed out also that the operation of the apparatus - such as indicated above - is influenced likewise by the quantity of uranium (or uranium compound) used. There is, in fact, all other things being equal, a critical value of the mass of the apparatus, below which the branching of chains will cease to be unlimited. Since science has at its disposal at the present time means for measuring the multiplication of neutrons, it will be easy to estimate by progressive experiments the value of the critical mass. This critical mass may be reduced by disposing around the apparatus diffusing bodies, in a more or less thin layer, and forming, for example, a complete or partial diffusing sheath around the mass, such as 2 in the example described, which does not absorb and reflects the neutrons towards the interior of the uranium-bearing mass. This sheath - being capable of returning to the uranium-bearing mass a fraction of the neutrons which have escaped therefrom and which may be produced in the sheath - favors the formation of chains. Such diffusing bodies may be made not only of iron, as in the example cited, but also of lead, of beryllium, of calcium carbonate (see Tables annuelles de constantes et donnees numériques pour la physique nucléaire, chapter entitled Neutrons, Paris, 1938).

The critical mass may be also reduced by increasing the density of the substance which constitutes it. For a given composition, the critical mass is in fact proportional to the inverse of the square of the density. Thus, to increase the density, there may be used high density compounds (metallic uranium, carburetted or not, uranium carbide, etc.). For the same reason it is preferable to use moderator elements of as high density as possible (use of paraffin in place of water).

It is likewise possible to use, for higher density, granular or powdered compounds of uranium (oxides for example) and compress them greatly; or melt such compounds or else cause mass crystallization; such means are not indicated by way of limitation.

As already shown previously here, a certain number of critical conditions must be realized in order to permit operation of the apparatus described and of the modifications cited. Among these conditions is the determination of the critical mass and, consequently, of the external shape of the apparatus, including that of the diffusing and/or absorbing elements, etc.

Needless to say that, as soon as the apparatus has been put in operation by starting up the reaction, it is advantageous to put into effect progressively the critical conditions (by operating progressively in a sequence opposite to that described for stopping the apparatus) and so as to raise the temperature of mass only gradually.

All means for starting up and/or controlling and/or stopping the operation of the apparatus should preferably allow manipulation at a distance or from behind shields.

To increase the number of effective neutrons produced in the apparatus by fast neutrons, there may be introduced an element (deuterium or beryllium for example) capable, by absorbing a fast neutron, to emit two or more neutrons having a lesser energy.

To maintain the operation of the apparatus, it might be necessary to introduce into the mass supplementary quantities of some of its constituents whose concentrations have been changed as a result of such operation itself.

Finally it should be mentioned that by-products may be obtained from the apparatus, which are the result of its operation; new elements (iodine, potassium, radioactive elements, rare isotopes or mixtures of isotopes in unusual proportions, etc.) appear in the mass as well as in the shields and exterior shells.

The elementary composition of the mass then changes slowly and the instant comes when - the apparatus no longer being able to function - nothing else can be done but open it up and withdraw the elements for recovery of the by-products mentioned above.

In everything that has been stated above, the uranium may be replaced as a whole or in part by any other element having properties similar to those of uranium, for example by thorium. The uranium and thorium, or other similar element, may be used either in the metallic state or in the combined state.

Claim:

Apparatus for the conversion of nuclear energy into another form of energy, which comprises a base substance capable of producing under the action of neutrons an emission of neutrons in chains, containing in its body a neutron-moderating element designed to slow down at least a portion of the latter, in approximate thermal equilibrium with the medium so as to effect a substantial stabilization of the development of the chains and permit liberation of the energy furnished by the transmutations of the base substance for the purpose of its utilization.

Sub-Claims:

1. Apparatus according to the Claim, in which the base substance is a material on uranium base.

2. Apparatus according to the Claim, in which the base substance is a material on uranium and thorium base.

3. Apparatus according to the Claim. in which the base substance is a material on thorium base.

4. Apparatus according to the Claim, in which the moderator element is distributed homogeneously throughout the mass of the base substance.

5. Apparatus according to the Claim, in which the moderator element is distributed heterogeneously throughout the mass of the base substance.

6. Apparatus according to the Claim, in which the moderator element is in the free state.

7. Apparatus according to the Claim, in which the moderator element is in combined state.

8. Apparatus according to the Claim, in which the moderator element is a light element of atomic weight not over 16.

9. Apparatus according to the Claim, in which the moderator element is hydrogen.

10. Apparatus according to the Claim, in which the moderator element is helium.

11. Apparatus according to the Claim, in which the moderator element is beryllium.

12. Apparatus according to the Claim, in which the moderator element is carbon.

13. Apparatus according to the Claim, in which the moderator element is deuterium in combined state.

14. Apparatus according to the Claim, in which the moderator element is oxygen.

15. Apparatus according to the Claim, in which the moderator element is mixed with the base substance.

16. Apparatus according to the Claim, in which within the base substance there is distributed an absorbing element designed to absorb the slowed-down neutrons in a proportion which is the greater, with respect to the absorption by the base material, the higher the temperature.

17. Apparatus according to the Claim and the Sub-Claim 16, in which the absorbing element is on cadmium base.

18. Apparatus according to the Claim and the Sub-Claim 16, in which the absorbing element is distributed homogeneously throughout the base substance.

19. Apparatus according to the Claim, in which the absorbing element is distributed heterogeneously throughout the base substance.

20. Apparatus according to the Claim, in which the absorbing element is introduced in the form of metallic strips inserted into the base substance.

21. Apparatus according to the Claim, in which the base substance is surrounded by a shell of a material which does not absorb and reflects toward the insider the new neutrons tending to escape.

22. Apparatus according to the Claim, in which the base substance is surrounded by a metal shell which does not absorb and reflects toward the inside the new neutrons tending to escape.

23. Apparatus according to the Claim, in which the moderator element is maintained in circulation to serve at the same time for the extraction of energy released in the apparatus.

24. Apparatus according to the Claim and the Sub-Claim 16, in which the absorbing element is maintained in circulation to serve at the same time for the extraction of the energy released in the apparatus.

25. Apparatus according to the Claim, in which the means designed to carry the calories produced and to transport them to the outside serve at the same time as a vehicle for introducing into the apparatus at least some of the substances acting upon the operation of the apparatus.

26. Apparatus according to the Claim and the Sub-Claim 16, in which the absorbing element is capable, on absorption of a fast neutron, to emit at least two neutrons having less energy.

27. Apparatus according to the Claim, which includes exterior protective members against the radiations emitted during its operation.

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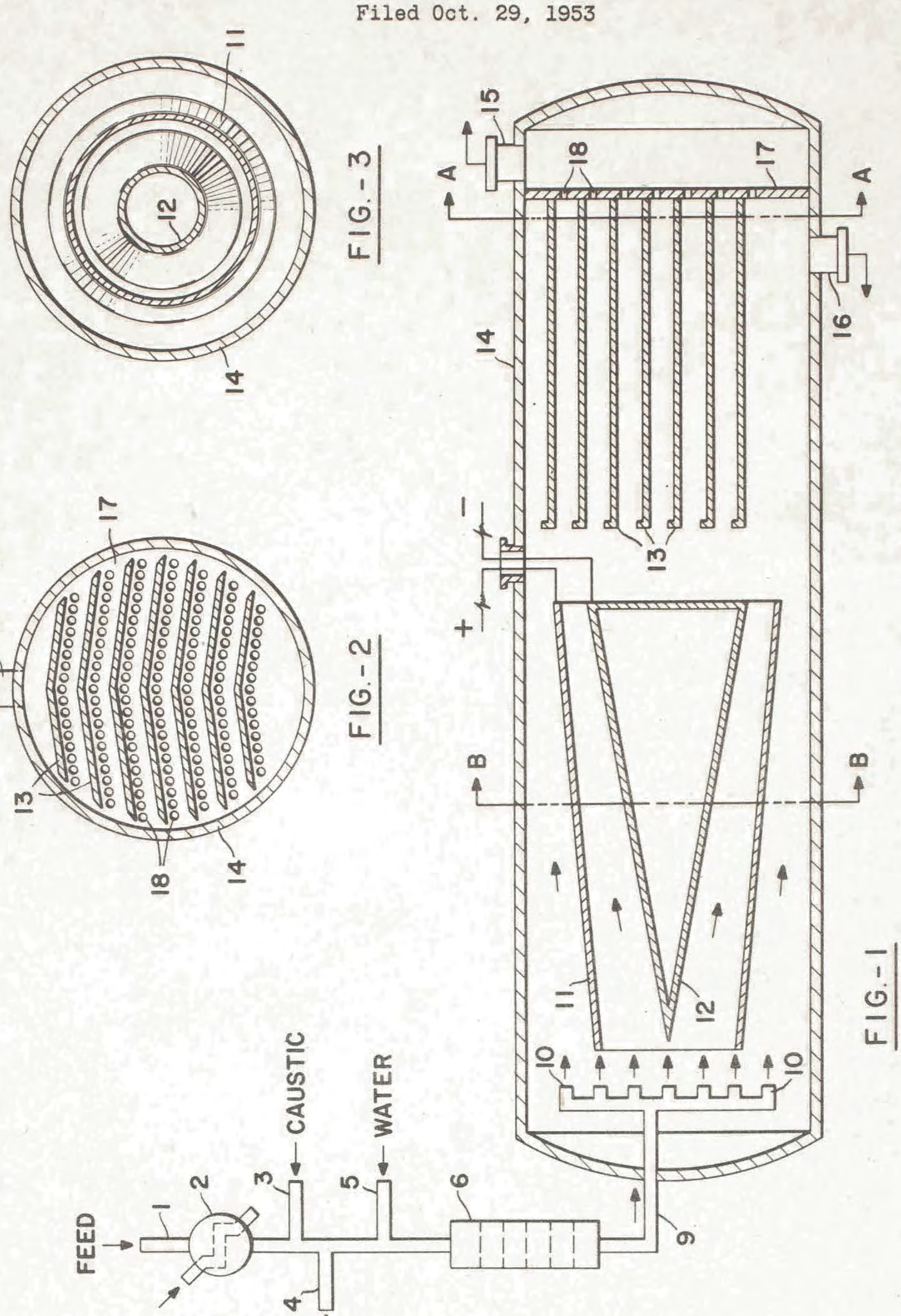
March 4, 1958 R. L. GREENE ET AL 2,825,686

ELECTRICAL COALESCENCE PROCESS

Filed Oct. 29, 1953



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United States Patent Office

2,825,686
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2,825,686

ELECTRICAL COALESCENCE PROCESS

Robert L. Greene and Arthur K. Scott, Westfield, N. J., assignors to Esso Research and Engineering Company, a corporation of Delaware

Application October 29, 1953, Serial No. 388,946

3 Claims. (Cl. 204—190)

The present invention relates to an improved electrical coalescence process and apparatus therefor. The invention is more specifically concerned with an improved arrangement of electrodes for the breaking of oil emulsions, as for example, aqueous oil emulsions. A special adaptation of the present invention relates to an improved process and apparatus for treating hydrocarbon oils to remove foreign substances therefrom, as for example, for the removal of salt from fluid hydrocarbon streams containing the same. The invention is especially concerned with an improved method of electrical desalting wherein the arrangement of electrodes and the flow of the fluid stream being desalted are controlled in a critical manner to secure increased potential per unit of spacing as the fluid hydrocarbon passes through the electrical field.

In accordance with the present invention, a hydrocarbon stream containing salt is chemically treated, emulsified and passed through a zone in which it is subjected to the effect of an increasing potential of electrical field per unit of spacing for improved efficiency of coagulation.

It is well known in the art that various petroleum crudes contain salts and other deleterious substances in various concentrations. These salts comprise magnesium chloride, calcium chloride and sodium chloride. Among other metals present are iron, strontium, potassium and vanadium. Their salts may be present as the bromides, the sulfates, the carbonates and the bicarbonates. It is necessary that these salts be removed from crudes or at least reduced to a large extent since the salts not only cause corrosion of the refining equipment but also plug equipment, as for example, heat exchangers, condensers and the like. While sodium chloride usually is present in the largest concentration, the magnesium chloride and the calcium chloride apparently cause the greatest amount of corrosion and resultant damage of the refining and distillation equipment. It is thus known to remove these objectionable salts by various procedures.

One conventional method employed is to add water to the crude containing these salts and to heat the mixture to an elevated temperature, as for example to about 300° F. The heated stream is maintained at an elevated pressure, as for example, of about 200 lbs. In a desalting operation of this character in order to secure excellent contact between the water and the salt in the crude, it is necessary to secure complete mixing of the water and the crude oil which results in the formation of an emulsion of the oil and water. The mixing may be secured by any means but is usually accomplished by passing the stream through a pressure reducing valve or equivalent. The resulting emulsion is usually passed through a bed of coagulation material which generally comprises sand. The stream is subsequently passed to a settling zone wherein the water and oil segregate. The water phase containing the salt is withdrawn from the bottom of the settling zone while the oil phase which is usually substantially free of salt is removed from the top of the settling zone. The extent to which the oil is freed of salt is to a large degree a function of the size of the equipment and the amount

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of water employed. Usually, in order to secure a satisfactory lowering of the salt content of the oil, it is necessary to employ relatively large equipment.

Various electrical processes have also been suggested. In general, these processes comprise adding water to the salt containing crude, heating the mixture to a temperature of about 250° F. at a pressure of about 200 lbs. and passing the stream through a pressure reducing valve or other mixing means to secure adequate mixing which results in emulsification. The emulsion is passed into a zone containing electrodes which maintain an electrical field between the same. Due to the effect of the electrical field, breaking of the emulsion results which permits the aqueous phase to segregate from the oil phase. The salt to a large extent associates itself with the water phase. While these processes have been satisfactory, it is necessary to employ relatively large equipment. In accordance with the present invention, employing a novel electrode design and arrangement, the potential is increased per unit of spacing as the liquid progresses and flows through the electrical field.

The present invention may be readily understood by reference to the drawings illustrating the apparatus employed therein.

Figure 1 illustrates a coalescent zone constructed in accordance with the invention showing a side view of the electrodes and the coalescent surfaces.

Figure 2 is a cross-sectional view of the coalescent zone of Figure 1 taken about the line A—A.

Figure 3 is a cross-sectional view of the coalescent zone of Figure 1 taken about the line B—B.

Referring specifically to Figure 1, a feed oil to be desalted is introduced into the system by means of line **1**, heated to the desired temperature in heating zone **2** and mixed with caustic which is introduced by means of line **3**. A demulsifier is added to the oil by means of line **4**. However, under certain circumstances it is preferable to add the demulsifier directly to the hot water stream. Hot water is added to the oil stream by means of line **5** and the entire mixture passed through a mixing zone **6**. It is to be understood that the mixing zone preferably comprises a valve wherein the pressure is reduced in order to secure the desired turbulence and suitable mixing. The emulsion is withdrawn from zone **6** by means of line **9** and passed through nozzles **10** in order to jet the emulsion into an electrical field supplied by electrodes **11** and **12** within coalescent zone **14**. A suitable voltage potential is maintained between the positive and negative electrodes **11** and **12** in order to secure breaking of the emulsion. The treated emulsion is withdrawn from the electrical zone and passed horizontally between coalescent surfaces **13**. These coalescent surfaces comprise preferably chevron type structures, as shown in Figure 2. The desalted oil is withdrawn from the upper part of the desalting zone **14** by means of line **15**. The aqueous layer containing the salt is withdrawn from the bottom of zone **14** by means of line **16**. This brine solution may be further handled in any manner desirable to remove entrained oil particles.

The brine droplets which accumulate on the top of surfaces **13** flow outwardly along these surfaces and downwardly along the inner side of the drum. These droplets are collected in the lower area of the drum, and are removed by means of line **16**.

A header element **17** (Figure 2) prevents the free flow of the respective streams between the coalescent elements **13**. The header element has a plurality of openings **18** immediately below each coalescent surface. The number of openings between the respective surfaces is so adjusted as to secure a uniform pressure drop between all elements, thus insuring equal distribution of flow of the streams between the respective coalescent elements.

As pointed out heretofore, Figure 2 is a cross-sectional view of the coalescent zone of Figure 1 taken about the line A—A showing the chevron type coalescent surfaces, the end baffle **17** and the openings **18** in the end baffle immediately below the coalescent surfaces.

The electrical section of coalescent zone **14** has an anode **11**, which is an elongated electrode of generally frusto-conical shape. Disposed within anode **11** is an elongated central cathode **12** of generally conical shape with its axis generally horizontal and with its apex directed toward the inlet end of the zone. The shapes of the cones are such that the distance between anode **11** and cathode **12** decreases in the direction of flow of the liquid.

Figure 3 is a cross-sectional view of the electrical section of coalescent zone **14** taken about the line B—B. It can be seen from Figures 1 to 3 that the spacing between the electrodes decreases and the area of the electrodes increases in the direction in which the oil flows through the electrical section of zone **14**. It is this electrode arrangement which gives increased potential per unit spacing as the fluid hydrocarbon passes through the electrical field.

Although the present invention has been described with its specific application to the desalting of a crude oil, it is broadly concerned with an improved electrical coalescence process and apparatus therefor. It may be adapted to the breaking of any emulsion, particularly aqueous emulsions. The invention is directed to a process wherein the feed stream is subjected to the effect of an electrical field and is subsequently passed to a distinct and separate settling zone. The particular pressures and temperatures employed in such an operation are dependent upon the character of the stream being treated, as well as upon the type and concentration of the dispersed substances present. As pointed out, the present invention is more broadly concerned with an electrical desalting operation wherein the electrical treating zone and the settling zone are separate and distinct areas, wherein chevron type coalescent surfaces are employed in the settling zone, and wherein the electrodes are so arranged so as to increase the potential per unit of spacing in the direction of fluid flow.

In accordance with the present invention, the oil to be desalted is treated with a neutralizing agent, as for example, with a caustic or carbonate solution. The oil is then contacted with a chemical de-emulsifying reagent and emulsified with water. It is preferred that the temperature of the water added be in the range of 150° F. to 250° F. preferably in the range from 190° F. to to 220° F. The chemical reagent may be any known de-emulsification material suitable for aiding emulsion breaking. The emulsion is passed through an electrical zone wherein it is subjected to the effects of an electrical field set up between electrodes arranged so that the potential per unit of spacing increases in the direction in which the oil flows. The voltage between the electrodes may be varied appreciably and may be in the range from about 5000 to 35,000 volts and higher; a desirable voltage is in the range of from about 16,000 to 20,000 volts. The respective phases flow from the electrical field and are passed to a settling zone.

The process involves emulsifying the feed stream which may comprise a crude oil or any refinery stream containing salt. The mixture of water and oil which may contain added chemicals is passed through a mixing zone, preferably a mixing valve or other equivalent means. However, the preferred method of mixing is to pass the stream through a differential pressure control valve resulting in the formation of an emulsion. The emulsion in order to break the same is introduced into a horizontal, preferably a cylindrical vessel containing electrodes operating at relatively high voltages. The emulsion flows horizontally between the electrodes and is subjected to the effect of the electrical field and is thus broken. The phases leaving the electrical field flow to a coalescent zone which is provided with parallel, closely spaced coalescent elements.

In essence, the process is conducted in two distinct stages which are specifically designed for distinct purposes. The electrical field stage is designed to efficiently subject the stream to the effects of the electrical field irrespective of settling requirements while the settling stage is designed to secure rapid and efficient settling irrespective of electrical field requirements.

The emulsification results from the extensive mixing of the respective phases which is necessary in order to secure the desired removal of the salt. As pointed out, various de-emulsification agents may be used, as well as agents for the adjustment of the pH value. One agent of the latter class is sodium hydroxide which is usually employed in a concentration which varies from about 0 to 15 lbs. of sodium hydroxide per thousand barrels of oil being desalted. The oil is usually heated to a temperature in the range from about 150° F. to 350° F. and maintained at a pressure in the range from about 25 lbs. to 300 lbs. per square inch. In accordance with the preferred adaptation of the present invention, the oil is heated to a temperature in the range from about 220° F. to 270° F., and maintained at a pressure in the range from about 100 lbs. to 250 lbs. per square inch gauge. The mixing is secured by passing the heated stream under pressure through a pressure-reducing valve or equivalent means so as to reduce the pressure thereon. It is desirable to have a pressure drop of from about 25 to 85 lbs. per square inch through the mixing valve. Obviously, if the feed stream contains a sufficient quantity of water, it may not be necessary to add additional water. A particularly desirable method of desalting a crude oil is to heat the same to a temperature of about 250° F. and to maintain the pressure on the stream at about 220 lbs. to 240 lbs. per square inch gauge. This stream is passed through a pressure reducing valve or equivalent means wherein the pressure is reduced, for example, to about 140 to 150 lbs. per square inch gauge.

By utilizing the particular electrodes of the present invention, unexpected desirable results are secured. In the first place, the use of such electrodes concentrates the electrostatic field and produces marked improvements in the coalescent action. Furthermore, the use of these electrodes eliminates the channelling of oil flow through the electrode zone. A very distinct advantage of the present invention is that the electrodes utilize the vessel cross-sectional area very efficiently.

What is claimed is:

1. In apparatus for breaking emulsions which comprises a horizontally disposed vessel, an emulsion feed inlet at one end of said vessel, and outlet for oil and an outlet for water at the opposite end of said vessel, a plurality of spaced-apart electrodes within said vessel adjacent said inlet, means for imposing electrical potentials of opposite polarity on adjacent electrodes, and a plurality of coalescent surfaces disposed within said vessel intermediate said electrodes and said outlets, the improvement which comprises an electrode arrangement including an elongated horizontally disposed central electrode and at least one additional electrode coaxially arranged with respect to said central electrode, said electrode arrangement being such that, in the direction away from said inlet and toward said coalescent surfaces, the spacing between adjacent electrodes decreases and the total effective area presented by the electrodes in a given vertical cross section increases.

2. An electrode arrangement as defined by claim 1 including an elongated central electrode of generally conical shape having its axis generally horizontal and its apex

toward said inlet and a second electrode of generally frusto-conical shape surrounding said first electrode.

3. In a process for removing salt from a liquid hydrocarbon which includes the steps of emulsifying said hydrocarbon with water and flowing the resulting emulsion through an electrical treating zone where it is subjected to an electrical field and then to a settling zone wherein separation between water and oil is effected, the improvement which comprises applying said electrical field in said electrical treating zone by flowing said emulsion through an electrode arrangement providing decreased electrode spacing and increased total electrode area in the direction of fluid flow.

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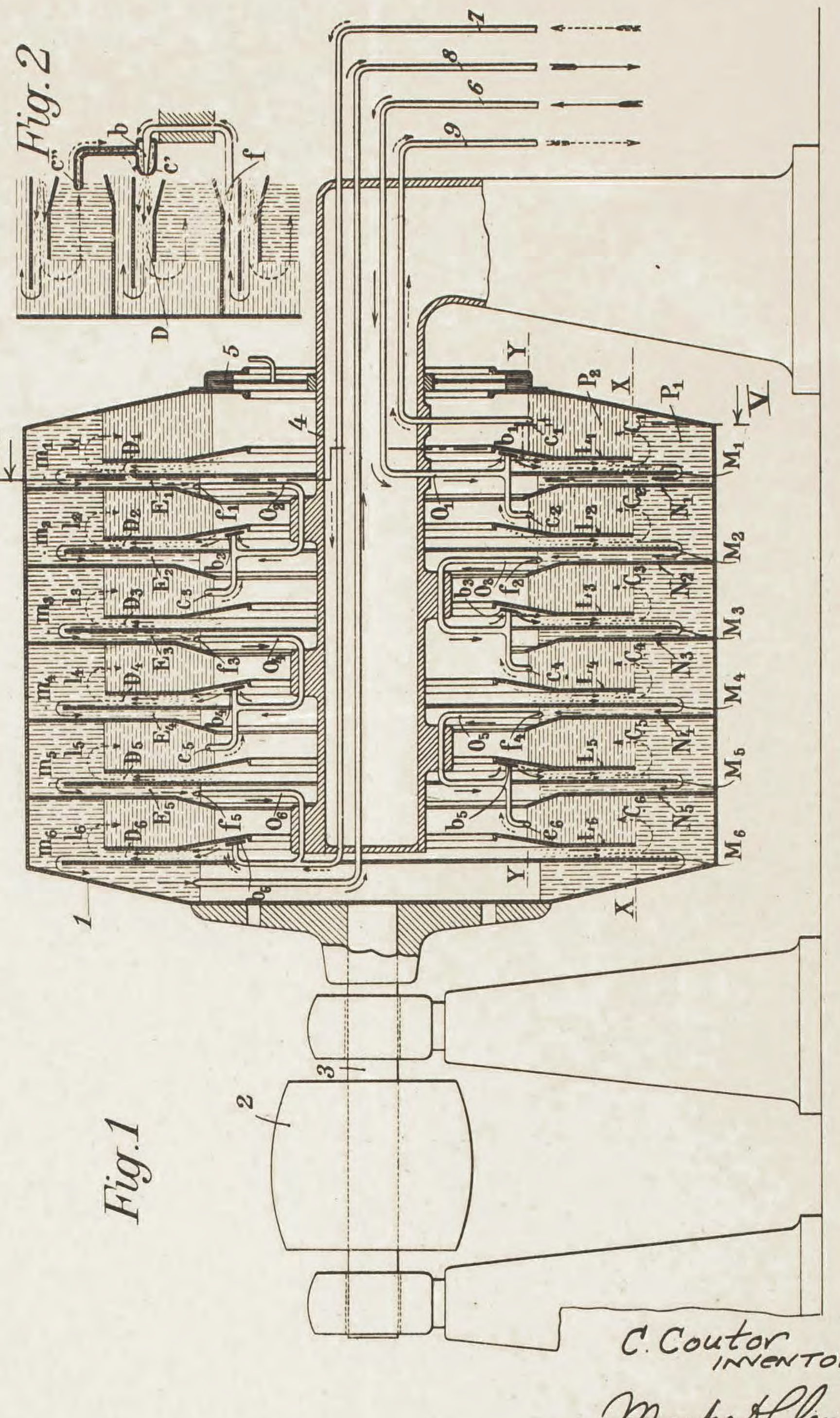
PROCESS AND APPARATUS FOR THE CONTINUOUS EXTRACTION OR TREATMENT OF LIQUIDS

Original Filed May 14, 1934 2 Sheets-Sheet 1



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PROCESS AND APPARATUS FOR THE CONTINUOUS EXTRACTION OR TREATMENT OF LIQUIDS

Original Filed May 14, 1934

2 Sheets-Sheet 2

Fig. 1a

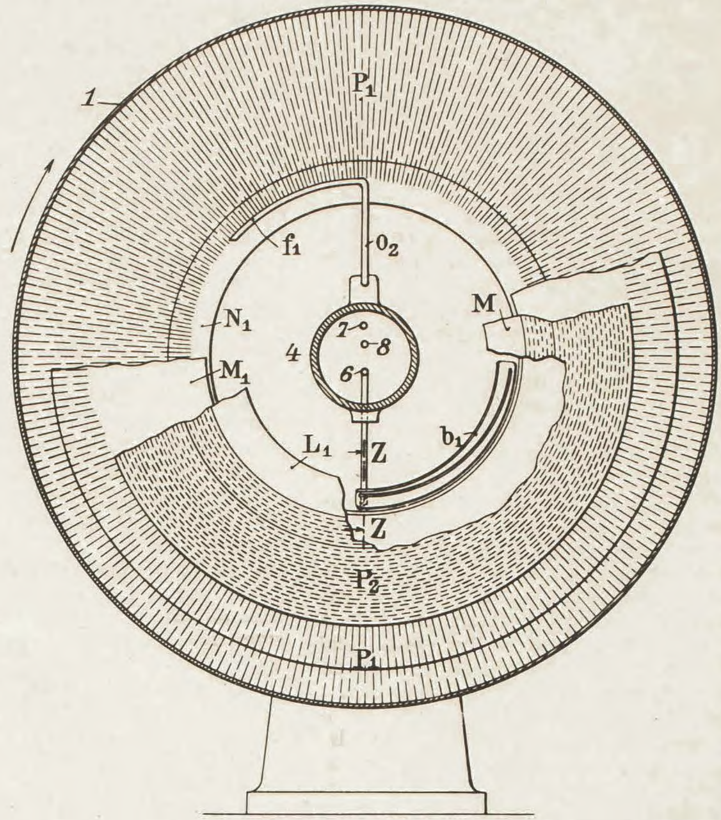
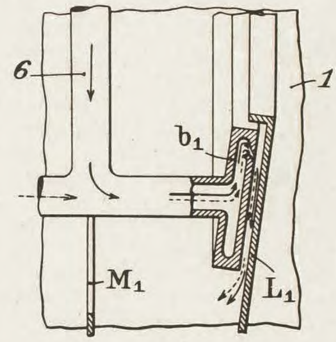


Fig. 1b



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UNITED STATES PATENT OFFICE

21,168

PROCESS AND APPARATUS FOR THE CONTINUOUS EXTRACTION OR TREATMENT OF LIQUIDS

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Original No. 2,036,924, dated April 7, 1936, Serial No. 725,630, May 14, 1934. Application for reissue March 17, 1938, Serial No. 196,576. In France May 19, 1933

18 Claims. (Cl. 196—45)

It is a common practice in industry to extract a definite body from a mixture constituting a liquid phase by a solvent or a reagent also liquid and non-miscible or incompletely miscible with the mixture under consideration.

For that purpose, use is generally made of columns of the counter-current type, with or without an inner lining, or a series of mixers provided with mechanical stirrers, followed by decanting apparatus; according to certain processes, the whole or a portion of the vapours of the solvent is used, in columns, for mixing or moving the liquids.

All these apparatus used have the inconvenience of being either of insufficient efficiency, or difficult to carry into practice, and are costly.

The present invention has for its object a process which makes it possible to effect, continuously, and by a single passage through a simple and compact apparatus, the methodical and complete extraction or treatment of a liquid by another liquid acting as solvent or reagent.

The process according to the invention is mainly characterized by the fact that the circulation and separation of the various products: mixture to be treated, solvent or reagent, intermediate and final products, are automatically ensured by centrifugal force, which is used, for that purpose, under the following conditions:

(*a*) The liquids are caused to circulate on the counter-current principle, for example, in a multi-stage apparatus, for ensuring a methodical and complete exhaustion of the mixture.

(*b*) Both liquids (solvent or reagent and mixture) are simultaneously caused to enter through fixed pipes, and they are simultaneously projected on conical walls rotating at a high speed.

(*c*) Preferably, use is made, concurrently with the movable walls, of fixed surfaces arranged very near the latter, so as to produce, by friction, a thorough stirring and intimate mixing of the liquids; this result can also be obtained by atomization, for instance, under the action of the available pressure of the liquids.

(*d*) The centrifugal force produces the separation of the emulsified mixture into concentric layers of different densities, viz.: into a layer comprising the solvent or reagent loaded with the body to be extracted, and into another layer formed by the empoverished mixture.

(*e*) The liquids of these various layers are separately drawn off by scoop-pipes similar to those of centrifugal apparatus of the so-called "cream separator" type, these scoop pipes conveying the various products as stated, that is to say on the counter-current principle and through several stages in which the above operations are repeated.

When these operations are terminated, the solvent or reagent and the body it has carried along are separated by any suitable process, for instance by distillation, or again by a treatment according to a process similar to that indicated above.

Of course, for carrying out the process the principle of which has just been set forth, it is possible to provide any suitable arrangements, capable of varying in the widest limits, according to the conditions of application (nature of the products to be treated, of the operations to be effected, etc.) without departing thereby from the scope of the invention.

The number and variety of the possible applications of this process are in fact very extensive: for instance, and without this enumeration being in any way limitative, there can be cited: the removal of tar from pyroligneous acids, removal of oil from methyl phlegms, purification of residual waters, extraction of acetic acid from its aqueous solutions, extraction of acetic acid from tars by washing with water, extraction of ethyl and methyl alcohols from their mixtures with ethers, separation of the anhydride-acetic acid mixture by petroleum, extraction of phenols, extraction of essential oils, acid or alkali treatments of petroleum on the counter-current principle, purification of oils and greases by oxidation or reduction, etc.

Likewise, any suitable plant can be devised for carrying this process into practice and especially any suitable modifications, considering the particular conditions of application, can be made in the dimensions of the apparatus, arrangement of the scoop-pipes, number of stages or of successive treatments, etc.

In certain cases it may be desirable or possible, considering the complexity of the mixture, to discern more than two concentric layers capable of being simultaneously separated; additional scoop-pipes and partitions can then be provided and suitably arranged.

Concerning that point, one may be led to draw off, in the form of sludge, a precipitate the density of which will be comprised between those of both liquids.

Likewise, it is possible to use as reagent a pulverulent product which practically behaves as a liquid in the various partitions of the apparatus, but, in this case, the scoop-pipes and mixing devices will of course be modified. This will be done when a liquid is treated by a carbon or decolouring earth, for instance.

Furthermore, use can be made, without departing from the invention, of a centrifugal apparatus rotating about an axis of orientation, the liquids can be introduced in said apparatus after previous cooling or reheating, and, consequently, the apparatus can be heat insulated or heated, the operation can be effected in presence of any gas, under vacuum or under pressure, etc.

By way of example, and in order that the invention may be more clearly understood, a form of construction of such an apparatus will be described hereinafter with reference to the accompanying drawings, this apparatus being adapted to be used for the extraction of a body dissolved in water, by means of a light solvent.

Fig. 1 is an axial vertical section of the entire apparatus.

Fig. 1^a is a cross section made according to broken line V—V of Fig. 1.

Fig. 1^b is a partial section, on an enlarged scale, made according to line Z—Z of Fig. 1^a.

Figure 2 is a similar partial view of a modification.

This apparatus comprises a turbine body 1, capable of receiving a rapid movement of rotation from a suitable motor (not shown), for instance through the medium of a transmission comprising a belt, a pulley 2 and a shaft 3.

This turbine rotates about a fixed hollow shaft 4 which passes through one end thereof, preferably through a hydraulic joint 5 ensuring fluid-tightness.

The shaft contains the inlet and outlet conduits for the products, viz.: a conduit 6 through which is admitted the mixture to be treated and a conduit 7 through which is admitted the solvent or reagent, a conduit 8 through which is discharged the exhausted mixture, and a conduit 9 through which is discharged the solvent or reagent loaded with the extracted product. The arrows in full lines indicate the mixture to be treated and the arrows in broken lines, the solvent or reagent.

The body 1 is divided into six juxtaposed compartments C_1C_2 . . . C_6 by five annular partitions N_1N_2 . . . N_5, and in each of these compartments are arranged two other annular partitions L_1M_1, L_2M_2 . . . L_6M_6, respectively; the partitions M_1 to M_6 have an outer diameter smaller than the inner diameter of the body 1 and the partitions L_1 to L_6 have a diameter smaller than that of the partitions M_1 to M_6. These partitions are arranged as follows:

The partition M_1 . . . M_6 (each partition bears indicia of the compartment to the left of which it is located in Fig. 1) is arranged at right angles to the axis of the turbine, so that a passageway m_1 . . . m_6 is provided between its outer edge and the wall of the body 1.

To the right of the preceding partition M_1 . . . M_6 is a partition L_1 . . . L_6 having a central frustum-shaped portion and the outer edge of which is offset relatively to that of M_1 . . . M_6, so as to provide a second peripheral passageway l_1 . . . l_6.

Finally, to the left of each of the partitions M_1 . . . M_5, is a third partition N_1 . . . N_5 secured to the inner wall of the body 1.

Free narrow spaces D_1 . . . D_6 exist between the partitions L, M and other narrow spaces E_1 . . . E_5 are provided between the partitions M, N.

The decanting compartments alone are relatively large.

The circulation of the products takes place moreover through fixed tubes, arranged in the following manner:

The solution is led through the compartment C_1 . . . C_6 from right to left on the drawings through scoop-pipes f_1 . . . f_5 one end of which opens in the space comprised between the two partitions M, N and having an extension constituted by a conduit O_2, O_3 . . . O_6 terminating in an annular jet b_2 . . . b_6 opening very near the frustum-shaped portion of the corresponding wall L_2 . . . L_6.

On the other hand, the solvent or reagent flows through the compartments C_6 . . . C_1 from left to right on the drawings through scoop pipes c_6, c_5, c_4, c_3 which extend from the compartment bearing the same indicia and leads to the annular jet b bearing a lower indicia.

The inlet ends of the scoop-pipes are so arranged that the liquids enter therein by inertia.

The conduit 6 through which is admitted the solution terminates in a conduit O_1 and an annular jet b_1 opening in proximity to the wall L_1 and to which leads the scoop-pipe c_2; the ends of these pipes extend through a relatively important arc of the circumference of the apparatus as diagrammatically indicated in Fig. 1*a*. The distance separating the fixed and movable surfaces is so adjusted as to ensure satisfactory emulsion of the solution and solvent.

The discharge conduit 9 for the extracted product is fed by a scoop-pipe c_1 opening in the compartment C_1.

The inlet conduit 7 for the solvent or reagent opens in the last annular jet b_6.

Finally, the discharge conduit 8 for the exhausted solution extends down, in the compartment C_6, beyond the last partition L_6.

The operation is as follows:

The solution to be treated, admitted through 6 and O_1, is projected by the jet b_1 on the frustum-shaped portion of the wall L_1, at the same time as the solvent or reagent which has already passed through the five compartments C_6 . . . C_2 and is led to this jet b_1 by the scoop-pipe c_2.

Both liquids, intimately mixed, thus enter the mixing space or chamber D_1 in which the exhaustion of the solution begins.

These liquids are subjected to the action of centrifugal force and, owing to their difference of density and of their non-miscibility, they separate and form two concentric annular layers P_1, P_2, the outer layer P_1 being formed by the solution, which is the heavier, and the inner layer P_2 by the solvent.

The separating surface X—X of the two layers reaches, during the rotation, a level which depends on the radial distance separating the inlet ends of the scoop pipes c_1 and f_1, c_2 and f_2, etc., and on the density of the liquids treated, and this radial distance is so adjusted that in each compartment the said surface of separation XX is located at a distance from the axis of rotation at most equal to the radius of the respective disc L_1 or L_2 . . . , and however large enough in order that the layer of solvent comprised between the level XX and the level YY of the inlet ends of the solvent scoop-pipes c_1c_2 . . . . should have a sufficient thickness.

The solvent of the layer P_2 is drawn off through the scoop-pipe c_1 and discharged through the conduit 9, whilst the solution, passing through m_1 and E_1 is drawn off through the jet f_1 and sent, through O_2, b_2, into the compartment C_2, at the same time as the solvent coming from the compartment C_3 passes through the scoop-pipe c_3.

The exhaustion thus progressively proceeds in the various compartments through which pass, on the one hand, the solution and, on the other hand, the solvent or reagent, according to the counter-current principle.

According to the modification illustrated in Fig. 2 each space D is supplied with a mixture of solvent and solution through a double jet having two concentric orifices: the inner jet serves for the admission of the solution, which is sent to it from one compartment by a scoop-pipe *f*, and the outer jet c', serves for the admission of the solvent, which is sent to it from the next compartment through a scoop-pipe c''

I claim:

1. An apparatus for removing at least one of the constituents from a liquid mixture by centrifugation of the mixture and scooping the separate liquid layers, comprising a drum rotatively mounted and laterally bounded by two annular discs, arranged for forming with the drum an inner annular compartment, means for causing this drum to rotate at a high speed, two annular discs secured within this drum and arranged for dividing said annular compartment into a lateral space of great width, a narrow intermediate space and a narrow lateral space, the disc limiting the narrow lateral space extending outwardly to a small distance from the periphery of the drum, and the disc separating the intermediate space from the space of great width extending outwardly to a greater distance from the periphery of said drum, a fixed nozzle opening at the inner periphery of said drum, in the intermediate space and directed towards the annular disc separating this space from the space of great width, a supply piping opening in this nozzle and adapted to lead from the exterior the mixture of liquids to be treated, a supply piping also opening in this nozzle and adapted to convey the solvent in the latter, a scoop-pipe extending from the lateral space of great width and adapted to evacuate the solvent laden with the constituent to be removed from the mixture, and a scoop-pipe extending from the narrow lateral space and adapted to evacuate the treated and exhausted mixture.

2. An apparatus for removing at least one of the constituents from a liquid mixture as claimed in claim 1, in which the inner peripheral portion of the disc separating the intermediate space from the space of great width, has a portion in the shape of a conical surface.

3. An apparatus for removing at least one of the constituents from a liquid mixture, as claimed in claim 1, in which the outlet orifice of said nozzle opens against the portion in the shape of a conical surface separating the intermediate space from the space of great width, said orifice being very close to said conical surface.

4. An apparatus for removing at least one of the constituents from a liquid mixture, as claimed in claim 1, in which the end of the scoop-pipe extending from the lateral space of great width and the end of the scoop-pipe extending from the narrow lateral space, are directed in a direction reverse to the direction of rotation of the drum.

5. An apparatus operating on the counter-current principle for removing at least one of the constituents from a liquid mixture as claimed in claim 1, in which the drum is internally divided into a series of annular compartments, each of which is divided into a lateral space of great width, a narrow intermediate space and a narrow lateral space, and has a nozzle within each intermediate space, the piping adapted to convey the mixture of liquids to be treated opening in the last nozzle at one of the ends of the drum, the piping adapted to convey the solvent opening in the last nozzle at the other end of the drum, the narrow lateral space of each compartment being connected to the nozzle of the following compartment, relatively to the direction of circulation of the mixture being treated, by a scoop-pipe, and the space of great width of each compartment being connected to the nozzle of the following compartment, relatively to the direction of circulation of the solvent, by another scoop-pipe.

6. A method for extracting a body from a complex liquid mixture by means of an auxiliary body acting as solvent or reagent on said body to be extracted, this auxiliary body being liquid and nonmiscible with the liquid mixture to be treated, said method consisting in introducing together the liquid mixture to be treated and the auxiliary body into a rotary vessel where they come in intimate contact, then separate in the form of concentric layers under the influence of centrifugal force, one of the layers being especially constituted by the auxiliary body and that of the liquid bodies it has dissolved, and the other layer being especially constituted by the impoverished liquid mixture, and in continuously extracting from each of these layers the portion situated nearest the axis of rotation by a scooping operation.

7. A method for extracting a body from a complex liquid mixture by means of an auxiliary body acting as solvent or reagent on said body to be extracted, this auxiliary body being liquid and nonmiscible with the liquid mixture to be treated, said method consisting in introducing together the liquid mixture to be treated and the auxiliary body into a rotary chamber where they come in intimate contact, then separate in the form of concentric layers under the influence of centrifugal force, one of the layers being especially constituted by the auxiliary body and that of the liquid bodies it has dissolved, and the other layer being especially constituted by the impoverished liquid mixture, in continuously extracting from each of these layers the portion situated nearest the axis of rotation by a scooping operation, and in discharging the liquids thus extracted respectively in two other rotary chambers where they again separate in the form of concentric layers and so on, so that the solution circulates in one direction and is consequently enriched with the body to be extracted, and the impoverished liquid mixture insoluble in the auxiliary body circulates in the reverse direction and is consequently purified, the evacuation and transfer of the liquids from one chamber to another being always produced by scooping out from portions of said liquid layers situated the nearest to the axis of rotation.

8. In a process of treating one liquid substance with another liquid substance of different density containing a solvent or reagent for a part of the first liquid substance, the steps of centrifugally stratifying said liquid substances in concentric layers about an axis, causing said layers while subject to centrifugal force to flow beside one another in a direction transverse to said axis against the action of centrifugal force in separated, non-contacting portions each having its surface nearest said axis free and substantially

parallel to the axis, and continuously scooping both liquid substances by their force of rotation from said separated portions.

9. In a process of treating one liquid substance with another liquid substance of different density containing a solvent or reagent for a part of the first liquid substance, the steps of centrifugally stratifying said liquid substances in concentric layers about an axis, causing said layers while subject to centrifugal force to flow beside one another in a direction transverse to said axis against the action of centrifugal force in separated, non-contacting portions each having its surface nearest said axis free and substantially parallel to the axis, continuously scooping both liquid substances by their force of rotation from said separated portions, and repeatedly subjecting said scooped layers in counter-current with one another after commingling them with one another to such centrifugal and scooping operations.

10. In a process of treating one liquid substance with another liquid substance of different density containing a solvent or reagent for a part of the first liquid substance, the steps of causing a continuous flow of said liquids in counter-current to one another through a centrifugal machine having several annular compartments, in each compartment centrifugally stratifying said liquid substances in concentric layers about an axis, causing said layers while subject to centrifugal force to flow beside one another in a direction transverse to said axis against the action of centrifugal force in separate, non-contacting portions each having its surface nearest said axis free and substantially parallel to the axis, continuously scooping both liquid substances by their force of rotation from the free surfaces thereof in each compartment, and repeatedly leading said scooped layers in counter-current to one another from compartment to compartment by their force of rotation.

11. In a process of treating one liquid substance with another liquid substance of different density containing a solvent or reagent for a part of the first liquid substance, the steps of causing a continuous flow of said liquids in counter-current to one another through a centrifugal machine having several annular compartments, in each compartment centrifugally stratifying said liquid substances in concentric layers about an axis, causing said layers while subject to centrifugal force to flow beside one another in a direction transverse to said axis against the action of centrifugal force in separate, non-contacting portions each having its surface nearest said axis free and substantially parallel to the axis, continuously scooping both liquid substances by their force of rotation from the free surfaces thereof in each compartment, repeatedly leading said scooped layers in counter-current to one another from compartment to compartment by their force of rotation, and finally scooping one repeatedly treated liquid from the first compartment and the other repeatedly treated liquid from the last compartment.

12. In a process of treating liquid hydrocarbons with acids, the steps of causing a continuous flow of said hydrocarbons and acids in counter-current to another through a centrifugal machine having several annular compartments, in each compartment centrifugally stratifying said hydrocarbons and acids in concentric layers about an axis, causing said layers while subject to centrifugal force to flow beside one another in a direction transverse to said axis against the action of centrifugal force in separated, non-contacting portions each having its surface nearest said axis free and substantially parallel to the axis, continuously scooping said hydrocarbons and acids by their force of rotation from said separated portions, and repeatedly leading said scooped hydrocarbons and acids in counter-current to one another from compartment to compartment by their force of rotation.

13. In a process of treating liquid hydrocarbons with alkalies, the steps of causing a continuous flow of said hydrocarbons and alkalies in counter-current to one another through a centrifugal machine having several annular compartments, in each compartment centrifugally stratifying said hydrocarbons and alkalies in concentric layers about an axis, causing said layers while subject to centrifugal force to flow beside one another in a direction transverse to said axis against the action of centrifugal force in separated, non-contacting portions each having its surface nearest said axis free and substantially parallel to the axis, continuously scooping said hydrocarbons and alkalies by their force of rotation from said separated portions, and repeatedly leading said scooped hydrocarbons and alkalies in counter-current to one another from compartment to compartment by their force of rotation.

14. In a process of treating one liquid substance with another liquid substance of different density containing a solvent or reagent for a part of the first liquid substance, the steps of centrifugally stratifying said liquid substances about an axis in concentric layers separated by an intermingled layer, continuously leading further liquid substances into the intermingled layer between said concentric layers, and causing said separated layers while subject to centrifugal force by their difference in specific gravity to flow separated by walls beside one another in a direction transverse to said axis, each separated layer having its surface nearest said axis free and substantially parallel to said axis, and continuously scooping each separated layer by its force of rotation.

15. In a centrifugal separator, a compartment mounted to rotate about an axis and having its portion remote from the axis closed, a partition in said compartment transverse to said axis dividing the compartment into two sections and providing a passage between said sections adjacent the outside of the compartment, and means to feed a mixture of liquids into one of said sections at a point closer to the axis than said passage but further from the axis than the inner edge of said partition, and means to scoop liquid from each of said sections in the portion adjacent said axis.

16. In a centrifugal separator, a compartment mounted to rotate about an axis and having its portion remote from the axis closed, a pair of partitions in said compartment dividing the same into sections and extending transversely to the said axis, the first of said partitions providing a passage between two of said sections adjacent the outside of the compartment, the second partition terminating closer to the axis of the shaft than the innermost point of said passage, means to feed a mixture of liquids to the section between said partitions, and means to scoop liquid from each of the outer sections in the portion adjacent said axis.

17. In a centrifugal separator, a compartment mounted to rotate about an axis and having its portion remote from the axis closed, a pair of partitions in said compartment dividing the same into

sections and extending transversely to the said axis, the first of said partitions providing a passage between two of said sections adjacent the outside of the compartment, the second partition terminating closer to the axis of the shaft than the innermost point of said passage, means to feed a mixture of liquids to a section on one side of said second partition, and means to scoop liquid from each of the other two sections in the portion adjacent said axis.

18. A centrifugal separator comprising a series of compartments mounted side by side for rotation about an axis, each compartment having its portion remote from the axis closed, a partition in said compartment transverse to said axis dividing the compartment into two sections and providing a passage between said sections adjacent the outside of the compartment, means to scoop liquid from each of said sections in the portion adjacent said axis, means to mix the liquid scooped from the second section of each compartment except the last of the series with the liquid scooped from the first compartment of the second succeeding compartment of the series, means for mixing the liquid scooped from the second section of the next to last compartment and from the first section of the second compartment of the series with fresh liquid, means for introducing such mixed liquids into the intermediate sections at points closer to the axis than said passages but further from the axis than the inner edges of said partitions, and means to remove liquids scooped from the first section of the first compartment and the second section of the last compartment.

CHARLES COUTOR.

File

Liquid Liquid extraction

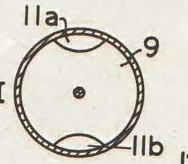
1126

Dec. 16, 1941. W. J. D. VAN DIJCK 2,266,521

COUNTERCURRENT CONTACT APPARATUS

Filed Dec. 9, 1939

Fig. II



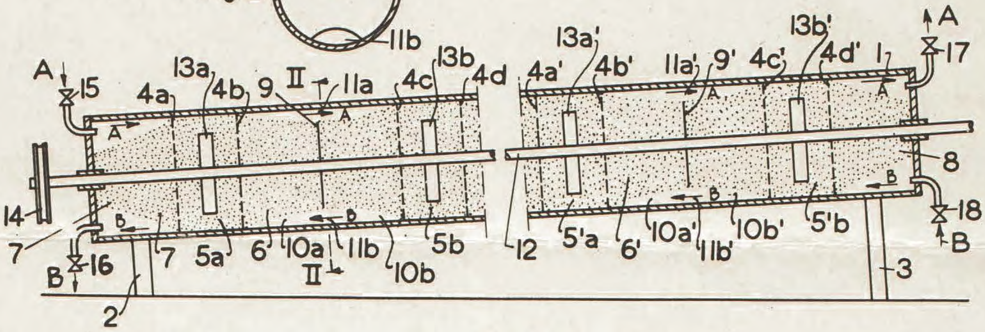


Fig. I

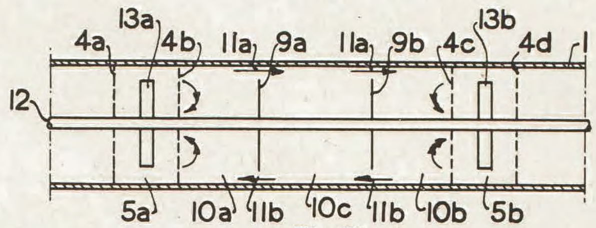


Fig. III

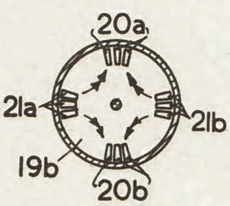


Fig. V

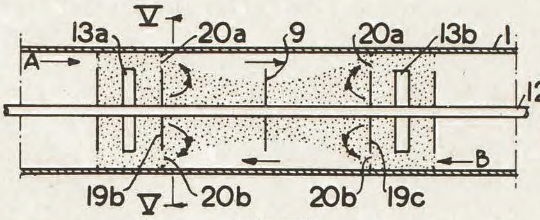


Fig. IV

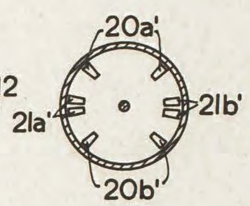


Fig. VI

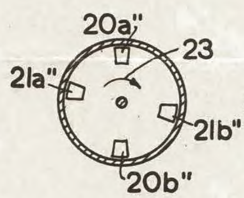


Fig. VIII

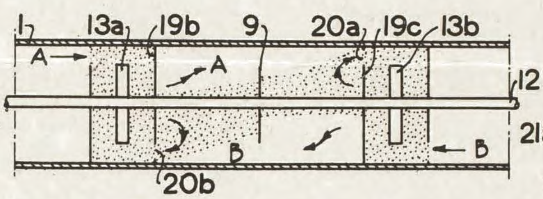


Fig. VII

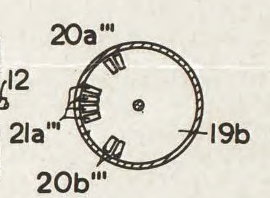


Fig. IX

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By his Attorney Oswald H. Milmore

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UNITED STATES PATENT OFFICE

2,266,521

COUNTERCURRENT CONTACT APPARATUS

Willem Johannes Dominicus van Dijck, The Hague, Netherlands, assignor to Shell Development Company, San Francisco, Calif., a corporation of Delaware

Application December 9, 1939, Serial No. 308,437
In the Netherlands December 14, 1938

9 Claims. (Cl. 23—270.5)

The invention relates to an apparatus for contacting continuously and countercurrently two non-miscible or only partly miscible liquids of different specific gravities such contacting being usually performed with the object of withdrawing one or more components from one liquid with the aid of the other liquid as, e. g., in extracting or washing operations, or with the object of subjecting one liquid to a chemical treatment with the other. The invention more particularly relates to improvements in an apparatus of the type wherein a horizontal, inclined, or vertical tube or shell is provided with transverse perforated partitions, subdividing the shell into a connected series of alternating mixing and settling zones and wherein the two liquids pass through these mixing and settling zones in opposite directions; certain features of the invention may, however, also be employed in devices wherein the mixing and settling zones are not arranged in the same shell. The stirring devices present in each mixing zone in the preferred embodiment may be mounted on a common rotatable shaft extending in the longitudinal direction of the tube or shell and turned by a pulley.

An apparatus of this general type is described in United States Patent No. 2,154,713. It provides a settler between every two mixers, in which settler the separation of the liquid phases contained in the mixtures leaving the mixing zones should take place and from which the separated liquids should be fed again to the mixing zones in such a manner that in all settling zones one liquid flows toward one end of the tube and the other liquid flows in the opposite direction. Because in such a device each intermediate settling zone receives mixtures from the two adjacent mixing zones and is in direct communication with both of these zones, it is unavoidable, especially if the stirring devices are capable of effecting an intensive circulation in the settler, not only that the liquid already treated in a mixing zone is returned to the same mixing zone—which inherently reduces the capacity of the apparatus—but also, what is even more objectionable, that this liquid is returned to the preceding settling zone and from there is allowed to enter the preceding mixing zone resulting in a decrease of the efficiency of the treatment per stage and thus in the case of extraction in a decrease of the sharpness of the separation.

It is an object of the invention to provide an apparatus of the type described wherein suitable structures, such as perforated walls, are provided in the settlers between any two mixing zones in such a manner that the above drawbacks of the usual countercurrent stirred column are obviated.

It is a further object of the invention to improve the structure of the partitions separating the mixing and settling zones, so as to improve the transfer of material from and to the mixing zones.

Other objects of the invention will be apparent from a reading of this specification.

In subsequent discussion and in the claims to avoid confusion the term wall has been used to designate the structures which subdivide the settling zone whereas the term partition has been reserved to designate the structures which separate the mixing and settling zones.

The apparatus according to the invention, comprises a connected series of alternating mixing and settling zones arranged to cause the two liquids to pass in opposite directions through the mixing and settling zones countercurrently to one another and one or more walls in each intermediate settling zone arranged to subdivide the settling zone into at least two spaces, one space being in direct communication with only one of the mixing zones adjacent to the said intermediate settling zone, and another space being in direct communication only with the other mixing zone adjacent to said intermediate settling zone The wall or walls are provided with openings located at different levels, and the walls are preferably substantially imperforate between the levels of said holes, so that only the lighter liquid separated in the settling zone flows through the opening at the higher level and only the heavier liquid flows through the opening at the lower level. By this arrangement mixing of mixtures from two different mixers and the return of a liquid to a preceding mixing or settling zone is minimized or obviated. The mixing and settling zones may be separate units connected with conduits, but are preferably located within a single cylindrical shell as illustrated. Such a shell may be placed in any position, such as from 0 to 90° from the horizontal, the only requirement being that the walls dividing the settling zones into spaces be not horizontal so as to permit openings in the walls to be located at different levels. This may, in certain installations, require that the walls be not perpendicular to the axis of the shell.

Figure I is a sectional elevation view of one preferred embodiment of the invention.

Figure II is a cross-sectional view taken on section line II—II of Figure I.

Figure III is a fragmental sectional elevation view of a modified apparatus wherein two walls are provided in the settling zone.

Figure IV illustrates a fragmental section of an apparatus provided with modified partitions between mixing and settling zones.

Figure V is a cross-sectional view taken on section line V—V of Figure IV showing the modified partition.

Figures VI, VIII and IX are sectional views similar to Figure V showing modified arrangements of the holes in the partitions.

Figure VII is a fragmental section of an apparatus similar to Figure IV illustrating a further modification in the partitions wherein certain openings are omitted.

Referring to Figure I, **1** is an inclined cylindrical shell carried by suitable supports **2** and **3** and subdivided by partitions **4***a*, **4***b*, **4***c*, **4***d*, **4***a'*, **4***b'*, **4***c'* and **4***d'*, etc., formed of perforated plates or sieves to provide alternating mixing and settling zones. Any suitable number of partitions may be provided, only four mixing zones **5***a*, **5***b*, **5***a'*, **5***b'* with intermediate settling zones **6** and **6'** in addition to end zones **7** and **8** being illustrated. Walls **9** and **9'** divide their respective settling zones into sub zones or spaces **10***a*, **10***b*, **10***a'* and **10***b'*. The walls **9** and **9'** at the top and bottom are perforated by openings **11***a*, **11***b*, **11***a'* and **11***b'* respectively. The space **10***a* is in direct communication only with the mixing zone **5***a* while the space **10***b* is in direct communication only with the mixing zone **5***b*.

A common shaft **12** carries agitators **13***a*, **13***b*, **13***a'* and **13***b'* such as propellers or stirring rods, and is turned by pulley **14** to provide mixing in the mixing zones.

Valves **15** and **16** control the feed to and outflow from the end settling zone **7** while valves **17** and **18** similarly control the outflow from and feed to end settling zone **8**.

Referring to Figure I, a light liquid A is fed from the left through valve **15** and a heavy liquid B from the right through valve **18**. These liquids pass through the apparatus countercurrently, and are repeatedly contacted with each other in the mixing zones so as to interact the light liquid A leaving the apparatus through valve **17** and the heavy liquid B through valve **16**.

During the operation of the apparatus a mixture is thus continuously produced in the mixing zones, which mixture, owing to, inter alia, the centrifugal effect and the differences in specific gravity, moves to the adjoining settling zones in which separation takes place. The regions within the shell zones containing mixtures of liquids have been indicated diagrammatically in the drawing by dots, regions containing single phases being left unmarked. The mixture fed into the settling zone stratifies, i. e., the light liquid rises and the heavy liquid descends so that the mixture has above it the separated liquid A and below it the liquid B. The space **10***a* receives the mixture only from mixing zone **5***a*, and the space **10***b* receives the mixture only from mixing zone **5***b*. Now it is the intention that of the stratified phases at the top only the A liquid should pass from the left-hand space **10***a* to the right in order to enter mixing zone **5***b* whilst at the bottom only the B liquid should pass from the right-hand space **10***b* to the left in order to reach mixing zone **5***a*. To this end openings **11***a* and **11***b* of suitable size, through which the two liquids move in the said directions as shown by the single-headed arrows, have been made in the wall **9** at top and bottom. The shell is shown placed slightly inclined, so as to obtain the displacement in the desired direction by a rising of the light and a falling of the heavy liquid, although such inclination is not essential.

The walls **9** and **9'** perform two distinct functions: they prevent the mixing of the two mixtures of liquids from the spaces **10***a* and **10***b*, etc., which mixtures were produced in different mixing zones and are, therefore, in different stages of treatment; and they prevent the moving of the liquids separated from these mixtures by settling in the undesired direction, thereby preventing flow to a mixing or settling zone where the liquid in question is still in a previous stage of treatment. In other words, the perforated wall only enables mixing of the separated liquids in the direction in which the liquid in question flows through the apparatus. Thus, the light liquid A in space **10***b*, which is already in a further stage of treatment than that in **10***a*, cannot return to space **10***a*, and thence to mixing zone **5***a*, in which case the efficiency of the treatment would be reduced.

Referring to Figure III, the construction is similar to that shown in Figure I, reference characters **1**, **4***a*, **5***b*, **4***c*, **4***d*, **5***a*, **5***b*, **12**, **13***a* and **13***b* designating the same elements. In this modification the settling zone between the mixing zones **5***a* and **5***b* is provided with two walls **9***a* and **9***b*, thereby separating the settling zone into terminal spaces **10***a* and **10***b* (in direct communication with mixing zones **5***a* and **5***b*, respectively) and an intermediate space **10***c*. The walls **9***a* and **9***b* are provided with holes **11***a* and **11***b*, as described for Figures I and II.

The intermediate space **10***c* permits liquid entrained with the material flowing through the holes **11***a* and **11***b* to settle out. Thus, the reavy liquid B moving to the left from the space **10***b* may contain an undesirable amount of the liquid A because the mixture in the space **10***b* is not entirely quiescent. This entrained liquid A rises in the intermediate space **10***c*, wherein substantially no agitation obtains. The heavy liquid B which flows through the bottom opening **11***b* of the wall **9***a* to the space **10***a* is thereby substantially free from the liquid A. In the same manner the light liquid A flowing from the space **10***a* is, in the space **10***c*, freed from entrained liquid B.

The fewer superfluous circulation currents there are the more rapid will be the demixing or stratification in the settling zones. Circulation (i. e., two way flow) between a particular mixing zone and the adjacent settling zone is, of course, necessary, because only one of the two liquids should move from said settling zone to the next mixing zone, whereas the other liquid must return to the said particular mixing zone. For bringing about this necessary circulation inclination of the shell or provision of pumps are not necessary; the disturbance of the equilibrium due to the mixing is sufficient. Thus, this mixing produces in the mixing zone of a dispersion having a density intermediate the densities of the separated liquids A and B in the settling zone. The separated liquids therefore flow through the openings at top and bottom of the partitions **4***a*, etc., from the settling zones to the mixing zones, whilst the mixture flows at an intermediate level from the mixing zones to the settling zones. Owing to the centrifugal effect of the rotating stirring devices, however, the liquids in the mixing zone near the shaft **12** will be caused to flow radially outward in the mixing zone, drawing in material from the settling zone near the shaft.

This sets up a circulation in the settling zone in the direction from the circumference of the tube to the center, as shown by the double-headed arrows in Figure III. This superfluous circulation causes an increased consumption of energy and a decrease of the capacity of a given apparatus. Now according to the invention one may prevent this superfluous circulation due to centrifugal effect by providing the connections between mixing zones and settling zones in an otherwise closed partition at points substantially spaced from the shaft, preferably adjacent to the shell and at equal distances from the center line of the rotating shaft. In order to maintain the circulation resulting from the disturbance of the equilibrium by the mixing action, openings have been provided at least both at the level of the rotating shaft and above and below it. This is illustrated in Figures IV and V.

Referring to Figures IV and V, reference numbers **1**, **9**, **12**, **13***a* and **13***b* designate the same elements as in Figure I. The device in these figures differs only in that the sieve-like partitions **4***a*, etc., are replaced by partitions **19***a*, **19***b*, **19***c*, and **19***d*, which are imperforate except for the radial inlet openings **20***a* and **20***b* at the top and bottom and the radial outlet openings **21***a* and **21***b* at about the level of the shaft **12**. The distribution and shape of the radial openings is shown in Figure V.

The circulation of the mixture and of the separated liquids between the mixing zone and the settling zone adjoining it are shown in Figures IV and V by the double-headed arrows, the flow of the separated liquids between the spaces of the settling zone being shown by the single-headed arrows. The mixture formed leaves the mixing zone through the openings **21***a* and **21***b* situated at the level of the shaft and the separated liquids return to the mixing zone through the top and the bottom openings. If these currents are compared with those, as shown in Figure III, caused by the centrifugal effect, it is found that, on account of their direction, the currents according to Figures IV and V, are much more favorable with a view to creating a place of comparative quiescence and with pure liquids A and B at the top and bottom, respectively, of the settling zone near wall **9**; the dimensions of the settling zone, measured in the direction of the shaft, may then be smaller.

The intensity of the circulation thus created by the disturbance of the equilibrium depends, besides on the difference in specific gravity between the two liquids, on the vertical distance between the outlet openings **21***a* and **21***b* and the inlet opening **20***a* as well as on the vertical distance from the outlet opening to the inlet opening **20***b*. If, with the openings **20***a* and **20***b* provided right at the top and at the bottom, this circulation should be too intensive, outlet openings **20***a'* and **20***b'* may be provided at levels nearer to the level of the outlet openings **21***a'* and **21***b'* as shown in Figure VI.

One may also provide all the openings, not on the circumference of the partition, but at smaller equal distances from axis of the shell.

Attention may be drawn to the shape of the openings **20***a*, **20***b*, **21***a* and **21***b* in partition **19***a*, etc., as shown in Figures V and VI; each of them consists of a number of radial slots. The object of this shape is to prevent propagation of the rotation of the liquid mixture in the mixing zone about the axis of the tube, which rotation is caused by the rotation of the stirrers **13***a*, **13***b*, etc., through these openings into the settling zone. It has been found that the radial slots offer great resistance to flow in a direction having a tangential as well as an axial component with respect to the shell.

It will be observed that the current in the upper left-hand part of the settling zone in Figure IV and that in the lower right-hand part both shown by the double-headed arrows are such as to cause the movement of the liquid A or B to counteract the movement required to create a continuous flow of A or B through the whole apparatus. From this point of view it may, therefore, in certain cases be better to omit the group of upper inlet openings **20***a* of partitions **19***b* and **19***d*, and the group of lower inlet openings **20***b* of partitions **19***a* and **19***c* altogether, or to reduce their size or to provide them at a level nearer the center of the shaft.

One example of such an arrangement is shown in Figure VII, wherein all reference characters indicate the same elements as in Figure IV, but the openings **20***a* in partitions **19***b* and **19***d* and the openings **20***b* in partitions **19***a* and **19***c* are omitted.

Besides the causes of circulation between a mixing zone and the adjoining settling zone already considered, another cause of such circulation may be mentioned. The rotation in a single direction of the stirrers involves that the distribution of light and heavy liquids over the mixing zone is asymmetrical with respect to a vertical plane through the shaft of the stirring device, in such a manner that in the horizontal plane through the shaft the percentage of heavy liquid in the mixture is higher on the side of the shaft where the stirrers rise than on the side where they move downwards. The differences in pressure corresponding to this non-uniform distribution create a compensating circulation current extending through the settling zone in a horizontal plane from the opening past which the stirrers rise to that past which the stirrers move downwards. In order to avoid this undesirable circulation the outlet openings through which the mixture flows from the mixing zone to the settling zone may be displaced circumferentially in the direction of rotation of the stirring device, so that these openings come to lie at levels where the mixture in the mixing zone has practically the same composition.

A modified form of the partition wherein the outlet holes **21***a''* and **21***b''* are located in this manner to avoid circulation currents due to asymmetrical distribution of light and heavy liquids is shown in Figure VIII. The direction of rotation of the shaft is indicated by the arrow **23**. The inlet openings **20***a''* and **20***b''* are located at the top and bottom, but may be located as shown in Figure VI.

It is also possible to provide one or more openings for the passage of mixture from the mixing zone to the settling zone on one side of the shaft only. Such an arrangement is shown in Figure IX, showing the inlet openings **20***a'''* and **20***b'''* and only one group of outlet openings **21***a'''*.

Each of the figures shows only part of the complete apparatus, which may be equipped with a large number of mixing and settling zones connected in series. The apparatus in Figure I may be conceived to consist of a number of sections, separated by the walls **9**, **9'**, etc., each of which comprises a central mixing zone and settling space on both sides thereof; one of these settling spaces supplies the separated A liquid treated in these sections to the adjoining section, the other settling zone supplies the B liquid to the other adjoining section.

The apparatus may be adapted in a known manner to the distribution of the components of a third liquid C over the two liquids A and B, which for this purpose is fed into one of the mixing zones at an intermediate point between the two ends of the apparatus.

I claim as my invention:

1. Apparatus for contacting continuously and countercurrently two at least partially immiscible liquids of different densities comprising a longitudinal cylindrical shell, a plurality of partitions situated transversely to the axis of said shell subdividing the shell into a series of alternating mixing and settling zones, inlet openings in said partitions for the flow of liquid from the settling zones into the mixing zones, outlet openings in said partitions for the flow of a mixture of liquids from the mixing zones into the two settling zones, adjacent each mixing zone, a stirring device in each mixing zone mounted on a common rotatable shaft, said shaft running longitudinally through said shell, whereby said liquids can flow in opposite directions through said mixing and settling zones, and a wall in an intermediate settling zone dividing said settling zone into spaces, said wall being substantially imperforate except for openings at its outer edges, one space being in direct communication with only one of the mixing zones adjacent to the settling zone and another space being in direct communication with the other adjacent mixing zone only, and openings in said wall for the passage of the liquids located at different levels.

2. The apparatus according to claim 1, wherein the shaft of the stirring devices is located substantially at the center of the shell and the openings in the partitions between the mixing and settling zones are situated at substantial distances from the shaft.

3. The apparatus according to claim 1, wherein the shaft of the stirring devices is located substantially at the center of the shell and the openings in the partitions between the mixing and settling zones are situated at substantial distances from the shaft, and at equal distances from the center line of the rotating shaft.

4. Apparatus for contacting continuously and countercurrently two at least partially immiscible liquids of different densities comprising a longitudinal, cylindrical shell disposed in a position other than vertical, a plurality of partitions situated transversely to the axis of said shell, dividing the shell into a series of alternating mixing and settling zones, inlet openings in said partitions for the flow of liquid from the settling zones into the mixing zones, outlet openings in said partitions for the flow of a mixture of liquids from the mixing zones into the two settling zones adjacent each mixing zone, a stirring device in each mixing zone mounted on a common rotatable shaft, said shaft running longitudinally through said shell whereby said liquids can flow in opposite directions through said mixing and settling zones and a wall in an intermediate settling zone dividing said settling zone into spaces, one space being in direct communication with only one of the mixing zones adjacent to the settling zone and another space being in direct communication with the other adjacent mixing zone only and openings in said wall for the passage of the liquids located at different levels, the openings conducting the denser liquid being situated at a lower level than the opening conducting the lighter liquid, said openings being at the outer edges of said wall, and said wall being otherwise substantially imperforate.

5. Apparatus according to claim 4, wherein the partitions between the mixing and settling zones contain at least two outlet openings located substantially diametrically opposite to each other, one opening being slightly above and the other slightly below the level of the shaft at the position of the respective partitions.

6. Apparatus according to claim 4, wherein the outlet openings in the partitions between the mixing and settling zones are situated approximately at the level of the shaft of the stirring device at the position of the respective partitions and are provided on one side of the shaft only.

7. Apparatus according to claim 4, wherein the outlet openings in the partitions between a mixing zone and a settling zone are shaped as radial slots radially arranged with respect to the shaft of the stirring device.

8. Apparatus according to claim 4, wherein the inlet openings in the partitions between the mixing and settling zones are situated at a substantial distance from the extreme top and bottom of the partitions.

9. Apparatus for contacting continuously and countercurrently two at least partially immiscible liquids of different densities comprising in combination a series of alternating mixing and settling zones connected by suitable inlet and outlet conduits, said mixing zones being provided with mixing means, said inlet and outlet conduits being arranged to permit the two liquids to flow in opposite directions through said mixing and settling zones and a transverse wall, which is inclined to the horizontal, in an intermediate settling zone dividing the settling zone into two spaces, one space being in direct flow communication with only one of the mixing zones adjacent to said settling zone, and another space being in direct communication with the other adjacent mixing zone only, openings in said wall for the passage of the liquids, the opening conducting the denser liquid being situated at the bottom and the opening conducting the lighter liquid being situated at the top of said wall, the latter being substantially imperforate between said top and bottom.

WILLEM JOHANNES DOMINICUS VAN DIJCK.

Nov. 21, 1933. W. D. COOLIDGE 1,936,424

ELECTRICAL DISCHARGE DEVICE AND METHOD OF OPERATION

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Fig. 1.

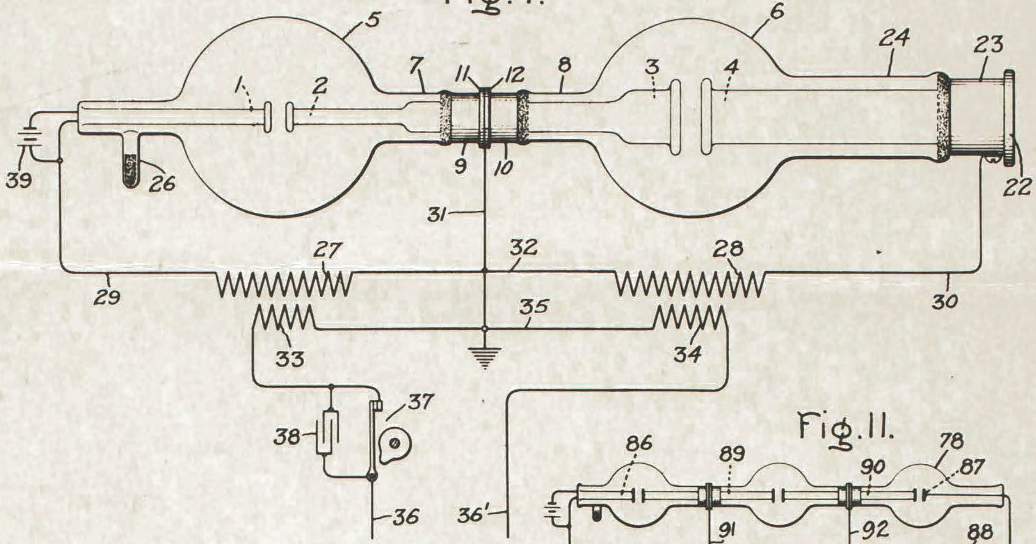


Fig. 11.

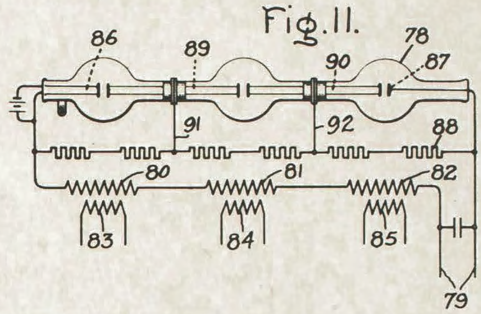


Fig. 2.

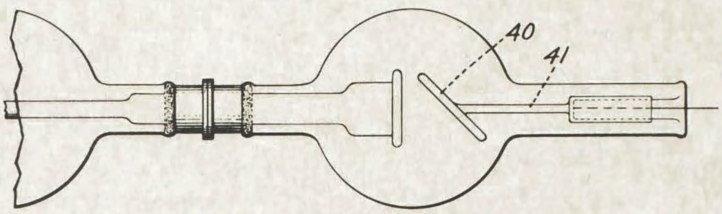


Fig. 10.

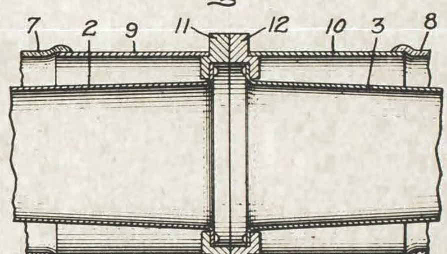
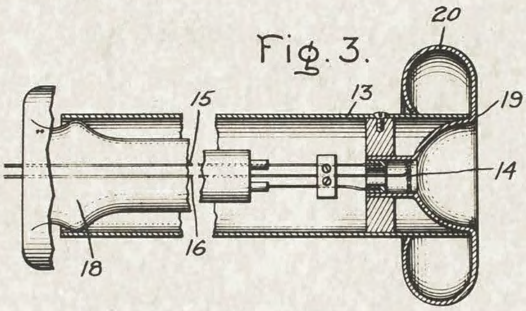


Fig. 3.



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Nov. 21, 1933. W. D. COOLIDGE 1,936,424

ELECTRICAL DISCHARGE DEVICE AND METHOD OF OPERATION

Filed Dec. 31, 1927 3 Sheets-Sheet 2

Fig. 4.

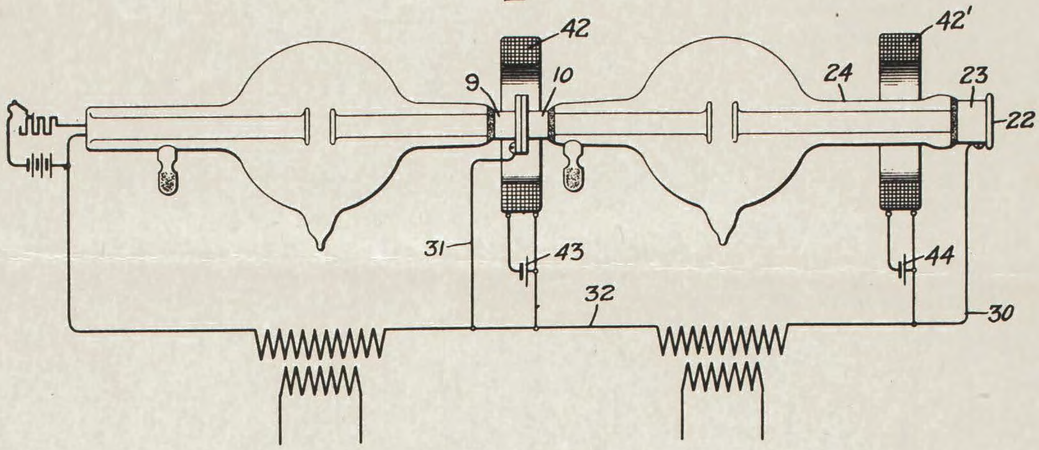


Fig. 5.

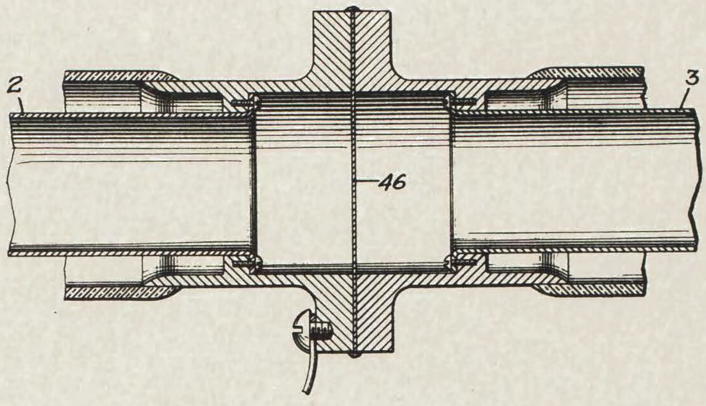


Fig. 6.

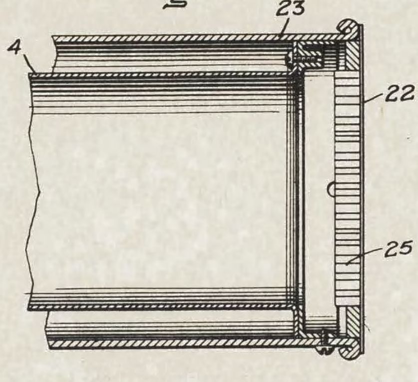
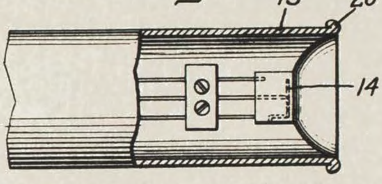


Fig. 7.



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Nov. 21, 1933. W. D. COOLIDGE 1,936,424

ELECTRICAL DISCHARGE DEVICE AND METHOD OF OPERATION

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Fig. 8.

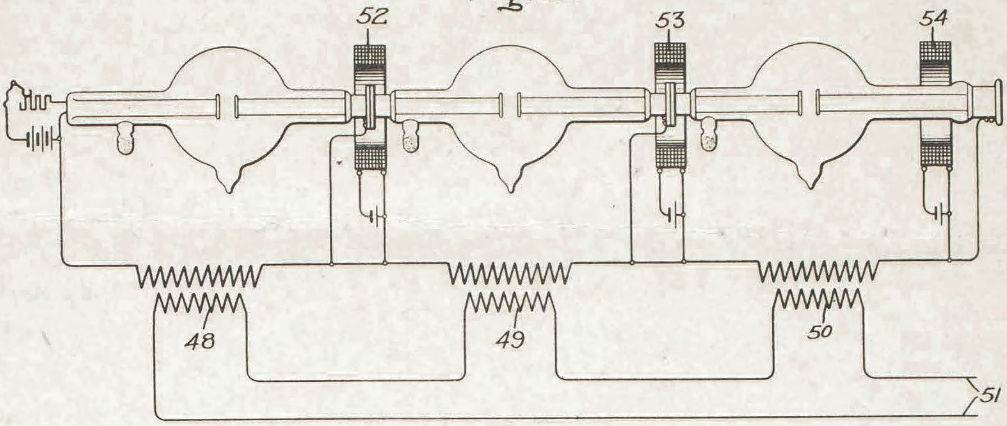
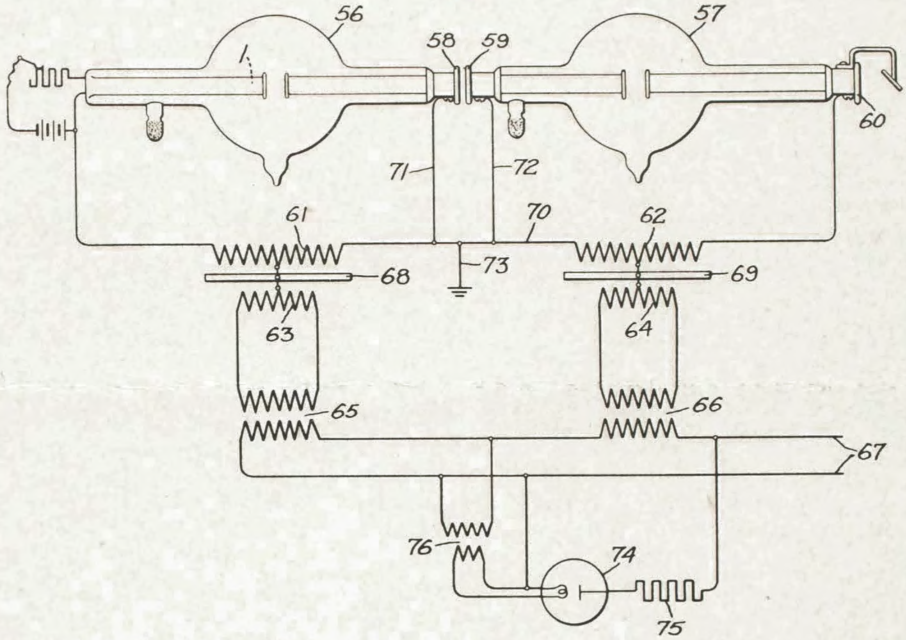


Fig. 9.



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Patented Nov. 21, 1933 1,936,424

UNITED STATES PATENT OFFICE

1,936,424

ELECTRICAL DISCHARGE DEVICE AND METHOD OF OPERATION

William D. Coolidge, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application December 31, 1927
Serial No. 244,014

16 Claims. (Cl. 250—35)

The present invention relates to electrical discharges, and its main object is to provide electronic devices which shall be capable of operation at high voltages. For example, I have constructed devices embodying my invention which are operable at impressed voltages of the order of one million volts.

In accordance with my invention, which includes both a process and a device for carrying out such process, electrical discharges are given successive cumulative accelerations of the same order of magnitude. In other words, the total impressed potential is subdivided among a plurality of electrodes placed in cascade and electrons are caused to travel successively through a discharge path in such manner as to gather acceleration in their progress.

In accordance with one modification of my invention the successive electrode stages are subdivided by walls permeable to electrons but not to positive ions, thereby intercepting the positive ions, but this construction is not a necessary part of my invention.

My invention is illustrated by the accompanying drawings in which Fig. 1 is a side elevation of a device embodying my invention; Figs. 4 and 8 are side elevations partly in section of modifications in which a permeable wall or window is provided between adjoining sets of electrodes. Figs. 3, 5, 6, 7 and 10 are sectional views illustrating various detail structural features, Figs. 2 and 9 are side elevations of modifications of my invention adapted particularly for generating X-rays, and Fig. 11 is a diagram illustrating a modified circuit connection.

Referring to the drawings, and in particular to the device embodying my invention shown in Fig. 1, two sets of electrodes 1, 2 and 3, 4 are provided, although a greater number of sets may be used as shown, for example, in the modification illustrated in Fig. 8. These sets of electrodes are respectively contained in bulbous glass tubes 5, 6 joined at their necks 7, 8. As illustrated also by Fig. 10, tubular coupling members 9, 10 consisting of thin metal, are fusion-sealed to the rims of the glass necks 7, 8 of the glass tubes and the thickened edges 11, 12 of these metal tubes 9, 10 are soldered or welded to each other to make a vacuum-tight connection.

The electrode 1, as shown in Fig. 3, comprises a metal tube 13, in which is mounted an incandescible cathode filament 14, consisting of tungsten, tantalum or other suitable refractory material. The leading-in wires 15, 16 for this filament are sealed into a stem 18. The wires 15, 16 are connected to a focussing device 19 which in turn is connected to one extremity of the filament 14. The outer edge of the focussing device 19 is connected to a rounded evolute field equalizer 20. Fig. 7 shows a slightly modified form of cathode in which the field equalizer 20 is much smaller.

A beam of electrons, or cathode rays, may be produced by the cathode 1 and projected into the hollow, tubular electrode 2 which with the tubular electrode 3 forms a chute or conduit extending between adjacent discharge chambers in line with one another and in non-overlapping relation. As the tubes 2, 3 are electrically connected, both being joined to the metal members 11, 12, they constitute in effect a single electrode which is intermediate in potential to the electrodes 1 and 4 and which shields the cathode from the high potential field of the main anode. The edges of the tubular electrodes 2, 3 and 4 also are provided with rounded field equalizers 20.

The outer extremity of the electrode 4 is provided with a thin metal closure 22, (Fig. 6), which functions as a window for permitting the electron beam to emerge from the tube for use in the open air.

As shown in Fig. 6, the window 22, which may consist of nickel foil about 0.0005'' in thickness is joined at its edges to a metal tube 23 which is in turn fusion joined to the glass neck 24 of the bulb 6. The window also may consist of copper, or molybdenum, or of a suitable alloy, such for example, as the alloy known as "No. 4 Resistol" and comprising 43.8% iron, 35% nickel, 18% chromium, 3% silicon and 0.2% carbon. It is supported against the pressure of the atmosphere by a grid or grating 25. This form of window electrode is described in my prior United States patent application Serial No. 26,469, filed April 28, 1925, (Italian Patent 249,225).

The bulbs 5 and 6 are deprived of occluded gases and evacuated to a vacuum sufficiently high to permit passage therethrough of a pure electron discharge, that is, an electron discharge unaccompanied by positive ionization. A suitable auxiliary exhaust means may be connected to the tube during operation. The drawing shows for illustrative purposes a side tube 26 containing charcoal or other material suitable for absorbing gases. This side tube, may be cooled in liquid air during operation of the device.

Electric energy for operating the discharge in the described device may be derived from any suitable source of direct or alternating current. The drawing shows, as an example, an induction coil, the secondary windings 27, 28 of which are connected in series by the conductors 29, 30 to the electrodes 1 and 4. The intermediate electrodes 2, 3 may be considered as a single electrode which is connected by conductor 31 to the grounded neutral connection 32 between the windings 27, 28. The primary windings 33, 34 are also grounded at the intermediate connection 35 and are connected by the conductors 36, 36' to a suitable source of low potential current, preferably direct current. A suitable interrupter 37 shunted by condenser 38 may be included in the supply circuit.

Electrons emitted by the cathode filament 14 when heated to an emission temperature by an external source such as an insulated battery 39 are caused by the electric field of the focusing electrode 19 to pass as a beam (cathode rays) through the intermediate conduit-shaped electrode constituted by the tubes 2 and 3, and to pass into the tubular electrode 4, finally emerging from the window 22 at the extremity of the device. The electrons receive in their passage from the cathode 1 into the tubular anode 4 successive accelerations by the electric fields produced by the applied electromotive forces of windings 27 and 28.

In some cases, for example, when it is desired to produce X-rays instead of causing the cathode rays to emerge through a window the cathode rays may be caused to impinge on an electrode of high atomic number, for example, tungsten. Such an electrode is shown in Fig. 2 in which the window 22 is replaced by a target 40 supported upon a stem 41, the construction of the device and its connection to a source of energy otherwise being similar to the device shown in Fig. 1.

In the device shown in Fig. 4 solenoids 42, 42' are provided around the path of the cathode rays in order to assist in confining the electrons to a circumscribed beam by the action of the electromagnetic fields generated by these solenoids. These solenoids may be energized from any suitable source of direct current as represented by the batteries 43, 44 and they may be connected as indicated to the intermediate conductor 32 and to the conductor 30.

As shown in Fig. 5 a window 46 consisting of metal foil similar to the window 22 or thinner may be provided to separate the spaces within the electrodes 2, 3, that is, to physically separate the bulbs 5 and 6 as an intermediate partition. In the operation of the device the beam of cathode rays will pass through the intermediate window while positive ions, produced by the ionization of residual gas, travelling in the reverse direction, that is, from the most positive electrode back to the incandescent filament acting as cathode, are intercepted. However, the use of such an intermediate partition which is permeable to electrons is not necessary when a sufficiently high vacuum is maintained in the device. In the outfit shown in Fig. 8, three primary windings 48, 49, 50 are provided, these windings being connected in series to supply conductors 51. The solenoids 52, 53, 54 may be omitted in some cases.

It is not necessary that the unit electron devices which are arranged in cascade relation should be joined physically as shown in Figs. 1, 4 and 8. Electrons may be projected from one device into another through the open air as shown in Fig. 9.

The devices 56, 57 are positioned in line with one another so that electrons passing through the window electrode 58 of the device 56 can enter the device 57 through a window electrode 59. The electrons receive a second acceleration in the vacuous space within the bulb 57 and finally emerge through the window electrode 60. The window electrodes 58, 59 and 60 may be provided with a supporting grid as described in connection with the anode of Fig. 1 and shown in Fig. 6. The cathode may be the same as the cathode of Fig. 1 and as shown in detail in Figs. 3 and 7.

In Fig. 9 the devices 56 and 57 are shown as connected to the secondaries of the transformers by the conductors 71, 72. The primaries 63, 64 of these transformers are connected respectively to insulating transformers 65, 66 which in turn are supplied in series by the mains 67. The insulating transformers 65, 66 may have a 1 to 1 ratio. The high potential, step-up transformers 61, 62 have the middle points of their primary and secondary windings connected to the magnetic cores 68, 69, as indicated. The high potential secondaries of these transformers are connected by a conductor 70 which in turn is connected to the electrodes 58, 59 by the conductors 71, 72, and also is grounded as indicated at 73; as half waves of only one polarity are utilized by the devices 56, 57 a rectifier 74 and a resistance load 75 is connected across the mains 67. The cathode of this transformer is of the thermionic type and is maintained heated by a transformer 76, as indicated to receive energy during the opposite half wave intervals, thereby avoiding the building up of undesired high potentials in the transformers during the idle half waves. Of course the illustrated energy supply system may be used in connection with other described forms of devices embodying my invention.

In some cases, especially for the operation of rectifiers embodying my invention, the potential between the various electrodes may be equalized by a potentiometer connection as shown in Fig. 11. The arrangement here shown comprises a multi-stage device 78 connected to a load circuit 79 in series with the secondary transformer windings 80, 81 and 82 having respectively primary windings 83, 84 and 85. A condenser may be connected across the load circuit. The potential difference between the cathode 86 and the anode 87 is subdivided by connecting an impedance device 88 between these electrodes and connecting the intermediate electrodes 89, 90 to intermediate points on the impedance device 88 which in the case illustrated is constituted by the ohmic resistance.

In the arrangement illustrated the conductors 91, 92 connect the intermediate electrodes 89, 90 to such points on the resistance, that the potential is divided substantially equally among the respective stages but this is not always required.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An electron discharge device comprising an envelope containing cooperating electrodes, means for producing an electron discharge between said electrodes and imperforate means intermediate said electrodes for mechanically intercepting positive ions.

2. An electron discharge apparatus comprising an envelope containing electrodes capable of supporting an electron discharge therebetween, means for focusing said discharge, tubular conductors intermediate said electrodes closely surrounding said electron discharge without obstructing the same, whereby said discharge can be given successive accelerations in passing from

one electrode to the other, and means permeable to electrons but impermeable to positive ions for preventing the passage of positive ions from one electrode to the other, said means being positioned intermediate said tubular conductors.

3. A high potential electric discharge apparatus comprising an envelope including a plurality of non-conducting sections sealed to one another by conductive material, an anode and an electron-emitting cathode in said envelope, and a common means for successively accelerating the movement of electrons toward the anode and for electrically shielding portions of said sections adjoining the seals, said means including tubular members which surround the electron stream and are adapted to be positively charged.

4. An electrical discharge apparatus comprising a plurality of containers joined with one another by an electrically conductive coupling of lesser diameter than said containers, main cooperating electrodes whereby a discharge may be projected through said coupling and an intermediate tubular member connected to said coupling and projecting into the containers joined by said coupling, and a solenoid about said coupling to assist in projecting the discharge through the coupling.

5. An electrical discharge apparatus comprising a plurality of containers joined with one another by an electrically conductive coupling of lesser diameter than said containers, main cooperating electrodes whereby a discharge may be projected through said coupling and an intermediate tubular member connected to said coupling and projecting into the containers joined by said coupling, and a solenoid about said coupling to assist in projecting the discharge through the coupling, said solenoid being maintained at the same potential as the coupling.

6. An electric discharge device comprising a multi-sectional tube containing main electrodes, each of the sections being energized with progressively increased potentials whereby a high velocity cathode ray beam is produced between said electrodes, said beam being surrounded for the major portion of its length by intermediate metal tubular members arranged successively in end-to-end relation.

7. An electric discharge device comprising a multi-sectional envelope containing main and intermediate electrodes, all of said electrodes being energized with progressively increased potentials whereby a high velocity cathode ray beam is produced between the main electrodes, said beam being surrounded by metal tubular members which constitute portions of said envelope and are connected respectively to each of the intermediate electrodes.

8. An electric discharge device comprising a multi-sectional tube containing electrodes, the sections being constituted partly of metal, physically separate of one another and energized with progressively increased potentials whereby a high velocity electron stream is caused to flow between the electrodes and through the sections successively, said stream being closely surrounded for the major portion of its length by intermediate metal tubular members which form part of the respective sections.

9. An electrical discharge apparatus comprising a plurality of containers joined with one another by an electrically conductive coupling of lesser diameter than said containers, main cooperating electrodes whereby a discharge may be projected through said coupling, and an intermediate tubular member connected to said coupling and projecting into the containers joined by said coupling.

10. An electrical discharge apparatus comprising an elongated container constituted of wall members of electrically insulating and conductive material arranged in alternate relation, electrode means including an anode for producing therein a beam of electrons of restricted diameter, a plurality of tubular members of approximately the same diameter and each surrounding an appreciable part of said beam, said members being connected respectively to the conductive wall members and arranged end-to-end, with their ends spaced apart in proximity to adjacent parts of non-conductive wall members.

11. An electrical discharge apparatus comprising a plurality of bulbs, a metal tube connecting said bulbs, a pair of chutes supported in end-to-end relation by said tube and extending in opposite directions into said bulbs, means in one of said bulbs for producing a beam of electrons in line with said chutes, and means in another bulb connecting with the first bulb for receiving said electron beam.

12. An electron discharge device comprising a highly evacuated envelope containing a plurality of sets of cooperating electrodes, a metallic member positioned respectively between each pair of adjoining sets, said member being permeable to the passage of electrons from one set to another but being impermeable to the passage of positive ions from one set of electrodes to another.

13. An electrical discharge apparatus comprising an envelope including a plurality of pairs of non-conducting sections, conductive couplings respectively between each pair of said sections, conductive electron-accelerating chutes connected respectively to said couplings and being adjacent to and overlapping the major portion of said couplings in said envelope, means for producing a beam of electrons aligned to traverse said chutes in succession and an anode for receiving the successively accelerated electron beam.

14. An electrical discharge device comprising an elongated envelope made of non-conducting members, each adjoining pair of which is joined end to end respectively by a conductive coupling, main electrodes at opposite ends of said envelope for producing an electrical discharge, means for focusing said discharge in the form of a beam, tubular electron-accelerating members in said envelope respectively connected to said couplings, said tubular members having apertures sufficiently large to permit said beam to pass therethrough without intercepting any substantial part thereof, said tubular members being positioned to overlap the major portion of said couplings and extending substantially in line with one another in cascade relation.

15. An electrical discharge apparatus comprising a plurality of bulbs, a metal tube connecting said bulbs, a hollow electrode cooperating with said tube and projecting into said bulbs, means in one of said bulbs for producing a beam of electrons in line with said electrode and means in another bulb connecting with the first bulb for receiving said electron beam.

16. An electrical discharge device comprising an elongated envelope made of non-conducting members, each adjoining pair of which is joined end-to-end respectively by a conductor coupling, main electrodes at opposite ends of said envelope for producing an electrical discharge, means for

focusing said discharge in the form of a beam, tubular electron-accelerating members in said envelope respectively connected to said couplings, said tubular members having apertures sufficiently large to permit said beam to pass therethrough without intercepting any substantial part thereof, all of said tubular members being substantially in line with one another, longitudinally spaced and extending over substantially the entire length of the envelope between the main electrodes.

WILLIAM D. COOLIDGE.

July 28, 1936.

K. SCHMID

2,048,820

PROCESS FOR THE CONTINUOUS MUTUAL REACTION OF TWO LIQUIDS OF DIFFERENT SPECIFIC GRAVITIES ON THE COUNTER CURRENT PRINCIPLE

Filed Jan. 16, 1933

2 Sheets-Sheet 1

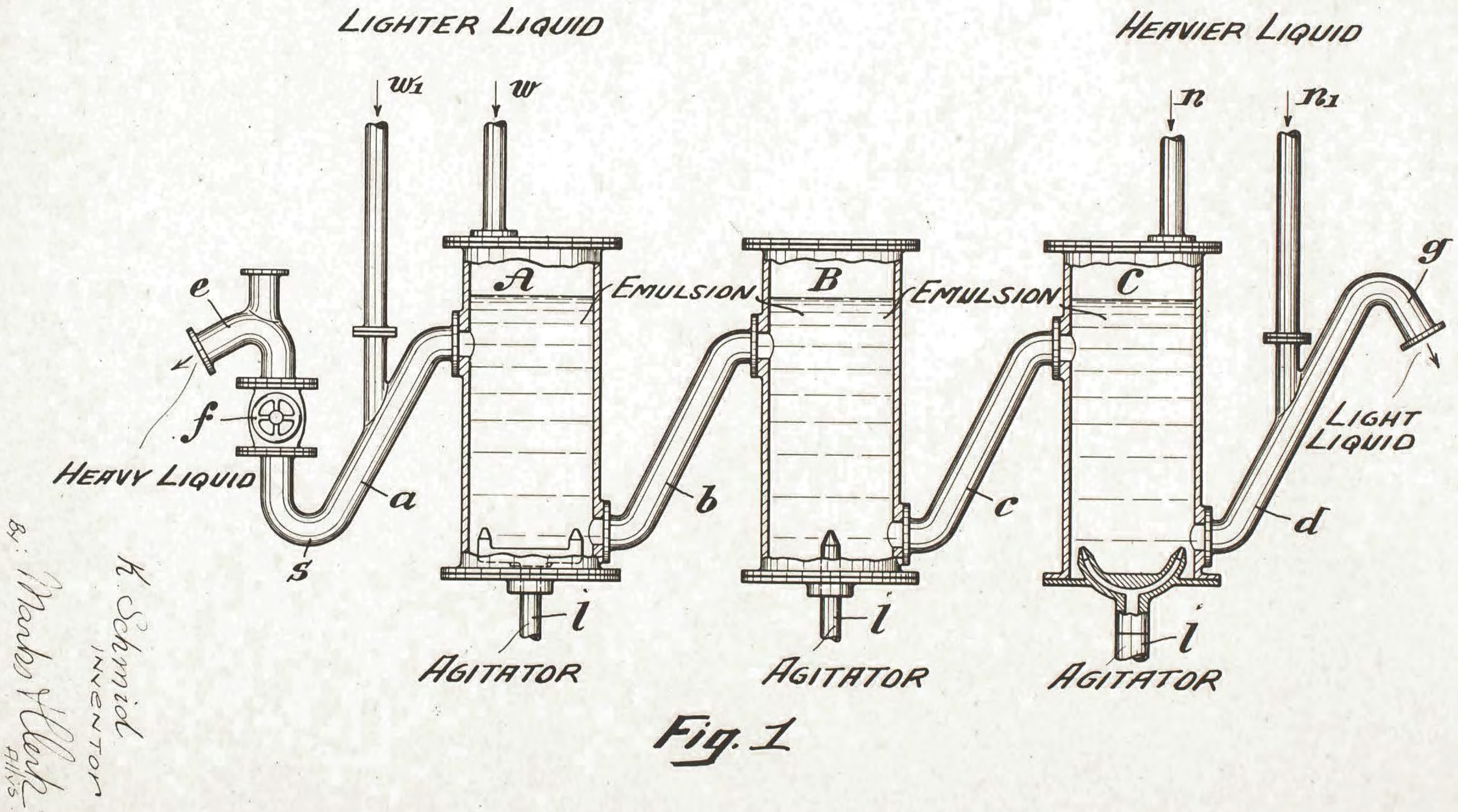
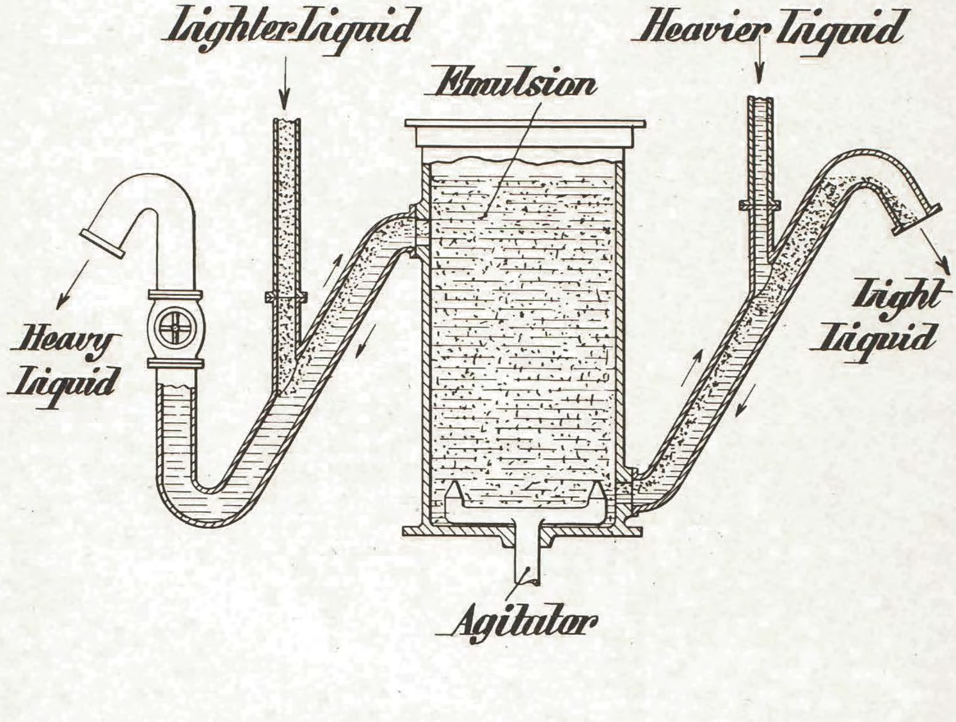


Fig. 1

Fig. 2



K. Schmid
INVENTOR

By: Marks & Clerk Attys.

Patented July 28, 1936

UNITED STATES PATENT OFFICE

2,048,820

PROCESS FOR THE CONTINUOUS MUTUAL REACTION OF TWO LIQUIDS OF DIFFERENT SPECIFIC GRAVITIES ON THE COUNTER-CURRENT PRINCIPLE

Karl Schmid, Vaduz, Liechtenstein

Application January 16, 1933, Serial No. 652,094
In Germany February 12, 1932

1 Claim. (Cl. 23—270)

This invention relates to a process for the continuous mutual reaction of two liquids of different specific gravities on the counter-current principle in an apparatus composed of a number of mixers through which flow both liquids but in opposite directions with respect to one another. Communication between the mixers is established by one or more pipes ascending in the direction of flow, the first mixer and the last mixer being in communication with overflow pipes by means of an ascending pipe. According to this process, the heavier liquid is introduced into the mixer provided with the outlet for the lighter liquid, while the lighter liquid is admitted to the mixer at the opposite end of the apparatus. In view of this novel arrangement of the ascending communication pipes between the mixers it is possible to fully dispense with separators necessary when working according to known processes of continuous reaction on the counter current principle. In these known processes, apparatus are employed in which mixing compartments are connected in series, however in these known apparatus a separator is arranged behind each mixing compartment in which the emulsion is separated, and thereafter the two liquids are again supplied to the next mixing compartment on the counter-current principle. Thus in the known processes a separator must be provided for every mixing compartment. A thorough separation of the liquids must take place in the separators, because otherwise the advantage of the counter-current principle is lost or otherwise diminished. In the known processes, the size of the separators must be suited to the speed of separation in order to cause a thorough separation. For instance in the case of washing nitroglycerine, the capacity of the separator must be suited for a flow of at least three quarters of an hour, for instance for a yield of 500 kilogrammes nitroglycerine per hour and a washing liquid of 500 kilogrammes, the separator must have a capacity of 750 kilogrammes. Now if six mixers are necessary for carrying out the process, the capacity of the separators has to be adapted to 4500 kilogrammes.

These drawbacks are avoided according to the present invention by arranging inclined passages between the mixers in place of separators.

Compared with the known example above described, in the event of like conditions, it is rendered possible according to the present invention to reduce the capacity of the communication passages between two mixing compartments to approximately 30 kilogrammes. In this case all the communication passages together are of a capacity of no more than 180 kilogrammes. This advantage would be still further enhanced in the case of a process in which the separation is carried out still slower.

With respect to the solubility of the two liquids it is remarked, that the specifically heavier initial product must be difficultly soluble or quite insoluble in the specifically lighter final product, and the specifically lighter initial product must be difficultly soluble or quite insoluble in the specifically heavier final product.

The apparatus according to the invention is suited for the reaction of two convenient liquids of different specific gravities, such as for instance nitro-esters or nitro-products with water or alkaline solutions for their clarification or neutralization, benzol, hydro-carbons or other substances with acids for nitration, crude petroleums with acids for refining and the like.

Diagrammatic views of the apparatus according to the present invention are illustrated by way of example in Figs. 1 and 2 of the accompanying drawings, it being supposed that acid nitroglycerine is washed with an alkaline washing liquid for the purpose of neutralization.

Fig. 1 shows an elevation partly in section of a plant comprising three vessels.

Fig. 2 shows in sectional elevation a plant in which the dots represent the lighter liquid and the dashes indicate the heavier liquid.

In the drawings, A, B and C designate vessels which are open at the top and in which are mixed two liquids of different specific gravities for instance acid nitroglycerine and alkaline washing liquid.

For carrying out the mixing operation, air is blown through the tubes *l* and into the liquid. If desired also mechanical agitators, not shown in the drawings, may be arranged in the vessels. The vessels A, B and C are interconnected by ascending pipes *b* and *c*, while inclined pipes *a* and *d*, provided with overflow pipes *e* and *g* respectively, are secured to the outer vessels A and C respectively. A cock *f* serves for closing or opening the overflow pipe *e*.

Before the process is started, the entire apparatus is charged with washing liquid up to a level with the overflow pipe *g*. Agitation takes place within the vessels A, B and C. The cock *f* is shut. Washing liquid is continuously admitted by way of the inlets *w* or *w*1 and flows uninterruptedly through the apparatus and finally leaves the same by way of the pipe *g*. The acid nitroglycerine uninterruptedly enters by way of the inlets *n* or *n*I and, being the specific heavier liquid, flows through the pipe *d* and into mixer C. In view of the mixing an emulsion is formed in the mixer C and the acidity of the nitroglycerine and of the washing liquid are balanced in accordance with the affinity of these two liquids with respect to the acid. The speed of the flow through the pipes *a*, *b*, *c*, and *d* can be controlled by suitably dimensioning the communication pipes. The emulsion in the mixer C is, however specifically heavier than the ascending lighter liquid for instance fresh water, and therefore the emulsion descends towards the ascending water in the direction towards the mixer B. The separators, which heretofore were arranged in apparatus operating on the counter-current principle between each pair of mixers, separated water and nitroglycerine according to the specific gravities. According to the present invention, a separation of both liquids is not necessary in view of the arrangement of the communication pipes. The emulsion in the mixer C consists of already washed nitroglycerine and acid water in fine distribution, whereby the nitroglycerine so to say is in suspension in the acid water. Now if this emulsion sinks in the communication pipe *c* towards the ascending fresh water, the acid from the water-phase of the emulsion coming from the mixer C is washed back into the latter by the fresh water. Drops of nitroglycerine which may pass into the mixer B are not separated, but the water surrounding the same does not contain any acid anymore, derived from the water-phase of the mixer C. The nitroglycerine, which has been washed already, is thoroughly mixed again with fresh or weak alkaline water and passes in the same way through the communication pipe *b* and into the mixer A and from here through the pipe *a* into *s*. The nitroglycerine is completely separated from the water at *s* and leaves the apparatus by way of the outlet *e* whenever the cock *f* is opened and if in the pipe *a* a sufficient quantity of nitroglycerine has accumulated, so that at least the whole ascending pipe is filled between *e* and *s*, whereby this liquid-column of nitroglycerine prevents the discharge of water through this overflow. The height of the overflow pipe *e* must be adjusted in accordance with the specific gravities of both liquids and the now purified nitroglycerine flows out continuously by way of the pipe *e*. The washing water flows in a similar way towards the pipe *g* and leaves through the latter, so that the two liquids flow in opposite directions, i. e. in the counter-current principle.

In the vessel C, the washing liquid with the highest percentage of acid meets the nitroglycerine with the highest percentage of acid from which it still carries off some acid, while in the vessel A already cleaned nitroglycerine and clean washing liquid which may be slightly alkaline are meeting, whereby the latter fully cleans the former. Any desired number of mixing vessels A, B, C may be provided. In this way purified neutral nitroglycerine is obtained with the smallest quantities of water and alkali. An excess of alkali, taken in by the nitroglycerine during the washing process, can be washed out again in the vessel A, because clean water can be charged into the vessel A while alkali is added in the vessel B only. Further it is possible to introduce or lead off any heat by enclosing the mixing vessels and separation pipes in a heating jacket or in a cooling jacket. Thus in this apparatus any separation of the two liquids according to their specific gravities does not take place between the mixing places, but practically the same effect can be attained in that the like phases assimilate and force back one another in the communication pipes through which the two liquids must flow in opposite directions to each other, because no other way of communication is at disposal. In the illustrated example, the acid from the water of the emulsion originating in the mixer C is washed back from the pipe *c* into the mixer C by the ascending fresh water.

The assimilation of like phases in emulsions is a general rule and therefore this is possible in all those cases in which two liquids can be washed, cleaned or enter into reaction on the counter-current principle.

By bending the communication pipes or by arranging obstacles, screens or the like within the same it is possible to readily mix both liquids during their passage in opposite directions through the communication pipes, whereby the assimilation to the like phases is promoted.

The construction of the mixers does not form a part of the present invention and therefore the same are illustrated diagrammatically in the drawing. The mixing is carried out by air current or by propeller but it must be such that the heavier liquid entering at the bottom is raised and is discharged at the top. If the overflow pipe *e* is disposed higher than the overflow pipe *g*, the apparatus will be filled with the heavier liquid and in this event the lighter liquid is forced downward by agitation from the top where it enters the mixer and leaves the same at the bottom outlet. The mixer may be such as is shown and described for instance, in the specification of U. S. Patent No. 1,893,447, dated January 3, 1933.

What I claim is:—

Process for the continuous mutual reaction of two mutually insoluble or difficultly soluble liquids of different specific gravities on the counter-current principle in an apparatus comprising interconnected mixers, which consists in introducing the lighter liquid at one end and the heavier liquid at the other end of the apparatus, allowing said liquids to flow continuously but in opposite directions through a passageway connecting two adjacent mixers and ascending in the direction of flow of the lighter liquid, whereby the heavier liquid descends through the ascending lighter liquid and washes back into the previous mixer from said lighter liquid the heavier particles carried by it and vice versa the lighter liquid ascending through the descending heavier liquid and washes back into the next mixer from said heavier liquid the lighter particles carried by it, and after leaving the first mixer and the last mixer allowing said liquids to ascend and descend respectively through passageways inclined in the same direction and connected with overflows.

KARL SCHMID.

Sept. 27, 1927. W. J. BLANCHARD 1,643,441

CENTRIFUGAL SEPARATOR BASKET

Filed June 1, 1925 2 Sheets-Sheet 1

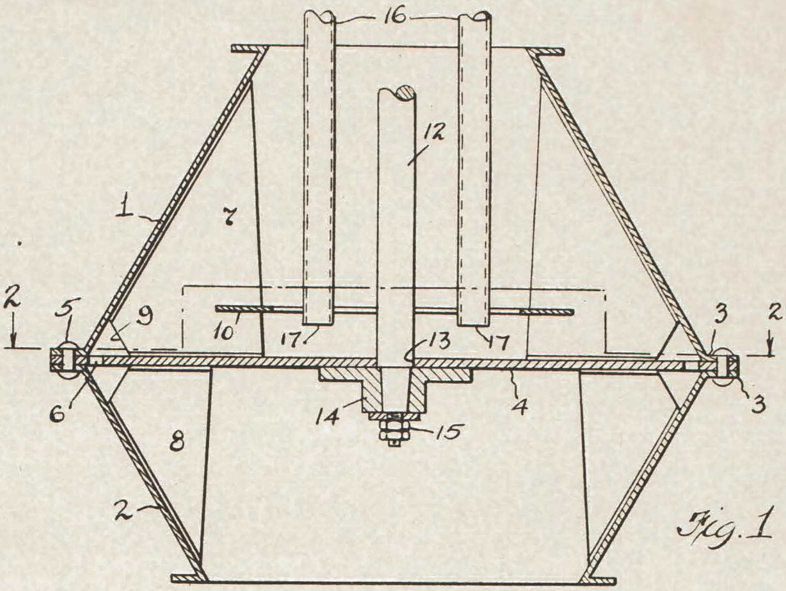


Fig. 1

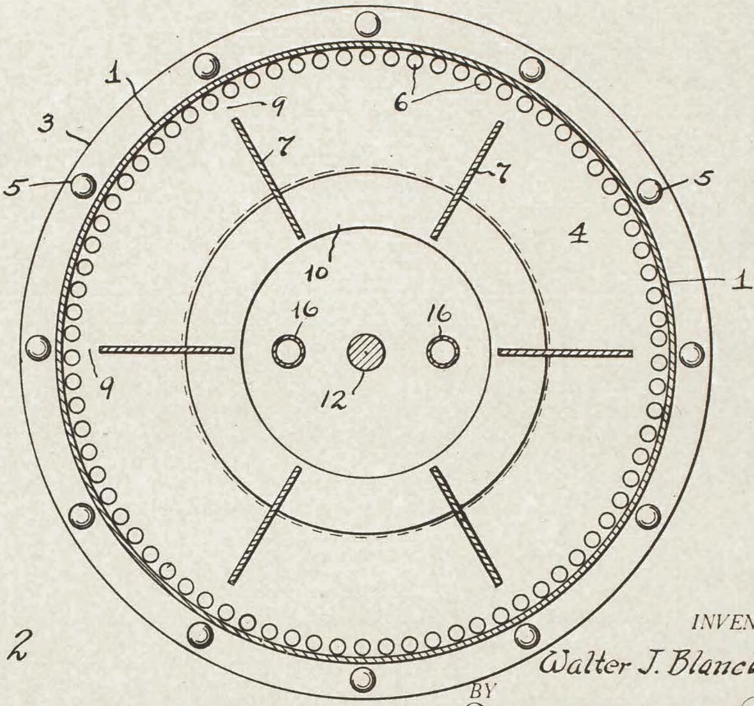


Fig. 2

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CENTRIFUGAL SEPARATOR BASKET

Filed June 1, 1925 2 Sheets-Sheet 2

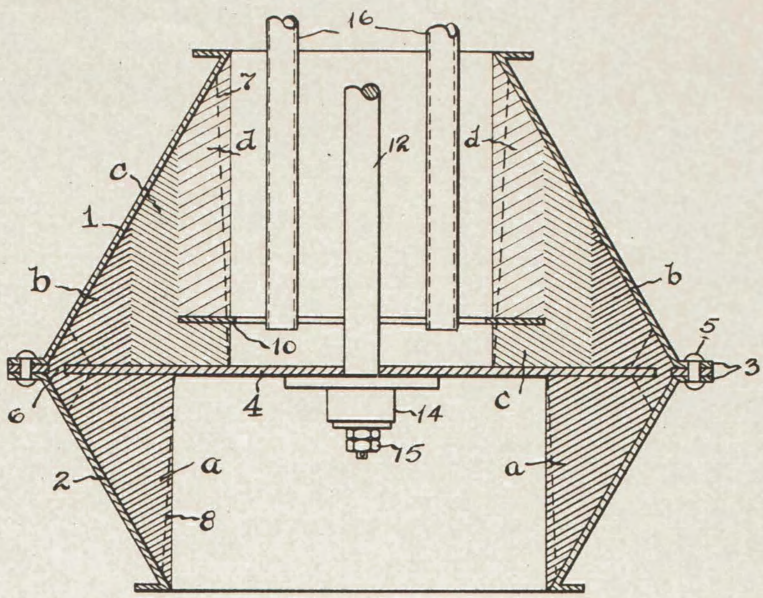

Fig. 3

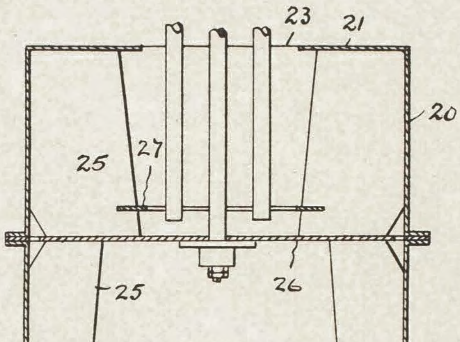

Fig. 4.

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UNITED STATES PATENT OFFICE.

WALTER J. BLANCHARD, OF CLEVELAND, OHIO.

CENTRIFUGAL-SEPARATOR BASKET.

Application filed June 1, 1925. Serial No. 34,004.

The present invention relates to centrifugal separator baskets and more particularly to a separator basket construction adapted for automatically and continuously separating certain materials having different specific gravities. The present basket makes use of the principle of balanced columns, which may be best illustrated by considering a tube bent to the shape of a V with both ends open, one leg of the tube being longer than the other by a certain amount which is dependent upon the relative weights of the materials being separated. Then assume that the tube is revolving in an orbit with the point of the V outward from the center of rotation.

Assume that the shorter leg of the tube is full of the heavy element of the feed mixture which is being separated and that the longer leg is filled with a combination column, which starting from the point of the V consists of a section of heavy material, a section of mixed material and a section of the light material being separated. Assume that the legs of the tube are of such relative lengths and the proportions of the sectionalized materials in the combination column in the longer leg are such that when the tube is revolved, that the pressures at the point of the V produced by the two columns are balanced, and that there is no discharge from either end of the tube. The columns are then in a balanced state and illustrate what is termed "balanced columns."

If mixed material is introduced into the tube at the point designated as the mixed material section, this material will separate and the light material will climb the upper longer leg thus forcing separated light material therefrom, and the heavy material will be forced toward the point of the V and will add to the section of heavy material above the point thus overbalancing the heavy material in the short leg, and will cause a discharge therefrom. Continuous feeding of mixed material will therefore produce a continuous discharge of light and heavy materials from the tube.

In particular the present invention relates to the construction of a separator adapted to use this principle of balanced columns. To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims.

The annexed drawings and the following description set forth in detail certain mechanism embodying the invention, such disclosed means constituting, however, but one of various mechanical forms in which the principle of the invention may be used:

In said annexed drawings:—

Fig. 1 is a vertical sectional view through my improved basket; Fig. 2 is a sectional view on the line 2—2 of Fig. 1. Fig. 3 is a view similar to Fig. 1 but showing diagrammatically the relative positions of the heavy, mixed and light materials. Fig. 4 is a diagrammatic sectional view of a modified form.

The present basket consists of two truncated cone-shaped members 1 and 2, the small end of truncated cone member 1 being of smaller diameter than that of member 2, these members each having a flange 3 between which is mounted a separator plate 4 the flanges 3 and plate 4 being secured together by rivets 5 or other suitable fastening means. This separator plate 4 is provided adjacent the outer edge with a series of apertures 6.

Mounted radially of the separator plate are series of vanes 7 and 8 which are generally triangular in shape and which extend along the members 1 and 2 and radially inward thus dividing the basket into a series of pockets and forcing the material being separated to rotate with the basket. These vanes are mounted both above and below the plate 4, the vanes 8 of the lower member being smaller than the vanes 7. The rear corner of the vanes of both series is cut off, forming an opening 9 around the basket for equalization of the load.

A horizontal baffle plate or ring 10 is mounted above the separator plate 4, said baffle plate or ring extending across between the vanes for a portion of the radial distance and thus forming chutes or pipes from the central basket portion to an intermediate portion. The basket is adapted to be rotated and a central drive shaft 12 is provided which extends through a suitable aperture 13 in the separator plate and into a housing 14 mounted on the underside thereof. The shaft is secured in place by means of a washer and lock nuts 15 or in any other suitable manner. Thus the basket is rotatably carried with said shaft which may be hung in any suitable type of bearing not shown. Extending into the upper open end of the basket are a series of feed pipes 16 the outlet ends 17 of which are adjacent the separator plate 4 and below the level of the horizontal baffle plate or ring 10 as best shown in Fig. 1.

The operation of the device is diagrammatically illustrated in Fig. 3. In starting, the basket will be revolved and brought up to normal speed and then a charge of high density material is fed in, until an overflow occurs at the bottom and then the regular run of mixed solution is fed into the basket. As mixed material is fed through the feed pipes 16 it is forced outwardly through the space between the baffle plate 10 and the spearator plate 4 into the separating area "*c*". The heavier charge material will flow through the holes 6 and finally fills the area "*a*" the size of the lower vanes 8 and the area "*b*" above the plate 4. Next to the high density or heavy material will be a layer of the mixed material to be separated which will occupy the area "*c*" and then inwardly will be a strata of the light separated material over the area "*d*". It is of course to be understood that the stratification will not be as definite as indicated as there will be no line of absolute demarcation between layers but in a general way the condition illustrated will be maintained.

Once the basket is fully charged and the separated condition obtained, the addition of more mixed material will cause a discharge, the light material being discharged through the upper central opening and being caught in any suitable container while the heavy material increasing will cause a portion thereof to fall from the bottom opening until a balanced condition is again obtained. Continuous feeding of the mixed material will therefore cause a continuous flow of the separated materials from the two basket members.

It is to be understood that the basket need not have a V shaped wall as it is obvious that the wall may be curved or formed as shown in Fig. 4, in which form the basket 20 is cylindrical with horizontal flanges 21 and 22 at the ends the flange 21 having an opening 23 of smaller diameter than the opening 24 in flange 22. The vanes 25 and separator plate 26 are the same as in the preceding form and a baffle plate or ring 27 is also used as previously described. It is only necessary to provide the pockets above and below the separator plate, one set of the pockets being larger than the other and having its discharge edge of less diameter. It is also to be understood that suitable discharge openings may be formed in the wall, the radial distance from the axis of rotation to the openings determining the action of the device.

Other modes of applying the principle of my invention may be employed by me instead of the one explained, change being made as regards the mechanism herein disclosed, provided the means stated by any of the following claims or the equivalent of such stated means be employed.

I therefore particularly point out and distinctly claim as my invention:—

1. A centrifugal separator basket for use with a separator using the principle of balanced columns, of a shape formed by attaching two open-ended cone-shaped members together along their largest diameter, a separator plate mounted at the junction of such members and having apertures allowing communication between said members, a series of vertical vanes in said members attached to the walls thereof, one of said members having its free end of less diameter than the other member, and a baffle ring mounted parallel to said separator plate and on the side of the member having the opening of lesser diameter, said baffle ring extending into the body of the material being separated, and means for feeding material to be separated to said separator plate.

2. A centrifugal separator basket comprising a shell of the shape of two truncated cones joined at their largest diameters, one of said cones having a smaller outlet opening than the other, a separator plate mounted between said two cones and provided with openings adjacent the cones to permit flow of material to both sides of said plate, radial vanes on the walls of said cones to force the material to rotate with said basket, and a baffle plate parallel with said separator plate and adapted to force the material fed into said basket into an unseparated strata of the material undergoing separation.

3. A centrifugal separator basket for use with a separator using the principle of balanced columns, comprising two open ended hollow compartments, joined at their largest diameters, the discharge end of one compartment being of smaller diameter than the other, a separator plate mounted between said two compartments and provided with openings adjacent the wall to permit flow of material to both sides of said plate, radial vanes on the walls of said compartments to force material to rotate with said basket, and a baffle plate parallel with said separator plate and adapted to force the material fed into said basket into an unseparated strata of the material undergoing separation.

Signed by me this 25th day of May, 1925.

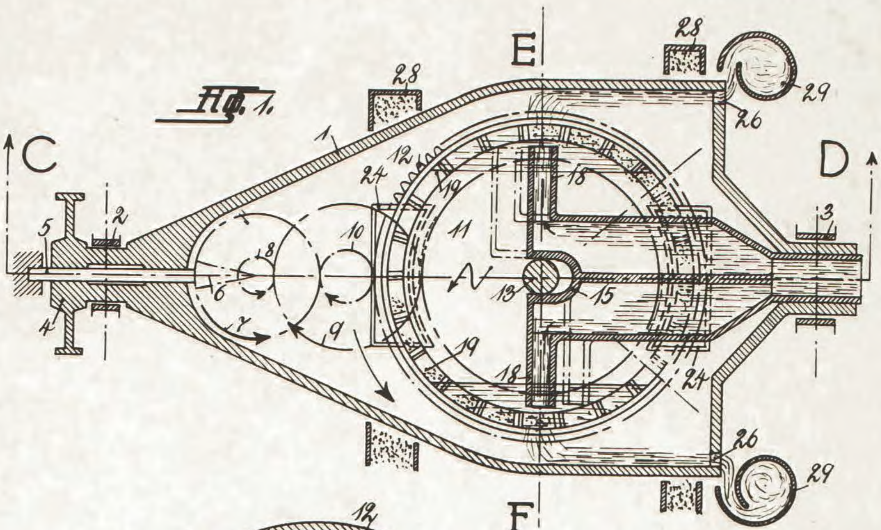
WALTER J. BLANCHARD.

March 9, 1937. H. SCHULZ 2,073,496

CENTRIFUGAL MACHINE

Filed May 1, 1934 2 Sheets-Sheet 1

Fig. 1.



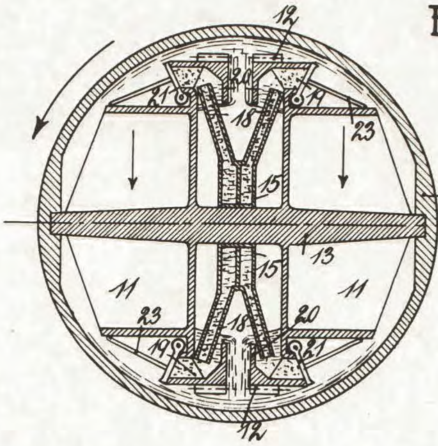


Fig. 3.

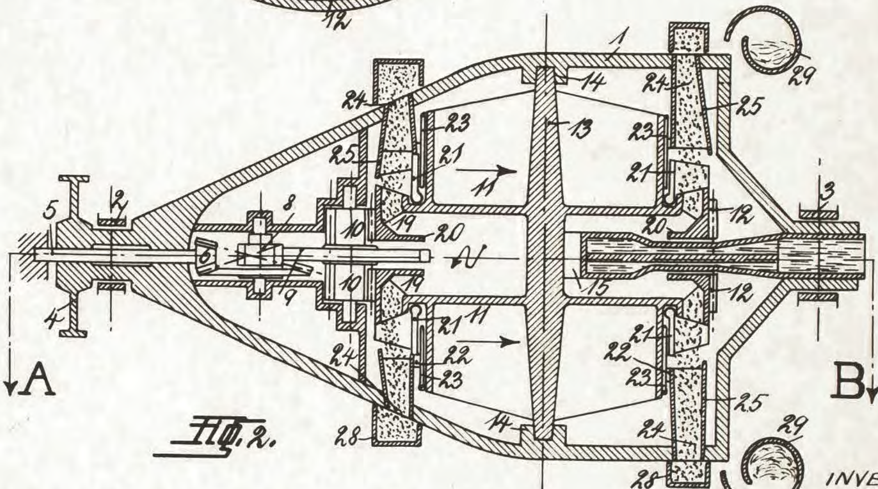


Fig. 2.

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CENTRIFUGAL MACHINE

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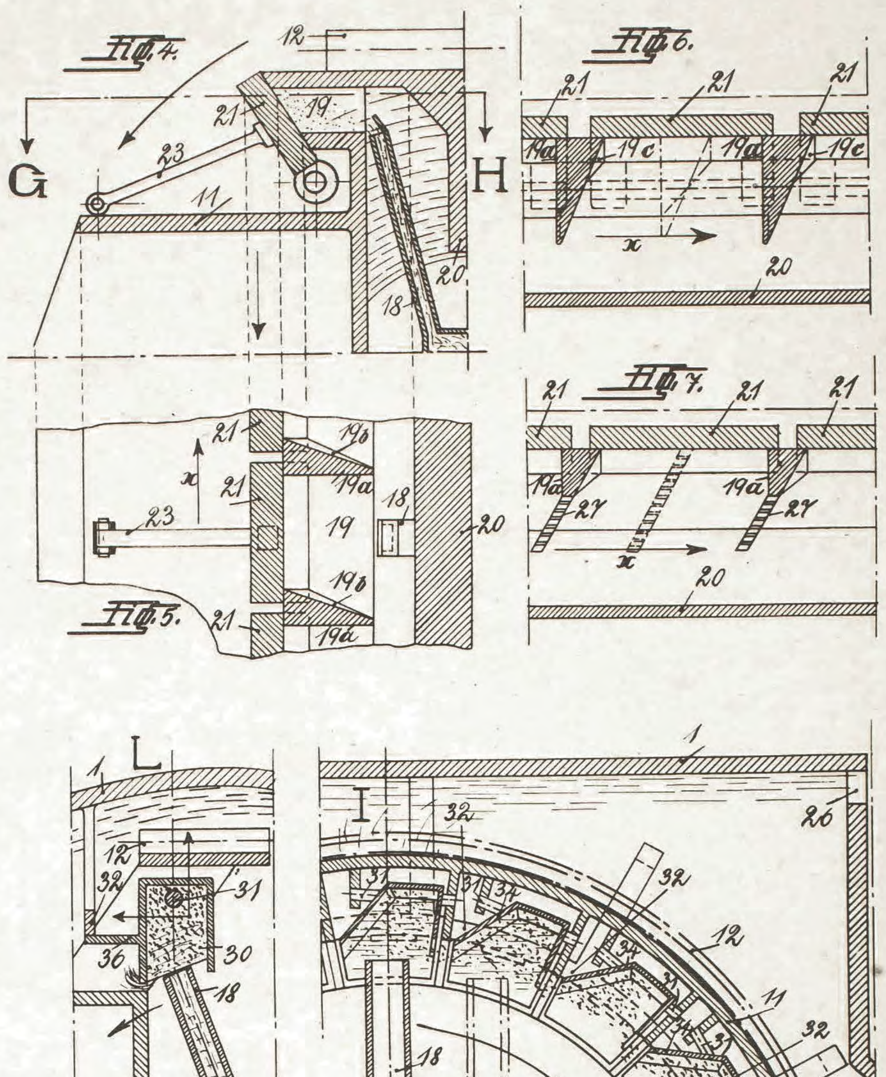

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Patented Mar. 9, 1937 2,073,496

UNITED STATES PATENT OFFICE

2,073,496

CENTRIFUGAL MACHINE

Herbert Schulz, Berlin, Germany

Application May 1, 1934, Serial No. 723,290
In Germany May 10, 1933

7 Claims. (Cl. 233—20)

This invention relates to centrifugal machines and is an improvement of the device described in my Patent No. 1,979,909, issued November 6, 1934.

In centrifugal machines which have a high rate of rotation the capacity is increased and the time required for precipitation is reduced by leading the precipitable substances at the highest possible velocity in the direction of the centrifugal effect direct to the places where the solid substances collect and allowing the incompletely dry substances to slip back to the said places. In general the solid particles to be precipitated vary greatly in mass and size and the finest particles separate from the liquid only with great difficulty when the time allowed for precipitation is short, and thereby prevent a dry ejection of the solid substances. This disadvantage is particularly evident in continuously operating centrifugal machines having a very short precipitation period, in which for example two rotary members are employed to rotate one within the other at a very high speed for the purpose of attaining a high rate of rotation and precipitation of even the finest particles, the inner member having a slow individual movement about a different axis and being provided with containers or cells at its periphery, and the mixture to be separated being flung from the feed conduit into the containers or cells in a direction other than the centrifugal direction and therefore not arriving immediately at the places where the solid substances collect. Solid substances and liquid are therefore carried in the cells to the place of discharge.

To avoid this disadvantage, the walls of the containers or cells at that side which is opposed to the individual movement of the inner rotary member are formed inclined towards the direction of rotation.

The containers or cells may be arranged fixed or movable on the inner rotary member and empty their contents from time to time automatically in the vicinity of the quickly rotated shaft, whilst the mixture is flung with the greatest possible velocity on to the collecting places in the containers or cells, whereby the cooperation of the pressure of flow and the centrifugal effect causes the solid substances to be pressed together at the collecting places in the containers or cells and consequently produces a higher degree of dryness than is possible by means of centrifugal effect alone. During transportation to the place of discharge only absolutely dry substances remain on the slanting container or cell walls due to the angle of repose thereof, whilst all liquid or mushy substances which have no angle of repose are forced to slip back to the collecting places and are again subjected to the precipitating operation.

The finest particles can thus be separated from the liquid and only comparatively dry substances can be transported to the place of discharge.

Both rotary members can be formed framelike or as casings and the individual movement of the containers or cells in which the mixture is fed and be effected by any suitable means. In the constructional example shown in the accompanying drawings, the outer member is in the form of a closed casing and the inner member takes the form of a drum with open hollow members extending to both sides in the axial direction.

In the said drawings:

Figure 1 is a longitudinal section according to line A—B of Figure 2 and through a centrifuge with quickly rotated outer casing and a slowly rotated inner drum which turns about a cross axis.

Figure 2 is a longitudinal section according to line C—D of Figure 1.

Figure 3 is a cross-section according to line E—F of Figure 1.

Figure 4 is an enlarged representation of the containers and inflow parts on the drum according to the cross-sectional Figure 3.

Figure 5 is a section according to line G—H of Figure 4.

Figure 6 is a section through the container walls with warped surfaces at that side which is opposed to the direction of rotation.

Figure 7 is a section through the container walls with sieve surfaces on that side which is opposed to the direction of rotation.

Figure 8 is a section through a drum with tiltable containers according to line I—K of Figure 9, and

Figure 9 is a section according to line L—M of Figure 8.

In the drawings, a casing **1** rests in a quickly rotatable manner in bearings **2** and **3** and is driven by means of a pulley **4**. By means of an externally fixed shaft **5** and reduction gearing **6**, **7**, **8**, **9**, **10**, a drum **11** is slowly rotated from the quick casing rotation through a toothed ring **12** provided on the drum periphery. The drum **11** has a shaft **13** mounted in bearings **14** of the casing **1** and performs a slow individual movement with the said shaft. An inflow bracket **15** for the mixture to be separated projects into the central part of the drum **11** and has guide nozzles **18** which are directed towards the drum cells or containers 19 lying inside the drum 11 over the whole periphery thereof. The cells or containers are closed by turnable flaps 21 and possess an overflow wall 20 for the escaping liquid. The axis of the shaft 13 of the drum is perpendicular to the axis of movement of the casing 1.

The flaps 21 are retained in the closed position by rods 23 which are moved outwardly by centrifugal effect, and stops 22 provided in the vicinity of the discharge place 24 force the rods 23 backwards and thereby enables the flaps 21 to be opened by centrifugal effect. At the discharge zones or places 24 the solid substances escape through the funnel 25 which penetrates the casing 1.

As can be more particularly seen in Figures 3, 4, and 8, the channels 18 of the inflow bracket 15 for the mixture lie radially relative to the centrifugal axis, whereby the escaping mixture is flung out of all the channels with uniform and full velocity and corresponding flow pressure into the depositing places, namely the cells 19 of Figures 1 to 6 or the cups 30 of Figures 8 and 9.

The side walls of the cells 19, as can be observed from Figures 5 to 7 are directed radially at that side 19*a* which faces the direction of rotation, see arrow X, and extend substantially parallel to the axis of the shaft 13 which participates in the individual movement. On that side 19*b* which is opposed to the direction of rotation, the walls however extend slantingly relative to the axis of the shaft 13, whereby during idle running every drop of liquid carried thereby, and during working, the mushy part of the solid substances must slip back from cell to cell to the depositing zone under centrifugal effect, and consequently the solid particles are given the opportunity to again deposit themselves.

As however all dry, solid substances possess an angle of repose, only completely dry, deposited solid substances cannot, due to this angle of repose, slip back, in spite of the slant of the wall 19*b*, and are carried to the places of discharge and are ejected.

In the constructional example according to Figure 6, the construction of the cell side walls 19*c* in warped form increases the pressure surfaces of the solid substances.

In the constructional example according to Figure 7 the walls of the cells are formed in part by slanting sieves 27 which operate as solid walls but let through any drops of liquid enclosed between solid substances and the cell walls.

The overflowing liquid passes to the exterior through openings 26 of the casing 9 and flow into the gutters 29 from which it can be led away. The solid substances are caught in the gutters 28.

In order to obtain absolute sealing of the cells independently of the individual flaps, the cells, according to the constructional example of Figure 9 are not closed by flaps, but are arranged tiltable. The cells constructed in the form of cups 30 rest on shafts 31 and for this purpose are swingably hung thereon and tilt over automatically at the places of discharge due to the position of the centre of gravity, whereby the contents can escape into the funnel 25, Figure 2.

As can be observed from Figure 9, the cups 30 are provided at that side which is opposed to the direction of rotation of the drum with walls 34 which are so slanted that the liquid and mushy substances must always slip back from cup to cup into the depositing zones and cannot reach the places of discharge of the solid substances. The solid substances contained in the mush can thereby precipitate themselves therefrom. Furthermore the cups 30 are provided with projections 36 which rest on guide rails 32 of the casing 1, whereby the cups are prevented from tipping and are retained in the filling position until they reach the vicinity of the places 24 of discharge. In Figure 9 the cup 30 situated in the discharge zone 24 can be seen in the tipped position, where it is discharging its contents outwardly.

The containers or cups on the drum can also be subdivided by separating walls which for example are formed sieve-like and extend slantingly or in a warped manner at that side which is directed away from the direction of rotation. These cups can also be formed completely of sieve walls.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. A centrifugal machine, comprising a casing having discharge openings formed therein, a drum rotatably mounted within said casing, means connected with said casing for quickly rotating said casing together with said drum, means for comparatively slowly rotating said drum relatively to said casing, and a plurality of containers carried by said drum on the periphery thereof and adapted to receive a mixture of liquid and solid substances introduced into the drum, the rear wall of each of said containers according to the direction of rotation of said drum being inclined from the bottom wall of said container, whereby said container may convey solid substances to said discharge openings according to the angle of repose, said inclined wall being inclined at such an angle that the liquid substances contained in said mixture are flowing to the place of the introduction of the mixture and off the containers opposed to the course of rotation of said drum before they reach said discharge openings, while the solid substances are carried to said discharge openings by said walls.

2. A centrifugal machine, comprising a casing having discharge openings formed therein, a drum rotatably mounted within said casing, means connected with said casing for quickly rotating said casing together with said drum, means for comparatively slowly rotating said drum relatively to said casing, and a plurality of containers movably mounted upon the periphery of said drum and adapted to receive a mixture of liquid and solid substances introduced into the drum, the rear wall of each of said containers according to the direction of rotation of said drum inclining rearwardly from the bottom of said container, said slanting wall being inclined at such an angle that liquid substances contained in said mixture are poured off the containers and flow to the place of introduction of the mixture and in a direction opposed to the direction of said drum before they reach said discharge openings, while the solid substances are carried to said discharge openings by the wall.

3. A centrifugal machine, comprising a casing having discharge openings formed therein, a drum rotatably mounted within said casing, means connected with said casing for quickly rotating said casing together with said drum, means for comparatively slowly rotating said drum relatively to said casing, and a plurality of containers rotatably mounted on the periphery of said drum and adapted to receive a mixture of liquid and

solid substances introduced into the drum, the center of gravity of said containers being so arranged according to the axis of rotation that they automatically tip over adjacent to the discharge openings, the rear wall of each of said containers according to the direction of rotation of said drum inclining from the bottom of said container, said slanting wall being inclined at such angles that liquid substances contained in said mixture are poured off the containers and flow to the place of introduction of the mixture in a direction opposed to the course of rotation of said drum before they reach said discharge openings, while the solid substances are carried to said discharge openings by said walls.

4. A centrifugal machine, comprising a casing having discharge openings formed therein, a drum rotatably mounted within said casing, means connected with said casing for quickly rotating said casing together with said drum, means for comparatively slowly rotating said drum relatively to said casing and a plurality of containers movably mounted upon the periphery of said drum and adapted to receive a mixture of liquid and solid substances introduced into the drum, the rear wall of each of said containers according to the direction of rotation of said drum inclining from the bottom of said container at an obtuse angle, said slanting wall being inclined at such angles that liquid substances contained in said mixture are poured off the containers and flow to the place of introduction of the mixture in a direction opposite to the course of rotation of said drum before they reach said discharge openings, while the solid substances are carried to said discharge openings by said walls.

5. A centrifugal machine, comprising a casing having discharge openings formed therein, a drum rotatably mounted within said casing, means connected with said casing for quickly rotating said casing together with said drum, means for comparatively slowly rotating said drum relatively to said casing, and a plurality of containers carried by said drum on the periphery thereof and adapted to receive a mixture of liquid and solid substances introduced into the drum, the rear wall of each of said containers according to the direction of rotation of said drum inclining from the bottom of said container at an obtuse angle thereto and being perforated to form a sieve adapted to convey comparatively large particles of solid substances to the discharge openings.

6. A centrifugal machine, comprising a casing having discharge openings formed therein, a drum rotatably mounted within said casing, means connected with said casing for quickly rotating said casing together with said drum, means for comparatively slowly rotating said drum relatively to said casing, and a plurality of containers carried by said drum on the periphery thereof and adapted to receive a mixture of liquid and solid substances introduced into the drum, the rear wall of each of said containers according to the direction of rotation of said drum inclining from the bottom of said container at an obtuse angle thereto, the slanting walls being inclined at such an angle that liquid substances contained in said mixture are poured off the containers and flow to the place of introduction of the mixture in a direction opposite to the course of rotation of said drum before they reach said discharge openings, while the solid substances are carried to said discharge openings by said walls, and a separate sieve-like wall forming a continuation of each of said slanting walls and inclined in a direction opposite to the direction of rotation of said drum.

7. A centrifugal machine, comprising a casing having discharge openings formed therein, a drum rotatably mounted within said casing, means connected with said casing for quickly rotating said casing together with said drum, means for comparatively slowly rotating said drum relatively to said casing, a plurality of containers carried by said drum on the periphery thereof, and guide nozzles carried by said drum and directed toward said containers and parallel to the directions of the centrifugal force, said guide nozzles being adapted to transmit a mixture of liquid and solid substances situated within said casing to said containers, the rear wall of each of said containers according to the direction of rotation of said drum inclining from the bottom of said container at an obtuse angle thereto, said slanting walls being inclined at such angles that liquid substances contained in said mixture are poured off the containers and flow to the place of introduction of the mixture in a direction opposite to the course of rotation of said drum before they reach the discharge openings.

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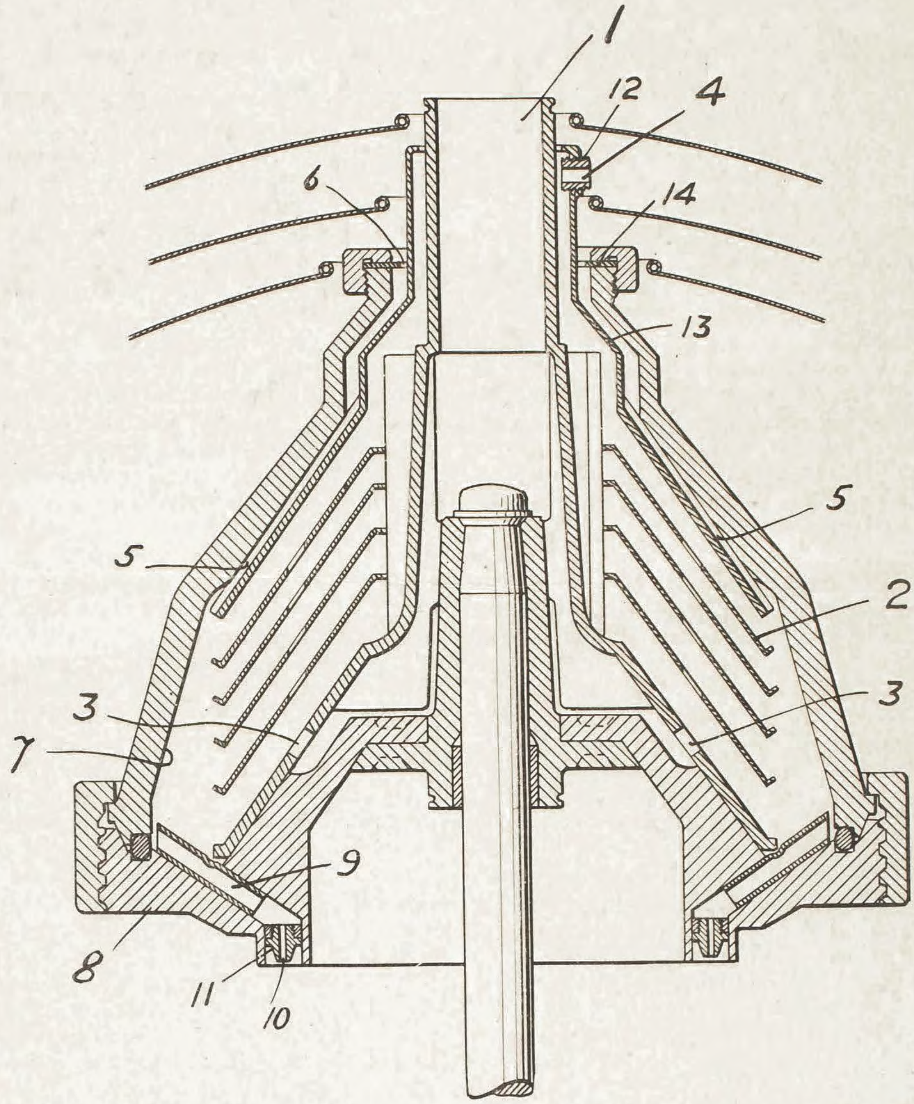
March 4, 1930. H. O. LINDGREN 1,749,291

CENTRIFUGAL SEPARATOR

Filed Aug. 24, 1928



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Busser and Harding

ATTORNEYS.

Patented Mar. 4, 1930 1,749,291

UNITED STATES PATENT OFFICE

HANS OLOF LINDGREN, OF APPELVIKEN, SWEDEN, ASSIGNOR TO THE DE LAVAL SEPARATOR COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY

CENTRIFUGAL SEPARATOR

Application filed August 24, 1928, Serial No. 301,829, and in Sweden October 26, 1927.

When centrifugating mixtures of two liquids of different specific gravities in order to separate them and continuously discharge them from the centrifugal bowl, there often accumulates at the bowl wall a layer of solids with higher specific gravity than that of the heavier liquid. With the object of preventing a reduction of the separating efficiency of the bowl resulting from such a deposit of solids, bowls provided with discs are generally provided with an annular space between the bowl wall and the discs, this space being sometimes designated a sludge space. It is necessary to stop the bowl and disassemble it in order to remove the sludge before said space is totally filled, so that the thickening layer of sludge deposits will be prevented from building up in between the discs, which would reduce the separating efficiency of the bowl in a high degree. When liquids containing large amounts of solids are to be treated in such separators, it is generally necessary first to submit the liquids to a pre-cleaning. Usually gravity settling tanks are employed for the purpose, in which tanks the solids deposit under influence of gravity as a bottom layer. It has also been proposed, and to a certain extent practically tried, to remove the coarse impurities by means of slowly rotating centrifuges of great diameter and provided with a large sludge space, and then to feed the liquid pre-cleaned in this way to a centrifuge revolving at a higher speed, in which the impurities which are more difficult to separate are removed.

Wash water from wool washeries may be specified as a specimen of such liquids. Said water contains, besides solid impurities (mainly finely divided sand and clay), waxy and fatty substances, "wool grease", in suspension, of lower specific gravity than the water. By centrifugating in separators similar to cream separators, it is possible to take out from this water, through the inner outlet of the bowl, a liquid mainly consisting of wax and fat. The wash water, more or less freed from fat, is led out through an outlet at a greater distance from the center of rotation. Experience has taught that, even after a gravity settling during a considerable length of time, such wash water contains so large quantities of solid impurities that, after a relatively short run, the bowl must be disassembled for cleaning. It has long been desired to be able to purify the wash water, to which soda and soap are added in order to facilitate the washing, from solid impurities and wax, so that the water, after such a purification, could again be used for washing. At the tests two centrifuges with the necessary pumps have been used in series with the wash apparatus. The wash water from the washer is fed into a slowly rotating centrifuge in which the coarse solid impurities are removed. The wash water, precleaned in this way, is thereupon treated in a separator of the cream separator type with the object of removing the wool grease. Experience teaches, however, that in this way it is not possible to obtain satisfactory results. The installation cost, as well as the working costs, become very high; and, furthermore, the wool grease is split up into such fine particles when the liquid streams out of the first separator that their separation in the second centrifuge is rendered highly difficult.

The object of the present invention is to provide a separator bowl which can be efficiently and economically used for treating a liquid, such as wash water from wool washeries, which is to be freed from lighter as well as from heavier components. The separator bowl is characterized by the fact that it is provided with two series of outlets at suitable distances from the center of rotation, which outlets permit a continuous discharge of two liquids of different specific gravity (in the illustrative case wool grease and wash water), and a third series of outlets communicating with a zone in the neighborhood of the bowl wall. The solid impurities, together with a suitable quantity of wash water, are continuously discharged through the last mentioned outlets. I am aware that it is not new to provide, in a centrifugal bowl, three outlets communicating with the separating space of the bowl at points at different distances from the bowl's axis in order to discharge components of different specific gravities. Such bowls are usually intended to prevent the accumulation on the bowl wall of a more or less viscous relatively heavy constituent, such as wax, which it is desired to separate from a lighter and more freely flowing constituent, such as oil, for which purpose there is introduced a still heavier carrier liquid, such as brine; the three substances being discharged from the bowl through outlets located at progressively greater distances from the center. The more especial object of my invention is to provide a bowl adapted to separate three materials of different specific gravities, the heaviest of which, ordinarily a mixture of solids, tends to accumulate in the bowl wall, and to utilize a part of the material of intermediate specific gravity, ordinarily a free flowing liquid, to wash out the heavier solids. The novel structural combination hereinafter described is more especially adapted to the separation of mixtures of this character, although it is capable of other uses, and it is intended to claim the novel construction irrespective of the uses to which it may be found adapted.

In the drawing, which shows a preferred embodiment of the invention, the figure is a vertical section through the centrifugal bowl.

1 indicates a central distributor into which the mixture to be treated is fed and from which it is led into the pile of discs 2 through distributing holes 3 at a suitable distance from the center of rotation. The liquid constituents divide into two parts between the discs; the lighter one that streams towards the centre of the bowl and is discharged through the outlets 4, and the heavier one that moves towards the periphery of the bowl and is discharged through the channels 5 from the above mentioned sludge space, which channels suitably have the openings 6 at the centre. While the heavy liquid streams outwards, a separation of the lighter components, as well as of the heavier solid impurities, takes place. Most of the solid impurities pass through the liquid layer in the sludge space and hit the bowl wall 7. The bowl wall is shown as conical in the illustration, a wall so shaped facilitating the sliding of the solid impurities down to the bottom of the bowl. In the bowl body 8 are channels 9 leading from the neighborhood of the bowl wall to outlets 10 suitably placed in exchangeable nozzles 11. The openings 10 should be so dimensioned as to prevent an unnecessarily large amount of liquid streaming out with the solid impurities. The solid impurities can be discharged through openings other than the channels 9 shown in the figure. The last mentioned device, is, however, preferred, as it is thereby possible to make the outlet openings for a certain quantity of liquid larger, thus reducing the danger of clogging.

In certain instances it has been found that the separated solid impurities have such a consistency that it is necessary to have transport devices in the bowl to transport the impurities to the zone from where they are discharged from the sludge space; or to transport such impurities, by means of scrapers and other devices, from the sludge space to that part of the bowl from where they are discharged. Such transport devices are known in the art and require no description.

To make it possible to treat, in one and the same separator bowl, different mixtures comprising liquids of various specific gravities and having different proportions of light and heavy components, the bowl should be provided with regulating devices, by which the distance of the outlets from the axis of rotation can be altered. The figure shows a bored regulating screw 12 placed in the top disc 13. By adjusting this screw the distance of the outlet zone from the axis of rotation can be altered, and, with it, also, the proportion of liquid streaming out through this opening. The outer outlet is provided with exchangeable discs 14, each provided with a central opening. An alteration of the proportion between the liquids streaming out through the different outlets can be obtained by using discs with holes of different diameters, and it is thus possible to adjust the bowl to adapt it to the different characteristics of different mixtures.

The regulating devices described are to be considered only as examples. Many such regulating devices are already in use on separators for milk and oil, and they can generally be adapted to bowls embodying my invention.

It is also advisable to provide the outlets for the solid impurities with regulating devices, it generally being necessary to discharge a certain quantity of liquid together with said impurities. If the content of solid impurities is increased in the liquid to be separated, it is, in general, also necessary to increase the quantity of liquid which is discharged with the solid impurities.

While the construction just described is intended and adapted for the continuous discharge of solid impurities, the invention is not limited to a continuously discharging sludge outlet. With the use of special sludge outlets there may be combined special intermittently operable valves or special devices for forcing the solids out of the bowl. These being known in the art (see, for example, Patent 1,304,621 to Sturgeon), a description is unnecessary.

What I claim and desire to protect by Letters Patent is:

1. The combination with a revoluble separator bowl provided with an inlet for a mixture of centrifugally separable materials, of a series of superposed conical discs adapted to divide the separating space of the bowl

into strata and afford an open annular sludge space between the outer edges of said discs and the wall of the bowl, the top disc providing outside and above it an outlet channel whose inlet end is in direct communication with the space adjacent the outer edge of the top disc, an outlet affording direct communication with the inner ends of the spaces between the discs and an outlet communicating with said sludge space at a distance substantially greater than the edge of said top disc from the center of rotation.

2. The combination with a revoluble separator bowl provided with an inlet for a mixture of centrifugally separable materials, of a series of superposed conical discs adapted to divide the separating space of the bowl into strata and afford an open annular sludge space between the outer edges of said discs and the wall of the bowl, the wall of the bowl being shaped to provide a sludge space of varying width, the outer edge of the top disc adjoining a narrower part of said sludge space, the top disc providing outside and above it an outlet channel whose inlet end is in direct communication with the space adjacent the outer edge of the top disc, an outlet affording direct communication with the inner ends of the spaces between the discs and an outlet communicating with a wider part of said sludge space.

3. The combination with a revoluble separator bowl provided with an inlet for a mixture of centrifugally separable materials, of a series of superposed conical discs adapted to divide the separating space of the bowl into strata and afford an open annular sludge space between the outer edges of said discs and the wall of the bowl, the wall of said bowl being so inclined as to diverge from the axis of rotation from about opposite the top disc to about opposite the bottom disc, the bowl having an outlet affording direct communication with the space above the top disc, an outlet affording direct communication with the space below the top disc, and an outlet communicating with the part of the sludge space adjacent that part of the bowl wall farthest from the axis of rotation.

4. A revoluble centrifugal separator bowl having a circumferential wall bounding its separating space and inclined at an angle to the bowl's axis of rotation, there being an outlet communicating with the separating space of the bowl nearest its axis of rotation, means, including a top disc inclined to the axis of rotation of the bowl, providing an outlet channel whose inlet end adjoins that part of said bowl wall which is nearest the bowl's axis of rotation, there being a third outlet communicating with the space adjacent that part of said bowl wall which is furthest from the bowl's axis of rotation.

5. A revoluble centrifugal separator bowl having a lower circumferential wall bounding its separating space and inclined at a relatively narrow angle to the axis of rotation of the bowl, and an upper circumferential wall extending above the lower circumferential wall at a relatively wide angle to the axis of rotation, discs in the bowl whose outer edges are about in line with the inner upper end of said lower circumferential wall, said discs including a top disc spaced from said upper circumferential wall and affording an outlet channel whose inlet end adjoins the inner upper end of said lower circumferential wall, there being a second outlet communicating with the inner ends of the spaces between discs, and a third outlet communicating with the space adjoining the outer lower end of said lower circumferential wall.

In testimony of which invention, I have hereunto set my hand, at Stockholm, Sweden, on this 7th day of August, 1928.

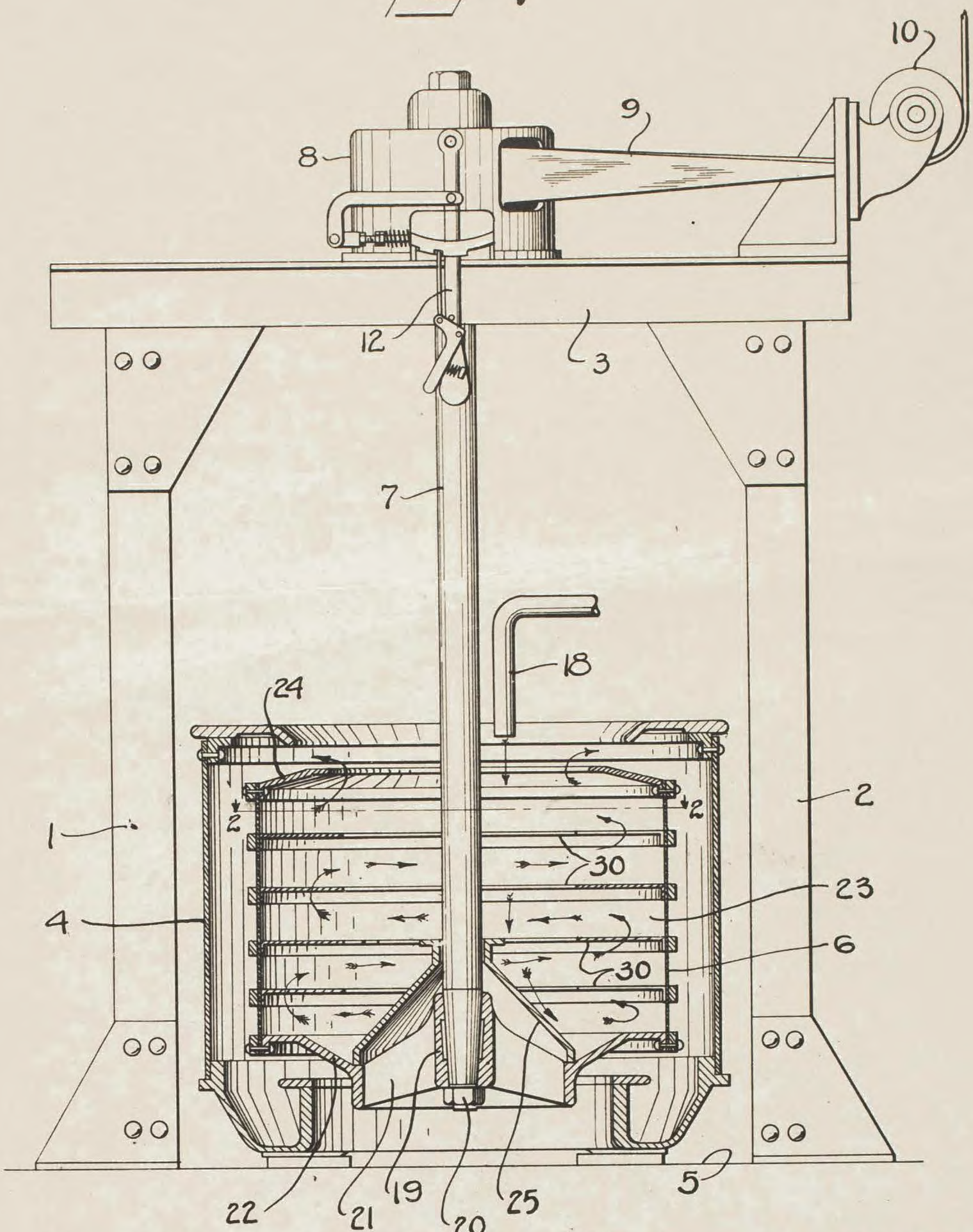
HANS OLOF LINDGREN.

April 23, 1929. T. A. BRYSON **1,710,447**

CENTRIFUGAL EXTRACTOR AND METHOD OF CENTRIFUGAL EXTRACTION

Filed Oct. 25, 1921 2 Sheets-Sheet 1

Fig 1



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April 23, 1929. T. A. BRYSON 1,710,447

CENTRIFUGAL EXTRACTOR AND METHOD OF CENTRIFUGAL EXTRACTION

Filed Oct. 25, 1921 2 Sheets-Sheet 2

Fig 3

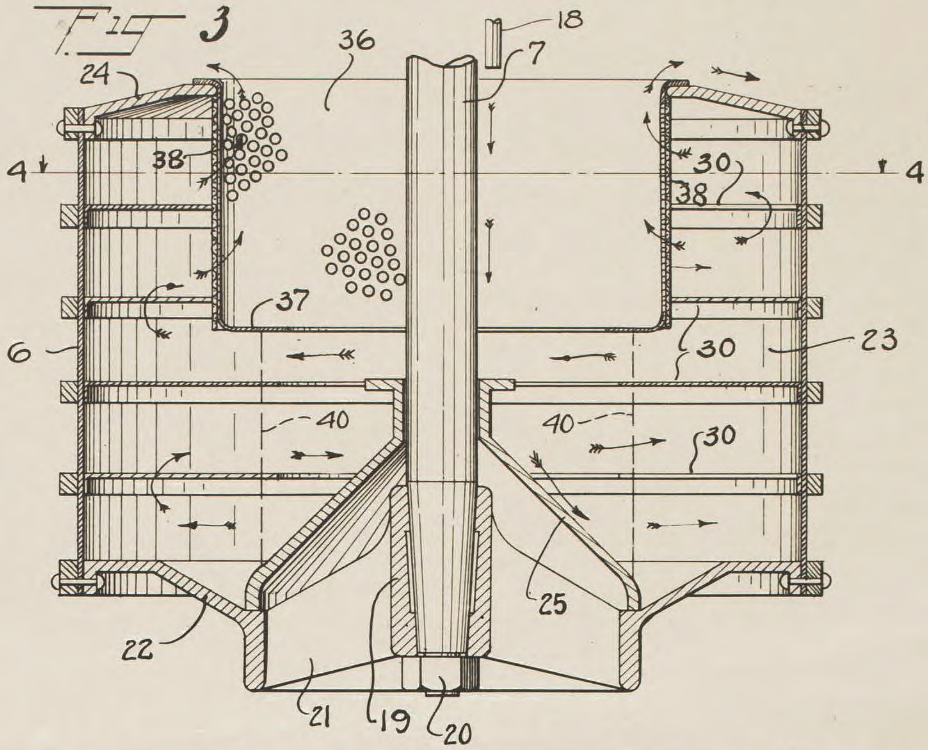


Fig 2

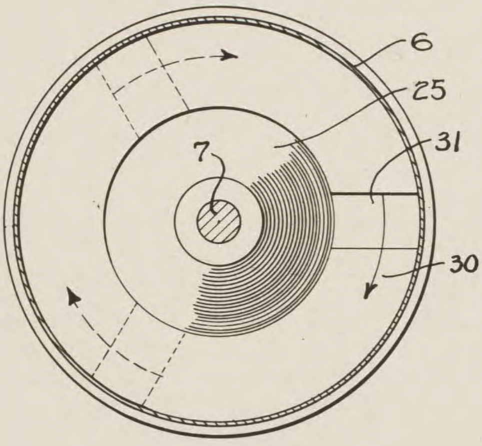
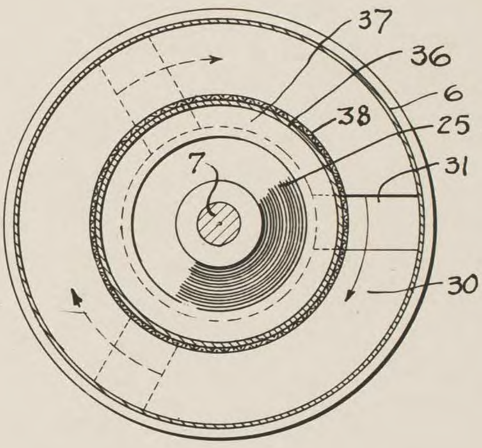


Fig 4



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UNITED STATES PATENT OFFICE.

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CENTRIFUGAL EXTRACTOR AND METHOD OF CENTRIFUGAL EXTRACTION.

Application filed October 25, 1921. Serial No. 510,344.

The invention relates to a machine and process for separating a liquid and solids in suspension therein, and more particularly to a novel machine and process for centrifugally separating the liquid and solids and discharging the separated liquid while retaining the solids in the machine.

Objects and advantages of the invention will be set forth in part hereinafter and in part will be obvious herefrom, or may be learned by practice with the invention, the same being realized and attained by means of the instrumentalities and combinations pointed out in the appended claims.

The invention consists in the novel steps, processes, parts, constructions, arrangements, combinations and improvements herein shown and described.

The accompanying drawings, referred to herein and constituting a part hereof, illustrate one embodiment of the invention, and a manner of carrying out the process, the same with the accompanying description serving to explain the principles of the invention.

Of the drawings:—

Fig. 1 is a central vertical section through an extractor embodying the invention, with the frame and certain other parts in elevation;

Fig. 2 is a full horizontal section taken on the line 2—2 of Fig. 1;

Fig. 3 is a central vertical section through a basket equipped with a screen or strainer for the liquid; and

Fig. 4 is a full horizontal section taken on the line 4—4 of Fig. 3.

The invention provides a centrifugal extractor for separating a liquid and solid matter in suspension therein, the solids being retained and the clarified liquid being discharged by the centrifugal action, the liquid being compelled to travel in a comparatively thin stream or streams for a relatively long circumferential distance compared with the flow or progress of the liquid axially, and preferably without any flow of the liquid in a radial direction. That is, the liquid is subjected to a very long flow in a relatively thin stream while subjected to the centrifugal action, and is preferably restrained from radial flow while its axial flow is closely controlled and is relatively very small as compared to the lineal or circumferential flow of the liquid.

Another object of the invention is to effect the separation of a liquid intermixture containing solid particles by restricting axial flow of the intermixture while same is under centrifugal action, thereby prolonging the centrifugal action so as to effect the separation of the solids and flowing off a separated liquid. While the intermixture is under centrifugal action, I permit only restricted axial flow of the rotating intermixture and thereafter cause one of the liquids to flow away after it is separated.

The remaining objects and features will be set out later in connection with the detailed description, and it will be understood that the foregoing and also the following description is explanatory and exemplary and is not restrictive of the invention.

Referring now in detail to the present preferred embodiment, illustrated by way of example in the accompanying drawings, and in accordance with certain features of the invention, the invention is applied to a centrifugal machine of the overhead suspended type, although so far as concerns other features of the invention it may be applied to other types of centrifugals.

In said illustrated form, a supporting frame is provided having uprights 1 and 2 and a horizontal cross-piece 3 supported upon the upper ends thereof. The centrifugal extractor comprises broadly a casing 4, which is preferably mounted in stationary position upon the floor 5, and is provided with any suitable means for carrying away or discharging the clarified separated liquid which is discharged from the basket or bowl 6 thereinto.

The basket or bowl 6 is suspended from, and rotated by, a shaft 7, which shaft is preferably resiliently mounted, to have also angular or gyratory movement with an unbalanced load, in any suitable supporting bearing, such bearing having connected therewith, or adjacent thereto, any suitable or desired form of driving means for the shaft 7. The enclosing housing for the bearing is shown at 8, and a belt 9 extends from the housing around guide pulley 10 and to any suitable driving means (not shown). A brake mechanism 12 is likewise preferably provided.

The liquid to be clarified is supplied in a suitable manner, and as embodied, a supply pipe 18 discharges downwardly and centrally into the bowl or basket 6, close to the shaft 7. The bowl 6 is provided at its bottom end with a central bearing hub 19, fastened on the bottom end of the shaft 7 in any suitable manner, as by a nut 20. The separated solid materials are preferably discharged from the central bottom portion of the bowl. Spider arms 21 extend radially from the hub 19, the spaces therebetween serving as the discharge openings. Carried by the outer ends of the spider arm 21 is the bottom 22 of the bowl. The side wall 23 of the bowl is imperforate and preferably cylindrical.

Means are provided for determining the depth or thickness of the wall of liquid which is subjected to the centrifugal action in the bowl 6, and as embodied, an inwardly projecting flange or shelf 24 is provided at the top of the bowl, the clarified or separated liquid flowing upwardly and outwardly over the inner edge thereof into the casing 4 and is then discharged therefrom. A valve 25 is provided as a closure for the discharge openings for the solids in the bottom of the bowl 6.

In the embodied form of means for controlling the hereinbefore described flow and action of the liquid during the centrifugal action, a plurality of flat annular baffle plates 30, preferably horizontally disposed, are provided, the outer periphery of these baffles abutting on the vertical cylindrical wall 23 of the bowl 6. The width or radial extent of the baffles 30 is preferably such that they extend radially inwardly a greater distance than the flange or shelf 24, and when so constructed they constitute means for preventing axial flow or currents in the liquid under centrifugal action, thereby preventing intermixture and consequent contamination of the inner separated or clarified liquid with the outward and denser and contaminated liquid, and likewise contributing largely to stabilizing the machine against gyration or angular displacement when the resilient form of suspension is employed. The flange or shelf 24, as indicated determines the depth or thickness of the wall of liquid within the bowl 6 and when the baffles 30 extend inwardly a greater radial distance than the lip or shelf 24 there is no axial flow of the liquid internally past a baffle.

The precise number of baffles employed, broadly considered, is immaterial, but the greater the number employed the longer the lineal flow which is imposed upon the liquid while under centrifugal action, and the smaller the stream into which the liquid is divided while so flowing, and consequently the more extended and thorough the separating action.

In the embodied form of means for permitting the axial flow in connection with the means for directing the lined or circumferential flow already described, the baffles 30 are imperforate except at preferably a single point, where there is an opening 31 therethrough, whereby the liquid may flow upwardly or in a general axial direction past the baffle plate 30. These openings 31 may be placed at various points as desired, but preferably are placed so as to give substantially or approximately the maximum lineal or circumferential flow beneath each baffle plate 30.

In many cases and with many liquids to be separated, I wish to avoid forcing the liquid, or the various particles thereof, radially so that it may escape upwardly. I provide means whereby no matter where a particle may be in the depth of fluid, it may escape by moving circumferentially and vertically without any radial movement thereof, except as such particle is impelled to radial movement due to centrifugal force or action.

This is effected in the present embodiment by making the openings 31 in the baffle plates 30 equal or nearly equal to the entire width, or radial extent, of the baffle plate, as is clearly shown in all the figures of the drawing. The passages or openings 31 are also proportioned to limit the upward flow of the liquid to a comparatively small sector of the annulus formed by its baffle plate, as shown in Figs. 2 and 4.

The particles therefore travel upwardly in a substantially helical path, winding about the axis of the basket shaft. The radial distance of a given particle from the basket shaft during its helical travel is substantially constant.

In certain cases, or with certain liquids or solutions, it is desirable to finally filter or strain the clarified liquid before it is discharged, as in certain cases, there may be in suspension in the liquid some substance, such as an exceedingly finely divided solid which is not entirely separated even by the unusually extensive and thorough centrifugal action of my invention, although such a condition in practice would be very rare and unusual.

Accordingly, in pursuance to one feature of the invention, there is provided, in cooperation with the current controlling and directing means already described, a suitable form of filtering means acting in the manner described. As preferably embodied, a cylindrical filtering member 36 is supported upon and extends downwardly within the lip or shelf 24 of the bowl 6, and preferably abuts upon and acts as a closure against the inner peripheral edge of one or more of the upper baffles 30. In view of the fact that the filter 36 will cause a certain amount of back-pressure due to the forcing of the liquid therethrough, the wall of liquid 40 below the screen or filter 36 will be thicker than around the filter, the difference in thickness being proportional to the amount of pressure necessary to overcome the resistance of the filter to the flow of the liquid therethrough.

As embodied, the filter 38 is preferably provided with a reenforcing cylindrical perforate plate 36, which supports the filter against the fluid pressure while permitting the filtered fluid to pass through freely. At the bottom end of the filter 38, and conveniently integral with, or attached to, the supporting plate 36, there is a flat angular imperforate baffle plate 37, the outer periphery of which is joined to the bottom end of the cylindrical plate 36. The baffle 37 serves to prevent upward axial flow from this thicker portion of the wall of liquid without its passing through the filter. The baffles 30 are also of greater radial extent below the filter, to maintain their rleation to the wall of liquid within the bowl 6, so as to prevent axial flow past the inward periphery of the baffles and to compel all of the liquid to take the long and prescribed path already described.

With the manner described of directing and controlling the liquid, there is a longer lineal and circumferential flow of the liquid under centrifugal action, while the axial flow is relatively exceedingly small. There is also a greatly reduced velocity of the flow through the bowl, which conduces greatly to complete separation of the solids, especially the more finely-divided solids and those of lesser specific gravity.

There is also less direct exit of the liquid, and the bowl is not clogged at as early a stage in the collection or separation of the solids. Nor will the lower baffles become clogged with the solids and leave or create conditions of instability in the upper part of the device.

Also in the manner of procedure described, I do not force clarified or separated liquid into close contact or admixture with the precipitated or separated solids or with the outer, denser parts of the liquid.

A very important advantage of the invention is that it promotes in a most effective manner the stability of the machine, when a resilient suspension or mounting is employed, by preventing or counteracting the angular movement, or tendency to such movement, of the bowl and its shaft, by controlling the position of the inner surface of the liquid and the relation or relative position of the mass, or center of mass, of the liquid to the bowl and shaft. Also, vertical surging of the liquid is eliminated and this likewise conduces to more complete and effective settling action.

It will be understood that the invention is not limited to the details of construction and procedure herein illustrated and described, but that departures may be made thereform within the scope of the accompanying claims, without departing from the principles of the invention and without sacrificing its chief advantages.

What I claim is:—

1. A centrifugal extractor comprising in combination a rotating basket, and a plurality of horizontally disposed annular baffles in the basket, the spaces between the baffles being unobstructed circumferentially, each baffle having an opening therethrough extending substantially from the outer edge to the inner edge thereof, the openings in the baffles having different angular positions with respect to the axis of rotation of the basket.

2. A centrifugal extractor comprising in combination a rotating basket, and a plurality of horizontally disposed annular baffles in the basket, the spaces between the baffles being unobstructed circumferentially, each baffle having an opening therethrough extending substantially from the outer edge to the inner edge thereof, the openings in the baffles having different angular positions with respect to the axis of rotation of the basket, each baffle extending inwardly through the substantially vertical liquid wall formed when the basket rotates at high speed.

3. A centrifugal extractor comprising in combination a rotating basket, and a plurality of horizontally disposed annular baffles in the basket, each baffle having an opening therethrough, each opening being in a different vertical plane from the opening in the adjacent baffle, each baffle being of a width to extend inwardly through the substantially vertical liquid wall formed when the basket rotates at high speed.

4. A centrifugal extractor comprising in combination a rotating basket, a flange at the upper part of the basket determining the position of the substantially vertical wall formed when the basket rotates at high speed, and a plurality of spaced, annular baffles positioned in the basket, each having an opening therethrough extending substantially radially from the outer edge to the inner edge thereof, the inner edge of each baffle being a less distance from the axis of the basket than the inner edge of the flange.

5. A centrifugal extractor comprising in combination a basket with an imperforate cylindrical wall, a flange extending inwardly from the top of the basket, determining the horizontal thickness of the wall of confined liquid, a plurality of horizontal baffles spaced apart and extending inwardly from the wall of the basket beyond the inside surface of the wall of confined liquid, openings in the baffles permitting the passage of liquid therethrough, said openings being variously angularly positioned to give approximately the

longest path of travel to liquid flowing upwardly for discharge at the top of the basket.

6. A centrifugal extractor comprising in combination a basket with an imperforate cylindrical wall, a flange extending inwardly from the top of the basket, determining the horizontal thickness of the wall of confined liquid, a plurality of horizontal baffles spaced apart and extending inwardly from the wall of the basket beyond the inside surface of the wall of confined liquid, openings in the baffles permitting the passage of liquid therethrough, said openings being variously angularly positioned to cause particles of liquid to flow upwardly in a substantially helical path, the axis of the helix being at substantially the axis of rotation of the basket.

7. A centrifugal extractor comprising in combination a rotating basket mounted to have angular or gyratory movement, and a plurality of annular baffles within the basket, each baffle having a radial opening therethrough in a different vertical plane from the opening in the adjacent baffle whereby a circumferential flow of material is induced, the baffles preventing surging of the liquid in the basket during gyratory movement thereof.

8. A centrifugal extractor comprising in combination a rotating basket mounted to have angular or gyratory movement, and a plurality of spaced, horizontally disposed annular baffles in the basket, each baffle having an opening therethrough extending from the outer edge to the inner edge thereof, which openings occupy different angular positions about the basket shaft, the baffles causing a circumferential flow of liquid between the baffles further serving to prevent surging of the liquid during the gyratory movement thereof.

9. A centrifugal extractor comprising in combination a rotating basket mounted to have angular or gyratory movement, a plurality of spaced, horizontally disposed annular baffles in the basket, each baffle having an opening therethrough extending from the outer edge to the inner edge thereof, adjacent openings being out of alinement, the baffle being of a width such that the inner edge projects through and inwardly of the substantially vertical wall of liquid formed when the basket rotates at high speed.

10. A centrifugal extractor comprising in combination a rotating basket, an annular flange at the top of the basket over which liquid flows and escapes from the basket, the inner edge of said flange determining the position of the substantially vertical wall of liquid formed when the basket rotates at high speed, and a plurality of spaced, horizontally disposed annular baffles in the basket, the inner edges of which extend farther inwardly than the inner edge of said flange so as to project through the said vertical liquid wall, each baffle having an opening therethrough, each opening being in a different vertical plane from the opening in the adjacent baffle.

11. A centrifugal extractor comprising in combination a rotating basket, an annular flange at the top of the basket over which liquid flows and escapes from the basket, the inner edge of said flange determining the position of the substantially vertical wall of liquid formed when the basket rotates at high speed, and a plurality of spaced, horizontally disposed annular baffles in the basket, the inner edges of which extend farther inwardly than the inner edge of said flange so as to project through the said vertical liquid wall, each baffle having an opening therethrough, each opening being in a different vertical plane from the opening in the adjacent baffle, and each opening extending in a substantially radial direction from the outer edge of the baffle to the inner edge thereof.

12. A centrifugal extractor comprising in combination a rotating basket mounted for gyratory movement, a flange at the top of the basket, a plurality of spaced, horizontally disposed annular baffles in the basket, the inner edge of each baffle extending further inwardly than the edge of said flange so as to project through the vertical wall of liquid formed when the basket rotates at high speed, each baffle having a radially disposed opening therethrough extending from the outer edge to the inner edge of the baffle, each opening being in a different vertical plane from the opening in the adjacent baffle, and a vertically movable valve in the bottom of the basket.

13. A centrifugal extractor comprising in combination a rotating basket, a plurality of horizontally disposed annular baffles in the basket, the spaces between the baffles being unobstructed circumferentially, each baffle having an opening therethrough extending substantially from the outer edge to the inner edge thereof, the openings in the baffles having different angular positions with respect to the axis of rotation of the basket, and a vertically disposed filter positioned near the top of the basket.

14. A centrifugal extractor comprising in combination a rotating basket, a plurality of horizontally disposed annular baffles located in the basket, each baffle having an opening therethrough, each opening being in a different vertical plane from the openings in adjacent baffles, the baffles being of a width so that their inner edges extend through and inwardly of the substantially vertical liquid wall formed when the basket rotates at high speed, and a filter near the top of the basket having a vertically disposed wall further out from the basket shaft than the inner edges of the baffles.

15. The process of centrifugally separating a liquid intermixture which comprises

maintaining a cylindrical body of the liquid undergoing centrifugal action, permitting restricted flow of the liquid in a general axial direction and causing one of the intermixed materials to flow away after it has been separated and retaining another separated liquid component in the cylindrical body.

16. The process of centrifugally separating a liquid intermixture containing solid particles which comprises maintaining a cylindrical body of the liquid undergoing centrifugal action, preventing radial flow of the intermixture, permitting restricted flow of the liquid in a general axial direction and causing one of the intermixed materials to flow away after it has been separated.

17. The process of centrifugally separating a liquid intermixture containing solid particles which comprises maintaining a cylindrical body of the liquid undergoing centrifugal action, causing a restricted flow at different places angularly and longitudinally of said cylindrical body, and causing one of the intermixed materials to flow away after it has been separated, and intermittently discharging a separated solid material.

18. The process of centrifugally separating a liquid intermixture which comprises subjecting a predetermined but progressively changing body of the intermixture to a relatively large rotational centrifugal separating action and to a simultaneous flow which is relatively small and having an upward axial component which is displaced successively angularly of the body of the intermixture, and flowing off a separated liquid.

19. The process of centrifugally separating a liquid intermixture which comprises subjecting a predetermined quantity of the materials to rotational movement to effect separation centrifugally and causing a substantially helical flow of the material to renew said quantity undergoing separation and to discharge a separated fluid while retaining a heavier separated fluid.

20. The process of centrifugally separating a liquid intermixture containing solid particles which comprises subjecting a predetermined quantity of the materials to centrifugal separating action, controlling fluent movement thereof in a non-radial direction to protract the period of the centrifugal action, and flowing off a separated component.

21. The process of centrifugally separating a liquid intermixture containing solid particles which comprises subjecting a body of the liquid to centrifugal action and restricting axial flow of the intermixture thereby subjecting it to a sufficiently prolonged centrifugal action and flowing off a separated liquid.

22. The process of centrifugally separating a liquid intermixture which comprises maintaining a cylindrical body of the liquid undergoing centrifugal action permitting restricted upward axial flow of the rotating intermixture and causing one of the intermixed liquids to discharge in the direction of axial flow after it has been separated.

23. The process of centrifugally separating a liquid intermixture which comprises maintaining a cylindrical body of the liquid undergoing centrifugal action, permitting restricted upward axial flow of the rotating intermixture and causing one of the intermixed liquids to flow away after it has been separated.

24. The process of centrifugally separating a liquid intermixture which comprises rotating a receptacle containing the liquid at a high speed, and restricting the axial flow of the liquid generated by the rotation to subject the liquid to the centrifugal separating action for a prolonged determinable period.

25. The process of centrifugally separating a liquid intermixture which comprises rotating a receptacle containing the liquid at a high speed, generally preventing the axial flow of the liquid generated by rotation, and causing a restricted flow at a plurality of different places angularly and longitudinally of the cylindrical body of liquid generated by the rotation.

26. The process of centrifugally separating a liquid intermixture which comprises rotating a receptacle containing the liquid at a high speed, generally preventing the axial flow of the liquid generated by rotation, and causing a restricted flow at a plurality of different places angularly and longitudinally of the cylindrical body of liquid generated by the rotation and flowing off a separated component of the liquid intermixture.

27. The process of centrifugally separating a liquid intermixture which comprises rotating a receptacle containing the liquid at a high speed, generally preventing the axial flow of the liquid generated by rotation, and causing a restricted flow at a plurality of different places angularly and longitudinally of the cylindrical body of liquid generated by the rotation and discharging a separated component of the liquid intermixture from the receptacle by continued axial movement.

28. The process of centrifugally separating a liquid intermixture which comprises rotating a receptacle containing the liquid at a high speed, and restricting the axial flow of the liquid generated by the rotation to subject the liquid to the centrifugal separating action for a prolonged determinable period, and removing the axial restriction to permit discharge of a separated material.

29. The process of centrifugally separating a liquid intermixture which comprises maintaining a cylindrical body of the liquid undergoing centrifugal action preventing radial flow of the intermixture, permitting restricted upward axial flow of the rotating

intermixture and causing one of the intermixed liquids to discharge in the direction of axial flow after it has been separated.

30. The process of centrifugally separating a liquid intermixture which comprises rotating a receptacle containing the liquid at a high speed preventing radial flow of the intermixture, and restricting the axial flow of the liquid generated by the rotation to subject the liquid to the centrifugal separating action for a prolonged determinable period.

31. The process of centrifugally separating a liquid intermixture which comprises maintaining a cylindrical body of the liquid undergoing centrifugal action, feeding intermixed materials substantially at the hollow center of the cylindrical body, generally preventing the upward axial flow of the liquid generated by rotation, and permitting a restricted upward flow at different places angularly and longitudinally of the cylindrical body.

32. The process of centrifugally separating a liquid intermixture which comprises maintaining a cylindrical body of the liquid undergoing centrifugal action, feeding intermixed materials substantially at the hollow center of the cylindrical body, generally preventing the upward axial flow of the liquid generated by rotation, and permitting a restricted upward flow at different places angularly and longitudinally of the cylindrical body, and removing the axial restriction at the top of the cylindrical body to discharge a separated component.

33. The process of centrifugally separating a liquid intermixture which comprises maintaining a cylindrical body of the liquid undergoing centrifugal action, feeding intermixed materials substantially at the hollow center of the cylindrical body, generally preventing the upward axial flow of the liquid generated by rotation, and permitting a restricted upward flow at different places angularly and longitudinally of the cylindrical body, partially removing the axial restriction at the top of the cylindrical body to discharge a separated component, and discharging another separated component at the bottom of the cylindrical body.

34. The process of centrifugally separating a liquid intermixture which comprises rotating a receptacle containing the liquid at a high speed, feeding intermixed materials downward at the hollow center of the cylindrical body of liquid undergoing centrifugal separation, preventing radial flow of the intermixture, permitting restricted upward flow of the liquid, and permitting one of the separated liquid components to discharge at the top of the receptacle.

35. The process of centrifugally separating a liquid intermixture which comprises rotating a receptacle containing the liquid at a high speed, feeding intermixed materials downward at the hollow center of the cylindrical body of liquid undergoing centrifugal separation, preventing radial flow of the intermixture, permitting restricted upward flow of the liquid, permitting one of the separated liquid components to discharge at the top of the receptacle and discharging a separated solid component at the bottom of the receptacle.

In testimony whereof, I have signed my name to this specification.

TANDY A. BRYSON.

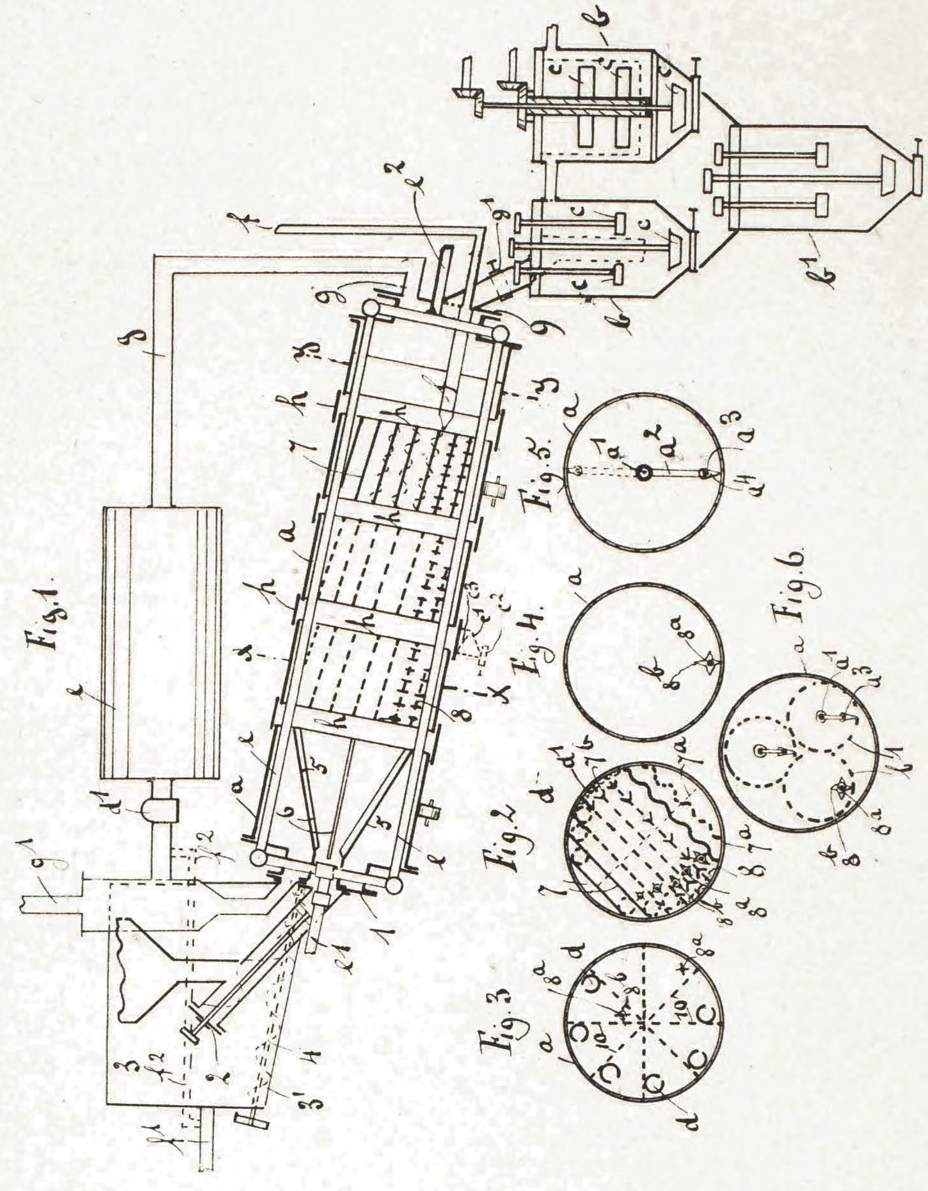
No. 756,271. PATENTED APR. 5, 1904.

P. NAEF.

APPARATUS FOR TREATING SOLIDS, SUCH AS ORES, LIQUIDS, OR GASES.

APPLICATION FILED APR. 18, 1901.

NO MODEL.



Witnesses.

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No. 756,271. Patented April 5, 1904.

UNITED STATES PATENT OFFICE.

PAUL NAEF, OF NEW YORK, N. Y.

APPARATUS FOR TREATING SOLIDS, SUCH AS ORES, LIQUIDS, OR GASES.

SPECIFICATION forming part of Letters Patent No. 756,271, dated April 5, 1904.

Application filed April 18, 1901. Serial No. 56,378. (No model.)

To all whom it may concern:

Be it known that I, PAUL NAEF, Ph. D., chemical engineer, a citizen of Switzerland, and a resident of 132 Woody Crest avenue and One Hundred and Sixty-fifth street, New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Treating Solids, such as Ores, Liquids, or Gaseous Fluids, of which the following is a specification.

This invention relates to improved apparatus for treating ores and other solids with liquids and gases or vapors for extracting or recovering certain of their constituent elements.

The apparatus is especially intended for the extraction of gold by cyanid or chlorin; but it is also applicable for the treatment of other materials, as for the extraction of glue from bones and the manufacture of bicarbonate of soda, &c.

The object of the invention is to provide means for moving the solid material through a liquid while the latter passes in the opposite direction to that of the solid and to bring the solid and the liquid into intimate contact with each other and with a gas or vapor.

With this object in view the invention consists in certain novel features of construction and combinations and arrangements of parts, as hereinafter set forth, and pointed out in the claims.

The drawings show a revolving cylinder *a*, supported on rollers and connected by means of a stuffing-box with a stationary cover 1 on the charging end. Solid material is fed into the cylinder *a*—for instance, by a conveyer 2. Liquor enters from the cylinder *a* into a chamber 3, having an inclined bottom 3′, on which solid material settles, and is brought back into the cylinder by a conveyer 4. In some cases I use no conveyer and incline the bottom sufficiently so that the solid flows back into the cylinder by gravitation. For the purpose of preventing overflow of materials from the charge end the conveyer 2 empties the fresh material into a funnel 5, which may have ribs 6 arranged in helicoid lines to assist the forward movement of the material. The cylinder, which is fitted with agitating devices in other parts, has no such devices in the charging end to prevent carrying over of solid with the liquor. Partitions 7 are arranged in sections and are made perforated, corrugated, or of wire-gauze. They are so arranged that they lift the material through the liquid and expose it also to the vapors or gases which may be circulating through the cylinder. The partitions also are so arranged that they move the material through the cylinder and may to further assist this be arranged in inclined position, as shown in Figure 1.

Radial partitions may be employed, as shown in Fig. 3, in which case the said partitions do not run in the direction of the axis of the cylinder on the periphery, but are bent so as to move the material.

If partitions are arranged in parallel position and longitudinal sections, each section is not arranged running in the direction of the axis, but as shown in Fig. 1. After each section the material is lifted and then passes downward over the partitions and at the same time is moved forward to be lifted and showered again by the next set of partitions. The arrangement can be applied in cylinders used for the treatment of solid material without the presence of liquids. At the lower end the cylinder is closed by a plate *g*, usually also connected to the cylinder by a stuffing-box. The liquor is with advantage conducted some distance into the cylinder—for instance, by inserting an inlet-pipe *f*, reaching into the cylinder.

The way of removing the material from the cylinder and treating it is varied according to the nature of the material. In many cases the material runs out as a sludge into a settling-tank *b*, which is fitted with a conical bottom and has stirrers *c* for preventing solidification in the lower part. Several of these tanks can be arranged side by side. The product of one or more cylinders is run into one of the tanks until it is filled. Then settling takes place as far as allowable without solidification of the solid and the clear liquor is drawn off. Afterward washing of the material takes place by addition of weak liquor or water and afterward settling and withdrawing of liquor. Stirring appliances are arranged in the upper and lower part of the vessels, which can be independently operated. Only the lower stirring devices are operated during settling, but both after wash-water has been added.

With the arrangement described the liquor from the cylinder has to be alternately run into and through different settling-tanks. In place of this arrangement liquor can be continuously run through one or more settling-tanks, as shown in the drawings. Clear liquor leaves the last tank continuously. The solids settle in the conical bottom and solidification is prevented by running the stirrers in the conical part, which in this case are alone required. The sludge is withdrawn from the bottom of the tanks b to tanks of similar construction on a lower level b', where it is washed, or it is conducted to a filter-press or centrifugal machine.

Hot or cold gaseous fluids can be conducted through the apparatus by suitable inlets g and outlets g'. Often it is of advantage to conduct the same gaseous fluid through the cylinder by a fan d'. A temperature-adjuster l, consisting of a vessel containing a pipe system, can be arranged in the pipe g, which returns the gas leaving the cylinder back to the same, so as to keep the temperature of the cylinder at a constant point. Ores can in this way be leached by cyanid in the presence of oxygen or of other gas. Ores can further be leached in this way by applying chlorin directly to the charge as well as to the liquor in which the leaching takes place.

The apparatus can be applied for dissolving bicarbonate without decomposing the same by effecting this dissolving in the presence of carbonic acid. The liquor thus obtained can be run continuously from the cylinder through a settling-tank and through a cylinder which may be arranged on a lower level, in which cooling takes place, carbonic acid being also at the same time passed through the apparatus. Pure bicarbonate is thus produced in a continuous and practically automatic manner.

The apparatus described finds with advantage application in the brewing industry for operations where solid materials have to be treated. Most of the operations in this industry can thus be effected in a continuous manner, the liquor flowing from one part of the plant to the other.

The cylinders offer especial advantage for heating and also for cooling beer, as the speed and degree of such operations are absolutely under control. They also offer great advantage for heating and cooling such fluids as beer in presence of a suitable gas. Cooling can, for instance, take place first in the presence of air and afterward in the presence of carbonic acid. By cooling sufficiently low a considerable amount of gas is taken up by the fluid, so that beer, for instance, can be casked in this cool state. The entire operations of the brewing industry are by these means entirely under control to obtain the best results from whatever material is used.

In the drawings, Fig. 1 shows a vertical longitudinal cross-section; Fig. 2, a section of Fig. 1 on line x x, and Fig. 3 a section on line y y. Figs. 4, 5, and 6 are modifications.

d d are lifters, usually arranged in the form of pipes with suitable perforations for lifting and showering the liquid on the partitions 7.

The pipes e e, Fig. 1, are arranged for the purpose of heating or cooling the cylinder a. e' is the inlet, and e^2 the outlet, for cooling fluid. f is the inlet-pipe for liquid to the cylinder, which reaches some distance into the latter, and f' is the outlet-pipe for liquid from the settling-tank. g is the gas-inlet pipe, and g' the gas-outlet pipe. Manholes h may be arranged between the agitating-sections of the cylinder.

Fig. 3 shows the last section of the cylinder near the discharge end with radial partitions to lift and discharge the material.

If operations are to be conducted in the apparatus under pressure, the settling-tanks are fitted with tight covers. Suitable valves are arranged above and below the feed-hopper, the latter being closed while the hopper is being filled and the upper valve being closed all the time, except when filling the hopper. In Fig. 2 it is shown that the partitions can be nonperforated, perforated, corrugated. They may also with advantage consist of wire-gauze 7^a, which may also be corrugated. In some cases the corrugations run across the cylinder. In others, especially if the material is heavy, they run longitudinally. The partitions are often with advantage fastened to a frame, as indicated by the dotted line 7^b, in such a manner that whole sections can be pushed bodily into the cylinder. The frames may be filled with suitable rollers facing against the periphery of the cylinder, so that the sections can easily be placed.

To prevent the formation of scale on the partitions and periphery, it is, when treating some materials, of advantage to use special devices. They may consist of rods or pipes 8^a, placed into the cylinder, which carry teeth 8^b to facilitate the removal of crust. These pipes may extend through the entire cylinder or be placed extending through each section of partitions.

Fig. 4 shows an empty cylinder with rod 8^a and teeth on the latter, 8^b. As the shell revolves the rod also begins to revolve, remaining at the same time in the lower part of the cylinder in a position depending on the speed of the periphery-surface moving under it. In Fig. 3 rods having teeth are shown between the radial partitions. As the cylinder revolves the rods slide on the surfaces, thus keeping partitions as well as periphery clean. In Fig. 2 rods 8^a, having teeth 8^b, are shown between the parallel partitions, on which they slide when the cylinder gets into a certain position alternately on one side of the surface and afterward on the other. In Fig. 2 it is further shown that the partitions can carry projections 9′, which act as lifters and can eventually replace the lifter *d*.

Instead of placing the rods 8^a in cylinder loosely guides can be arranged which allow only movement in certain directions, which may, for instance, be controlled by a slot in which the rods run. It is in this way possible to keep the rods and teeth a short distance from the surfaces and prevent wear and tear. If the surfaces are of round or nearly round cross-section, the arrangement shown in Figs. 5 and 6 can be adopted.

Fig. 5 shows a shaft or rod a' arranged in the center. On the shaft are hangers a^2, which carry another rod, a^3. On the latter numerous teeth a^4 are fastened in suitable manner, usually in such a way that they revolve freely on the rod a^3. The hangers a^2 are usually also loose, and their weight causes them to hang nearly perpendicular, the teeth being stationary and the cylinder moving. The rods a^3 are usually arranged in short sections. In smaller cylinders they can be avoided, teeth being placed on shaft a'. The arrangement can be so changed that the pieces a^2 are fastened tightly on the shaft a'. The latter is then revolved, preferably, in a direction opposite to the one of the cylinder. A good agitation is thus effected and the surfaces are kept clean. The pieces a^2 can reach right across the cylinder, as indicated by dotted lines. They can be arranged alternately at right angles to each other.

Fig. 6 shows a cylinder in which round surfaces, such as pipes b', are arranged, which are preferably perforated. In these pipes are arranged agitating and cleaning devices. They may consist of a loose rod 8^a with spikes 8^b, as shown, or of an arrangement similar to the one shown in Fig. 5. a' is a stationary or revolving shaft to which are fastened suitable scraping devices. The latter are fastened usually direct on a' and hang perpendicularly if the shaft is stationary, or they are fastened to a rod a^3, as described.

The sets of parallel partitions are with advantage radially offset, each set being in a different position than the adjoining set.

The apparatus can with advantage be adapted for the separation of materials of different specific gravity. Such separation can be effected before the material enters the cylinder as it passes through it and also after it has left it. Separation before the entrance is effected by arranging tanks of the same construction as *b*. Material is charged into one of these tanks, and agitation is kept up sufficiently to settle only heavy material which has to be separated and which can be drawn off from the bottom.

If several tanks are used successively, materials of various specific gravity can be separated in the different tanks. If gold ore has to be treated, a material can be separated in these tanks holding most of the coarse gold in concentrated condition. By discharging the same into a tank, as b', much of the coarse gold can be separated as such. Only material of great fineness enters the cylinder, whereby leaching is greatly accelerated.

By running the product from the cylinder through the tanks *b* and suitably adjusting the agitation again a most accurate sorting of material can take place according to specific gravity. The last traces of gold or concentrates can here be collected in one or more tanks sufficiently agitated to allow only them to settle. They are removed as already described.

In regard to separation of material of various specific gravity in the cylinder it can be effected by placing pockets on the circumference. Such pockets can encircle the cylinder. They may consist of a casing c' with doors or valves c^2 for withdrawing the material. Plate c^3 with suitable openings allows the heavy material to enter the pocket c', from which it is flushed from time to time through the valves c^2. A number of these pockets can be arranged.

In washing material such as coal and clay sufficient liquor is often circulated to carry the good material into the tank 3, which is then arranged in the same manner as tanks *b* or which leads to suitable screens. The heavy material passes in this case from the lower end of the cylinder, which can often be made shorter. The same liquid is used over again. It can, for instance, be returned by pipe f^2 to pipe *g*, no vessel *e* being required. By adapting the speed of the cylinder and the agitating devices, also the speed of the liquor, large quantities are cheaply separated, the heavy materials passing from the lower end and the light material from the upper end. Pyrites, concentrates of various ores, metals such as copper, gold are in this manner separated from rocks.

It is not always necessary to incline the cylinder from the charging to the discharging end. It can be sometimes with advantage horizontal, and sometimes it is better to charge the solid at the lower end in the same manner as shown, the funnel being then placed at the lower end. If gaseous fluid is conducted through the cylinder by a suitable blower, the agitation is improved and less liquid is required for the separation.

If especially good leaching is required, I arrange several cylinders in such a manner that liquid and material passes successively through them, preferably in opposite direction. If concentrates are to be separated, I place a settling-tank, as described, between each cylinder.

The cylinders can be operated discontinuously. They are constantly rotated, filled with liquor and solid, as shown, and afterward emptied by opening valve *g'*. A gaseous fluid can be passed through the cylinder at the same time.

As shown in Fig. 2, the partitions 7 can carry projections 7^b, which act as lifter. These projections can be arranged all over the surface. They lift more liquor than the ribs.

I do not confine myself to any particular kind of interior arrangement, as this is varied according to the material treated. In some cases suitable cross-partitions are arranged between the sections of perforated partitions, with suitable openings to guide the flow of solid and liquid in a zigzag way.

For the purpose of strengthening the perforated surfaces they may be fastened to carrying-rods, which form part of a frame which carries each set of partitions and may be movable, as described. In some cases the carrying-rods to which the partitions are fastened are held by suitable brackets on the periphery of the revolving cylinders.

For the purpose of strengthening the surfaces and also for the purpose of making the apparatus more efficient I sometimes arrange partitions which intersect the parallel partitions at a right angle, as indicated by dotted lines 7^b in Fig. 2. Instead of partitions rods may be run in the same direction, which form part of the frame carrying the surfaces.

The apparatus can be adapted to the purification of gaseous fluids or vapors by bringing them in contact with a liquid-purifying agent or a liquid-holding solid in suspension. The amount of liquid in the apparatus is varied according to the material treated. Pipe *f* is arranged in central position if radial partitions are used.

Having described the nature of my invention, what I claim is—

1. In combination with an apparatus for treating liquids and solids, a settling-tank, an inclined bottom on said tank and means to run sludge from said tank, back to the apparatus.

2. In combination with a revolving cylinder, means for passing liquid through the same, means to separate solids from the product leaving the cylinder and automatically returning the same to the cylinder.

3. The combination with a rotary apparatus, of a funnel located within one end thereof and rotatable therewith, means for feeding solid material to be treated, into the rotary apparatus through said funnel, and means for introducing fluid into said rotary apparatus.

4. In combination with a revolving cylinder, a funnel in the same near one end thereof, means for feeding solids into the funnel from the end of the cylinder and means to conduct liquor from said end.

5. The combination of a funnel-shaped pipe reaching into an apparatus, means for feeding solids into the same and means on said funnel, such as suitable ribs to insure the forward passage of the solids.

6. In combination with a revolving cylinder sets of parallel partitions and open spaces between said sets.

7. In combination with a revolving cylinder, means for passing a liquid and a solid into the same and perforated partitions arranged in such position as to effect a forward movement of the solid independently of the position in which the cylinder is disposed.

8. In combination with a revolving cylinder, perforated partitions arranged at an angle to the longitudinal and transverse axes of the cylinder, so as to effect a forward movement of solid material.

9. In combination with a revolving cylinder, perforated plates arranged diagonally with respect to the longitudinal axis of the cylinder in separate sets.

10. In combination with a revolving cylinder, a liquor-pipe and a gas-pipe communicating with one end of the cylinder and a discharge for solids at the same end thereof.

11. In combination with a revolving cylinder longitudinal bars carrying cleaning devices, such as spikes in the interior thereof.

12. In combination with a revolving cylinder surfaces in the interior and longitudinal bars carrying cleaning devices moving on said surfaces.

13. The combination of a revolving cylinder, perforated partitions dividing the cylinder into compartments and devices for cleaning the surfaces in each compartment.

14. The combination of a revolving cylinder divided into compartments in the interior and a bar carrying cleaning devices in each compartment.

15. In combination with a rotary apparatus bent surfaces in the interior and a loose bar carrying cleaning devices moving on said surfaces.

16. The combination of a revolving cylinder, parallel partitions and devices between the latter to clean the surfaces.

17. The combination of a revolving cylinder, longitudinal parallel perforated surfaces and means to keep said surfaces clean.

18. The combination of a revolving cylinder parallel surfaces in the interior and loose rods carrying cleaning devices between said surfaces.

19. The combination of an apparatus, means to pass a solid and a liquid through the same and means to circulate gaseous fluid through the apparatus and a temperature-adjuster the same fluid circulating several times.

20. The combination of an apparatus, means to pass a solid and a liquid through the same, means to circulate liquid through the apparatus and a temperature-adjuster.

21. The combination of a rotary apparatus, perforated surfaces and projections on said surfaces, which act as lifters.

22. In combination with a rotary apparatus means to separate material according to specific gravity.

23. In combination with a rotary apparatus, means to conduct liquid and solid through the same, means to separate solids from the liquid at each end means to return the liquid.

24. In combination with a rotary apparatus, means to pass solid and liquid through the same, means to pass gaseous fluid through the same and means to separate solid from the liquid at each end of the apparatus.

25. The combination of a series of apparatus, means to pass solid and liquid successively through the same and means to separate heavy material from the lighter material as the mixture passes from one apparatus to the other.

Signed at New York, in the county of New York and State of New York, this 17th day of April, A. D. 1901.

PAUL NAEF.

Witnesses:
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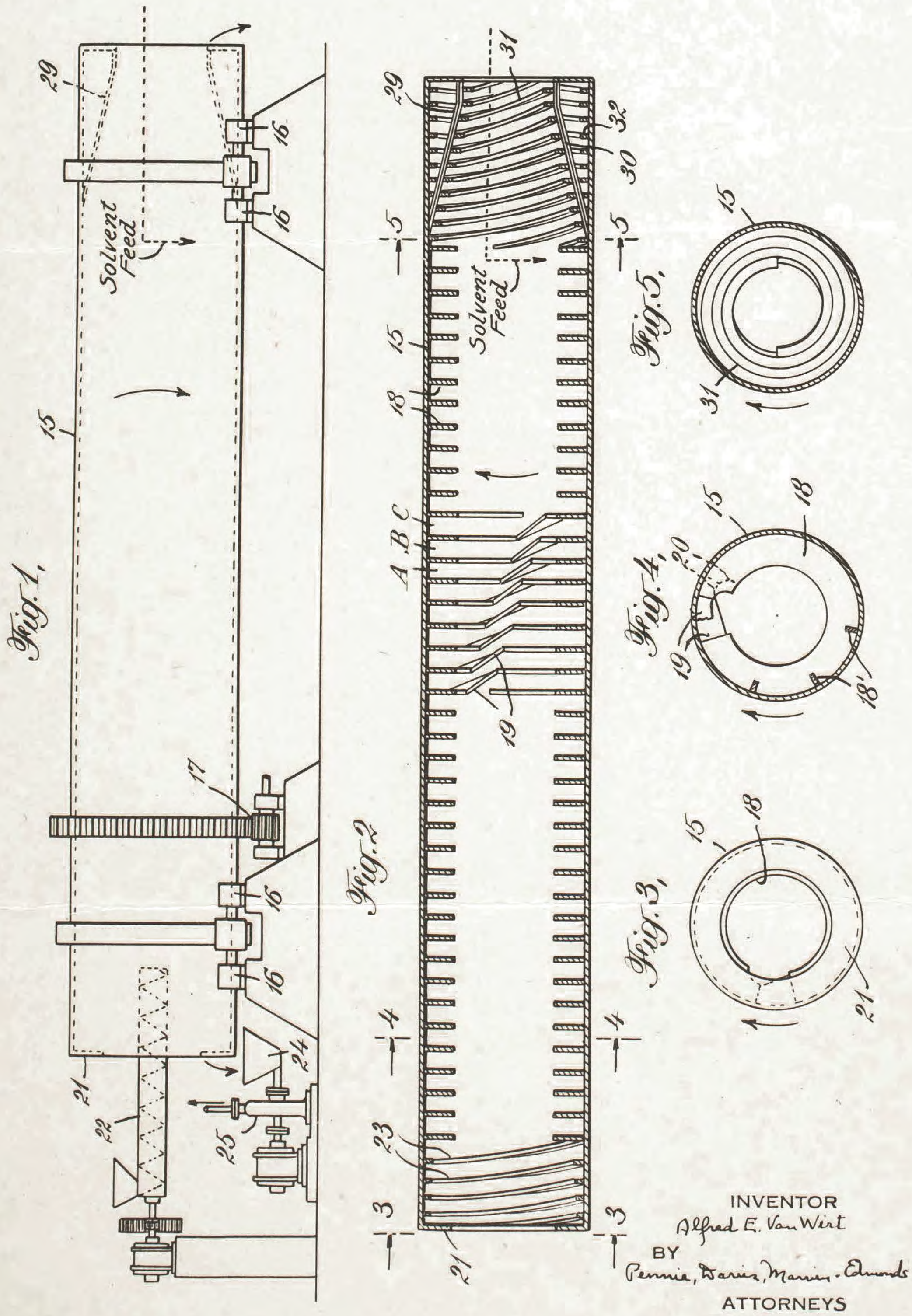
I. W. HOWE.

May 7, 1940. **A. E. VAN WIRT** **2,199,928**

ROTARY EXTRACTOR

Filed Feb. 9, 1938 2 Sheets-Sheet 1



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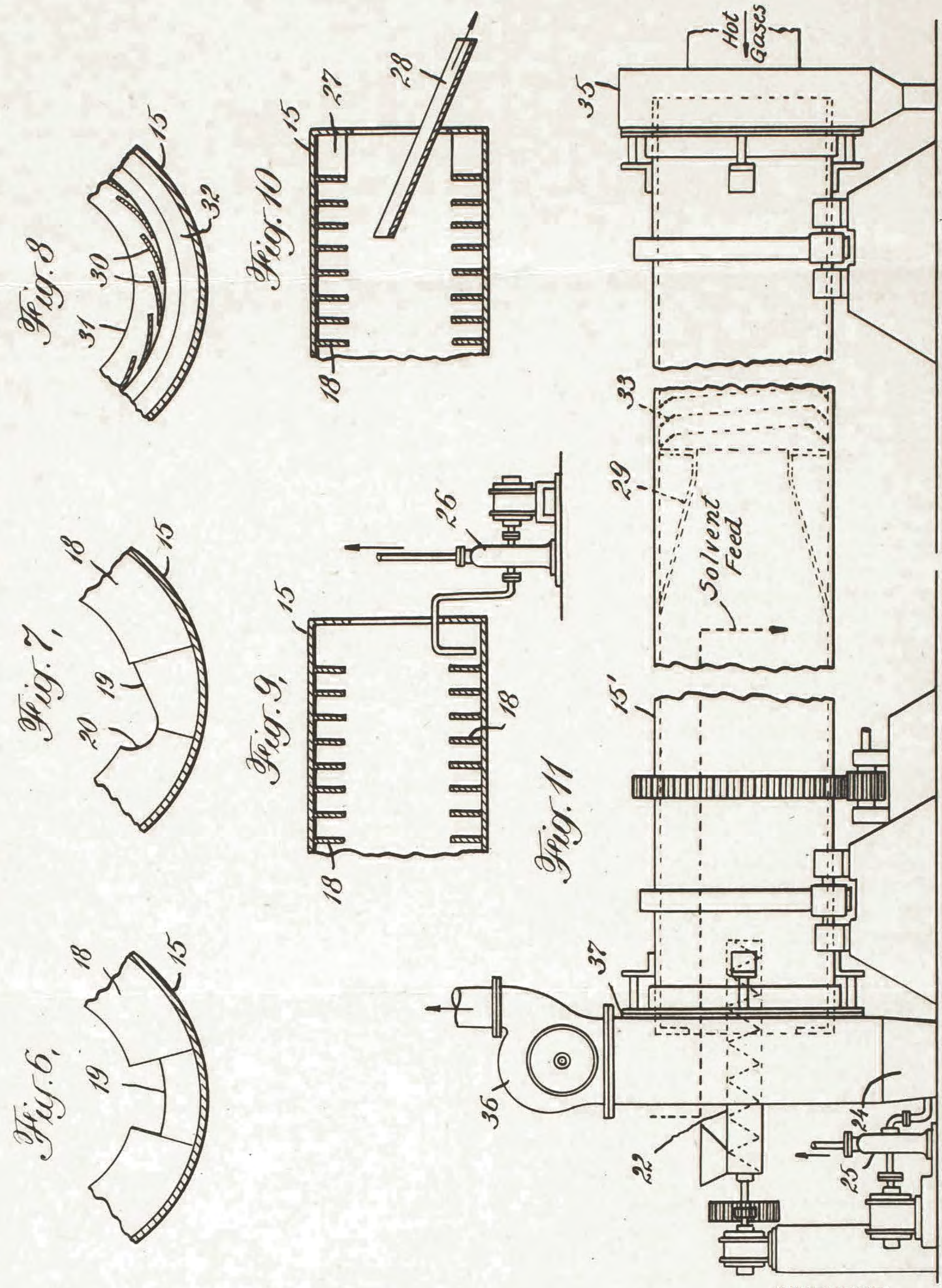
ROTARY EXTRACTOR

Filed Feb. 9, 1938 2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,199,928

ROTARY EXTRACTOR

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Application February 9, 1938, Serial No. 189,635

18 Claims. (Cl. 23—269)

This invention relates to extracting or leaching soluble material from a mixture of soluble and insoluble materials, and has for its object the provision of an improved method of and apparatus for extracting soluble material from such a mixture. More particularly the invention aims to provide an improved apparatus of the rotary type for continuously extracting the soluble material from the mixture containing the same in which the mixture and liquid solvent for the soluble material move countercurrently through the apparatus in consequence of its rotation.

The invention is of particular advantage wherever the amount of solvent used should be small in relation to the amount of insoluble material present. A typical example of such an application of the invention is in the extraction of soluble alkali chromates from the calcined product obtained by roasting chromite ore with an alkali agent, such as soda ash. The alkali chromate is dissolved from the calcined product by water, and it is desirable that the soluble material be very completely extracted in as small a volume of water as possible, so as to minimize subsequent evaporation and other process operations. In this as well as in other applications of the invention, it is desirable that the extracting operation be made continuous, thus permitting it to be operatively coupled with the calcining operation. To this end, the invention further contemplates the combination with the extractor of the invention of a drying chamber for the residual insoluble material.

Briefly, the method of the invention comprises countercurrently passing a liquid solvent for the soluble material and a mixture of the soluble and insoluble materials through an operatively connected series of rotating compartments in each of which agitation of the solvent and materials is effected in consequence of the rotation, and effecting the countercurrent movement of the mixture and flow of the solvent between each compartment and the next adjacent compartments during only a part of each complete revolution of each compartment. The apparatus of the invention is particularly adapted for carrying out this method, and in its preferred form comprises an elongated hollow cylinder mounted for rotation about its substantially horizontally-positioned longitudinal axis and having a series of annular segments circumferentially secured to the interior thereof in spaced and substantially parallel relation with one another and dividing the interior of the cylinder into a plurality of circumferential compartments. The segments are so positioned that the annular segmental space between the ends of any segment is angularly offset with respect to the annular segmental spaces between the ends of adjacent segments. Preferably, this angular displacement of the annular segmental spaces is generally along a spiral concentric to the longitudinal axis of the cylinder. The ends of each segment are connected respectively to the oppositely-positioned ends of the two adjacent segments by deflecting strips of slightly less depth than the depth of the segments.

The foregoing and other novel features of the invention will be best understood from the following description taken in conjunction with the accompanying drawings, in which

Fig. 1 is a longitudinal elevation of an apparatus embodying the invention,

Fig. 2 is a diagrammatic longitudinal sectional elevation of the apparatus of Fig. 1,

Figs. 3, 4 and 5 are diagrammatic sectional views on the section lines 3—3, 4—4 and 5—5, respectively, of Fig. 2,

Figs. 6 and 7 are diagrammatic sectional views showing two deflecting strip arrangements,

Fig. 8 is a diagrammatic sectional view of the conical frustrum solids discharge of Fig. 2,

Figs. 9 and 10 are diagrammatic sectional elevations of modified types of solids discharge, and

Fig. 11 is a longitudinal elevation of the combination with the apparatus of Fig. 1 of a drying chamber.

The apparatus illustrated in the drawings comprises a hollow cylinder 15, several times longer than its diameter. The cylinder is positioned with its longitudinal axis substantially horizontal. It is mounted for rotation on tire and trunnion supports 16 by means of a gear and pinion drive 17.

The cylinder 15 is interiorly divided into a number of circumferential compartments (e. g., A, B, C) by a series of annular segments 18 secured to the interior of the cylinder, concentric and perpendicular with its longitudinal axis, in spaced and substantially parallel relation with one another. The series of segments 18 constitute in effect spaced annular partitions, each circumferentially incomplete, extending radially inwardly from the interior surface of the cylinder towards but short of the longitudinal axis of the cylinder. The segments 18 are so positioned that the annular segmental space between the ends of any segment is angularly offset with respect to the annular segmental spaces between the ends of the adjacent segments.

The width or depth of the segments 18 may be greatly varied. For example, a depth of from about ¼ to ½ of the radius of the cylinder is typical for many applications of the invention. The space between the segments may also be varied over a wide range, but may conveniently be considered as about equal to the depth of the segments.

The annular segmental space between the ends of each segment, that is the circumferentially incomplete portion thereof, may conveniently be roughly 30° in length, and usually extends the entire depth of the segment, although this is not essential. As previously stated, these spaces are preferably not in line with each other along the cylinder axis, but are angularly offset from each other, preferably so as to be located at points of an imaginary spiral in the cylinder.

The ends of each annular segment are connected respectively to the oppositely-positioned ends of the two adjacent segments by deflecting or transfer strips 19 of slightly less depth than the depth of the segments. Thus, one end of a deflecting strip 19 is connected at the rear edge (that is trailing as the cylinder rotates) of the segmental space in the annular segment between a compartment (B, Fig. 2) containing solid material and the compartment (C) to which such solid materal is next to be delivered. The other end of this deflecting strip is connected at the front edge (that is leading as the cylinder rotates) of the segmental space in the annular segment between the compartment (B) containing the solid material and the compartment (A) from which such solid material was delivered thereto. The deflecting strips move solid material progressively from one compartment to the next adjacent compartment as rotation of the cylinder brings the deflecting strips into contact with such solid material. The deflecting strips may be of uniform depth throughout their length (Fig. 6), or of varying depth (Fig. 7) to more effectively fulfill their purpose. As shown in Fig. 7, the upper part of that end of the segment connected to the shorter end of the strip may be curved (20) to insure the desired flow of liquid from compartment to compartment, as more fully explained hereinafter.

The mixture of soluble and insoluble materials is fed into one end of the cylinder (left end in Figs. 1 and 2—solids feed end and solution discharge end) and the liquid solvent for the soluble material is fed into the other end of the cylinder (residue discharge end and solvent feed end). The segmental spaces between the ends of the segments permit interchange of liquid solvent and solid material between adjacent compartments. This interchange takes place during only a part of each complete revolution of each compartment, that is while the segmental space approaches and moves from its lowermost position. Due to the angular displacement of the segmental spaces, the interchange of liquid and solid between adjacent compartments occurs progressively with respect to the series of compartments.

The deflecting strips are arranged to move the solid material from the solids feed end of the cylinder to the residue discharge end, that is from left to right in Figs. 1 and 2. The liquid moves by gravity from near the residue discharge end of the cylinder towards the other end (right to left, Figs. 1 and 2), leaching out the soluble material as it progresses from compartment to compartment. The depth of liquid in each compartment is usually maintained slightly below the level (depth) of the annular segments. A convenient manner of maintaining the liquid level is to provide a continuous annular ring 21, of less depth than the annular segments 18, at the solution discharge end of the cylinder. The depth of solids in each compartment may be conveniently about half the depth of liquid therein.

The countercurrent movement of the liquid solvent and solid material will be best understood by considering the actions taking place in three adjacent compartments (A, B and C, Fig. 2) as the cylinder slowly rotates in the direction of the arrow. Assume that a charge of solid material has just been received in compartment B from compartment A, and that the segmental space of the annular segment between compartments A and B has just risen above the liquid level. The liquid and solvent are now confined in compartment B and isolated from the other materials in the cylinder by the annular segments which rise above the liquid level. Rotation of the cylinder tumbles the solid material over and at the same time agitates the liquid. The liquid dissolves out some of the soluble material, thus becoming more concentrated. This action continues for about 300° of rotation. The segmental space between the compartments A and B then enters the liquid level. Liquid immediately starts flowing out of compartment B into compartment A, and shortly thereafter liquid begins to flow from compartment C into compartment B. The amount of overlapping of these liquid flows depends on the angular displacement of the segmental spaces. As rotation continues, compartment B begins to receive (on one side of the deflecting strip secured to the annular segments forming the compartment B) solid material from compartment A and then to deliver solid material (from the other side of this deflecting strip) to compartment C. As the segmental spaces (of the annular segments forming compartment B) rise above the liquid level, the flow of liquid ceases. The transfer of solids ceases shortly afterwards and the cycle is repeated.

The separation of the liquid and solid material in each compartment depends on the settling of the solid material in the liquid, which in turn is dependent on the particle size of the solid material and the difference in gravity of the solid material and the liquid in contact therewith. Too much mixing of the liquid and solid material just previous to transfer may cause poor separation, and hence poor leaching action. Agitation is desirable to promote dissolving of the soluble material, and, when settling is rapid enough to permit it, it is advantageous to provide spaced transverse baffles or agitating strips 18' (Fig. 4) in each compartment through the first part (say, half or so) of the cycle following the delivery of solid material thereto. It is also desirable that the segmental spaces and deflecting strips be so formed as to transfer the liquid and solids from compartment to compartment with as little disturbance as possible. Also, the flow of liquid should be so controlled by the size, shape and angular displacement of the segmental spaces and, if necessary, by guide strips, that a minimum of liquid is moved more than one compartment in each revolution of the cylinder.

It is desirable in most cases that the solution discharged from the rotating cylinder be as free as possible of suspended solids. To this end, agitation of the solid material and liquid should be minimized at the solution discharge end of the cylinder. This may be accomplished by delivering the feed of solid material to the cylinder a short distance inwardly from the end thereof, so that the final solution discharge compartment will be subjected to a minimum of disturbance. The mixture of soluble and insoluble solid material may be fed to the rotating cylinder by a spiral conveyor 22. The final solution discharge compartment may be made a more efficient settling chamber by increasing its dimension along the longitudinal axis of the cylinder, and providing the compartment with an inwardly projecting spiral ribbon or strip 23 of just sufficient depth to move settled solid material into the adjacent agitation compartment. The solution discharged from the cylinder may be collected in an appropriate tank 24, from which it is withdrawn by a pump 25. The solution may be further clarified, if desired, by sedimentation, filtering, etc. The solid material resulting from such subsequent clarifying operations may frequently be advantageously worked back into the rotating cylinder.

The liquid solvent is introduced at a suitable temperature into the residue discharge end of the cylinder in any appropriate manner, as for example, by permitting it to run out of a pipe, preferably under volume control. As hereinbefore described, the liquid works its way through the cylinder to the solution discharge end by gravity. A slight amount of frictional resistance must be overcome, which means that the liquid must be at a slightly higher level at the residue discharge end than at the solution discharge end. This may be conveniently accomplished by positioning the cylinder with its longitudinal axis horizontal and permitting the liquid to build up progressively higher on the annular segments nearer the residue discharge end, or by slightly inclining the cylinder so that the liquid flows therethrough at such a rate that the depth of liquid on the annular segments is substantially the same throughout the cylinder.

The residual or extracted solids must be removed from the cylinder in such a manner as not to unduly disturb the liquid level throughout the cylinder. This may be effected in various ways, the choice depending somewhat on the nature of the materials and the desired ratio of solids to liquid in the solids discharge. Where a low solids content is permissible, a pump 26 (Fig. 9) may advantageously be used to remove both the solids and associated liquid from the final compartment at the residue discharge end of the cylinder, care being taken to agitate the mixture of solids and liquid. A scoop discharge may also be used, scoops or buckets 27 (Fig. 10) being provided on the inside of the final compartment to pick up a mixture of solids and liquid and deliver it to a chute 28 for conveying the mixture out of the end of the cylinder.

Where as dry a solids discharge as possible is desired, for example, when the residual solid material is to be subsequently dried, the conical frustrum discharge 29 illustrated in Figs. 1, 2, 8 and 11 may be advantageously employed. This discharge device comprises a hollow conical frustrum, the diameter of its base being approximately the same as the inside diameter of the cylinder and the diameter of its smaller frustrated end being less than twice the distance from the longitudinal center axis of the cylinder to the liquid level therein. The conical frustrum is preferably constructed of a large number of narrow plates 30 extending from the base to the frustrated end in straight lines. These plates overlap each other on their longitudinal edges so as to permit escape of liquid through the spaces between the overlapping edges (Fig. 8). The conical frustrum is positioned in the residue discharge end of the cylinder with its frustrated end facing outwardly and approximately in the plane of the end of the cylinder (or the extractor portion of the cylinder in Fig. 11). The overlapping of the plates is such that as the cylinder and frustrum rotate the spaces between the plates are under the plates on the rising side, simulating in effect a shingled roof. If a very wet mixture of solids and liquid is placed within the rotating conical frustrum above the liquid level in the cylinder, the solids tend to move up on the rising side of the frustrum and any free liquid tends to remain near the lower part of the frustrum and escapes sideways through the spaces between the overlapping plates.

Solid material delivered to the base of the conical frustrum from the adjacent agitating compartment of the cylinder is moved up the conical surface and outwardly by one or more spiral ribbons or strips 31 secured on top of the plates 30 inside the frustrum. The pitch of the spiral ribbon 31 is such that as the cylinder rotates solids are moved up the conical surface and discharged.

The conical frustrum may be of any desired length, but if too short difficulty is encountered in moving solids up the conical surface and the draining time is shortened. A hollow cylinder, constructed of overlapping plates similar to the conical frustrum, may be attached to the smaller end of the frustrum for further draining of solids if desired. The liquid escaping through the overlapping plates of this latter cylinder should fall into or be directed to the main cylinder, as in the case of the conical frustrum. Instead of making the conical frustrum of overlapping plates, the spiral ribbon 31 may be constructed of overlapping sections with sufficient space between the overlapping portions to permit the escape of liquid. If desired, both the conical frustrum and the spiral ribbon may be made of overlapping members.

Some fine solids will usually be carried under the overlapping plates of the conical frustrum by the escaping liquid. Such fine solids will tend to settle in the lower part of the cylinder under the conical frustrum, and may be moved back to the agitating compartment adjacent the base of the conical frustrum, through appropriate openings therein, by one or more spiral ribbons 32 secured to the inner surface of the cylinder between the cylinder and the conical frustrum. If desired, the fine solids collecting between the cylinder and the conical frustrum may be removed by tapping holes in the cylinder wall and drawing off controlled amounts of the solids and liquid.

If desired, the contents of the rotating cylinder may be heated or maintained heated during extraction in any appropriate manner. For example, the liquid solvent and solid material may each be preheated and delivered hot to the cylinder, or the cylinder may be either externally or internally heated. Where hot waste gases are available, which are not deleterious to the cylinder contents, they may be passed through the cylinder. In addition to heating the contents of the cylinder, such hot waste gases are scrubbed in the course of their passage through the cylinder, thereby removing solids and soluble materials therefrom, which in some cases is of advantage. If desired, the cylinder may be insulated to better retain its heat.

When the solid residual product discharged from the cylinder is to be dried, it is of advantage to embody the extractor and dryer in a unitary cylindrical structure. This modification of the invention is illustrated in Fig. 11 of the drawings. In this construction the conical frustrum is positioned intermediate the ends of the cylinder 15′. The wet solids discharged from the extractor portion of the cylinder by the conical frustrum 29 are delivered into the extended portion of the cylinder and are moved towards the end of the cylinder by a spiral ribbon 33 secured to the interior surface of the dryer portion of the cylinder. The dry solids fall into a bin 34 from which they are removed in any suitable manner. Hot waste gases are delivered to the dry solids discharge end of the rotating cylinder through a sealed hood 35 and are drawn through the cylinder by a fan 36 operatively associated with a sealed hood 37 at the opposite end of the cylinder.

The apparatus of Fig. 11 is particularly adapted for leaching soluble alkali chromates from the calcined product resulting from kiln roasting chromite ore and soda ash. The calcined product (after screening or grinding or both as desired) is delivered, preferably while still warm, to the solids feed end of the cylinder 15′, and hot waste gases from the kiln are conducted into the other end of the cylinder. The calcined product is leached in the extractor portion of the cylinder, as hereinbefore described, and the extracted wet residue is delivered to the dryer portion of the cylinder. Here the residue meets the hot gases from the kiln, and these gases after drying the residue pass into the extractor portion of the cylinder and impart heat to the contents thereof. Dust carried by the hot kiln gases is largely removed by the wet surfaces in the extractor portion of the cylinder. Thus, waste heat from the kiln is utilized to dry the extracted residue and to keep the extractor warm.

The apparatus hereinbefore described may be constructed of any material of sufficient strength and corrosion resistance. Ordinarily, sheet iron is satisfactory for the purpose. The size and dimensions of the rotating cylinder will be determined in practice by the nature of the mixture of soluble and insoluble materials, the soluble material and the liquid solvent therefor. The principal factors to be considered are the volume of soluble material to be extracted in a given time, the volume of liquid solvent to be used for extracting that amount of soluble material, and the time required to make such an extraction under the conditions of agitation and liquid concentrations characteristic of the apparatus. Knowing the number of cubic feet of solids to be handled per hour and the extracting time in hours, the volume of solids in the extractor is obtained by multiplying these two figures. This volume of solids may be treated in a short cylinder of large diameter or a long cylinder of small diameter. The depth to which the cylinder should be filled by the solid material may be greatly varied, but a quarter of the radius of the cylinder is typical. The cylinder proportions are determined on the basis of agitation produced, cost, space available and similar factors. After determining the cylinder proportions, the depth of the deflecting strips 19 is determined by the depth of solid material in the cylinder.

The liquid solvent delivered to the cylinder must be equal in volume to the liquid discharged from both ends of the cylinder, and to this end accurate control of the amount of liquid containing soluble material which is discharged at or near the residue discharge end of the cylinder is desirable and in some instances necessary. While the amount of solution discharged by the apparatus, at the solution discharge end, is limited, nothing fixes the amount of liquid within the apparatus and this may be widely varied. However, a liquid depth approximately twice the depth of solid material is ordinarily satisfactory. When the depth of liquid to be maintained in the cylinder has been determined, the depth of the annular segments 18 is determined so as to be greater than the liquid depth.

Increasing the number of compartments theoretically increases the efficiency of the apparatus, but the advantage becomes less as the number of compartments is increased. There is little practical advantage in extracting efficiency in increasing the compartments over about 30–40. The extracting length of the cylinder divided by the number of compartments gives the axial length of each compartment. If this axial length is substantially less than the depth of the annular segments 18, better results will ordinarily be obtained by lengthening the cylinder and reducing its diameter.

The number of revolutions per minute of the cylinder is determined by dividing the extracting time in minutes by the number of compartments. The cylinder need not necessarily be of the same diameter throughout. This applies particularly to the two portions of the cylinder used respectively for extracting and drying (Fig. 11).

The annular segments 18 may, if desired be circular disks with suitable openings cut therein corresponding to the aforementioned annular segmental spaces to permit the contemplated countercurrent movement of liquid and solids. However, with such an arrangement the interior of the cylinder is inaccessible and the arrangement offers little if any compensating advantage. Two or more deflecting strips 19 may, if desired, be used in each compartment, thereby dividing the compartment into two or more compartments and moving the solid material two or more times as fast per revolution.

While the mixture of soluble and insoluble material fed into the cylinder (e. g. by screw conveyor 22) has hereinbefore been generally described as dry, it need not be so. The soluble material may, for example, be a liquid or a solid dissolved in a small amount of liquid.

I claim:

1. The improvement in continuously extracting soluble material from a mixture of soluble and insoluble materials which comprises countercurrently passing a liquid solvent for the soluble material and a mixture of the soluble and insoluble materials through an operatively connected series of rotating compartments in each of which agitation of the solvent and materials is effected in consequence of the rotation, and effecting the countercurrent movement of the mixture and solvent between one compartment and the next adjacent compartments during only a small part of each complete revolution of each compartment while a relatively small amount of mixture and solvent is confined in other compart-

ments of the series, at which time the said other compartments are disconnected for the exchange of the mixture or solvent.

2. In the improvement according to claim 1, delivering the residual material from the final extracting compartment in said series to a rotating conical surface pervious to liquid along which the residual material is caused to move upwardly and to drain prior to its discharge as extracted material.

3. The improvement in continuously extracting soluble material from a mixture of soluble and insoluble materials which comprises countercurrently passing a liquid solvent for the soluble material and a mixture of the soluble and insoluble materials through an operatively connected series of rotating compartments, effecting the countercurrent movement of the mixture and solvent between one compartment and the next adjacent compartments by progressively establishing communication for the passage of the mixture and solvent between said one compartment and its adjacent compartments during only a relatively small part of each revolution thereof, and during such period of communication the other compartments of the series are disconnected for the passage of mixture or solvent and contain a relatively small amount of mixture and solvent which is confined for the major part of each reovlution, whereby the solvent is agitated with all the mixture in a series of separate extractions and short-circuiting of portions of the mixture is substantially prevented.

4. In the improvement according to claim 3, delivering the residual material from the final extracting compartment in said series to a rotating conical surface pervious to liquid along which the residual material is caused to move upwardly and to drain prior to its discharge as extracted material.

5. An apparatus for extracting soluble material from a mixture of soluble and insoluble materials, comprising a rotatably mounted hollow cylinder positioned with its longitudinal axis substantially horizontal, a series of spaced and radially-positioned partitions dividing the interior of the cylinder into a plurality of compartments, each of said partitions being circumferentially incomplete with the circumferentially incomplete portions of the partitions angularly staggered with respect to one another, and transfer strips of substantially less depth than the radius of said cylinder connecting the edges of the circumferentially incomplete portion of each partition to the opposite edges respectively of the circumferentially incomplete portions of the two adjacent partitions.

6. An apparatus for extracting soluble material from a mixture of soluble and insoluble materials, comprising a rotatably mounted hollow cylinder positioned with its longitudinal axis substantially horizontal, a series of spaced annular partitions extending radially inwardly from the interior surface of the cylinder towards but not reaching the longitudinal axis of the cylinder, each of said partitions being circumferentially incomplete with the circumferentially incomplete portions of the partitions angularly staggered with respect to one another, and deflecting strips of slightly less width than the radial depth of said partitions connecting one end of each partition to the oppositely-positioned end of the next adjacent partition.

7. An apparatus for extracting soluble material from a mixture of soluble and insoluble materials, comprising a rotatably mounted hollow cylinder positioned with its longitudinal axis substantially horizontal, means for feeding a mixture of soluble and insoluble materials and a liquid solvent for the soluble material into opposite ends respectively of the cylinder, a series of spaced annular partitions extending radially inwardly from the interior surface of the cylinder towards but not reaching the longitudinal axis of the cylinder, each of said partitions being circumferentially incomplete with the circumferentially incomplete portions of the partitions angularly staggered with respect to one another, deflecting strips of slightly less width than the radial depth of said partitions connecting one end of each partition to the oppositely-positioned end of the next adjacent partition, and means for removing from the cylinder the insoluble material and the liquid solution of the soluble material.

8. An apparatus for extracting soluble material from a mixture of soluble and insoluble materials, comprising a rotatably mounted hollow cylinder positioned with its longitudinal axis substantially horizontal, the interior of said cylinder being divided into a series of operatively communicating compartments through which rotation of the cylinder causes countercurrent movement of said materials and a liquid solvent for the soluble material, a hollow conical frustrum concentrically mounted within one end of said cylinder and operatively communicating at its base with a compartment near that end of the cylinder, and baffle means operatively connected to said frustrum for causing rotation of said cylinder to move insoluble material towards the smaller end of said frustrum.

9. In an apparatus for extracting soluble material from a mixture of soluble and insoluble materials in which said materials and a liquid solvent for the soluble material move countercurrently through a rotatably mounted hollow cylinder positioned with its longitudinal axis substantially horizontal, a hollow conical frustrum secured within the residue discharge end of said cylinder with its frustrated end outward and its base adapted to receive residue to be discharged from the cylinder, and means operatively connected to and projecting into the hollow portion of said frustrum for moving the residue received at its base towards the frustrated end thereof as the cylinder rotates.

10. An apparatus according to claim 9 in which the wall of the hollow conical frustrum is pervious to liquid.

11. An apparatus according to claim 9 in which the wall of the hollow conical frustrum is made of overlapping plates to permit escape of liquid therethrough.

12. An apparatus for extracting soluble material from a mixture of soluble and insoluble materials, comprising a rotatably mounted hollow cylinder positioned with its longitudinal axis substantially horizontal, a series of spaced annular partitions extending radially inwardly from the interior surface of the cylinder towards but not reaching the longitudinal axis of the cylinder, each of said partitions being circumferentially incomplete with the circumferentially incomplete portions of the partitions angularly staggered with respect to one another, deflecting strips of slightly less width than the radial depth of said partitions connecting one end of each partition to the oppositely-positioned end of the

next adjacent partition, and means for removing insoluble material from the cylinder including a hollow conical frustrum concentrically positioned within one end of the cylinder and having a spiral deflecting strip associated with the interior surface thereof for moving insoluble material towards the smaller end of the frustrum as the cylinder rotates.

13. An apparatus according to claim 12 in which the wall of the hollow conical frustrum is pervious to liquid.

14. An apparatus according to claim 12 in which the wall of the hollow conical frustrum is made of overlapping plates to permit escape of liquid therethrough.

15. An apparatus for extracting soluble material from a mixture of soluble and insoluble materials, comprising an elongated hollow cylinder mounted for rotation about its substantially horizontally-positioned longitudinal axis, a series of spaced annular partitions extending radially inwardly from the interior surface of the cylinder towards but not reaching the longitudinal axis of the cylinder, each of said partitions being circumferentially incomplete with the circumferentially incomplete portions of the partitions positioned generally along a spiral concentric to the longitudinal axis of the cylinder, and means operatively associated with adjacent partitions for causing solid material and liquid to move countercurrently through the cylinder progressively in separate step by step movements when the cylinder is rotated.

16. An apparatus for extracting soluble material from a mixture of soluble and insoluble materials, comprising an elongated hollow cylinder mounted for rotation about its substantially horizontally-positioned longitudinal axis, said cylinder having a substantial portion but not all of its longitudinal length provided with a series of spaced annular partitions extending radially inwardly from the interior surface of the cylinder towards but not reaching the longitudinal axis of the cylinder, each of said partitions being circumferentially incomplete with the circumferentially incomplete portions of the partitions angularly staggered with respect to one another, means operatively associated with adjacent partitions for causing solid material and liquid to move countercurrently through the cylinder when the cylinder is rotated, and a hollow conical frustrum concentrically positioned within and intermediate the ends of the cylinder and having a spiral deflecting strip associated with the interior surface thereof for moving insoluble material from that portion of the cylinder provided with said spaced partitions towards the smaller end of the frustrum and into the other portion of the cylinder.

17. An apparatus for extracting soluble material from a mixture of soluble and insoluble materials, comprising an elongated hollow cylinder mounted for rotation about its substantially horizontally-positioned longitudinal axis, said cylinder having a substantial portion but not all of its longitudinal length provided with a series of spaced annular partitions extending radially inwardly from the interior surface of the cylinder towards but not reaching the longitudinal axis of the cylinder, each of said partitions being circumferentially incomplete with the circumferentially incomplete portions of the partitions angularly staggered with respect to one another, means operatively associated with adjacent partitions for causing solid material and liquid to move countercurrently through the cylinder when the cylinder is rotated, a hollow conical frustrum concentrically positioned within and intermediate the ends of the cylinder and having a spiral deflecting strip associated with the interior surface thereof for moving insoluble material from that portion of the cylinder provided with said spaced partitions towards the smaller end of the frustrum and into the remaining portion of the cylinder, means for feeding a mixture of soluble and insoluble materials into and means for withdrawing the liquid solution of the soluble material from that end of the cylinder provided with said spaced partitions, means for introducing a liquid solvent for the soluble material into the cylinder approximate the larger end of said frustrum, and means for causing the rotation of said cylinder to move insoluble solid material through said remaining portion of the cylinder to a solids discharge end.

18. An apparatus according to claim 17, having means for introducing a stream of hot gas into said solids discharge end of the cylinder and for withdrawing the gas from the opposite end of the cylinder.

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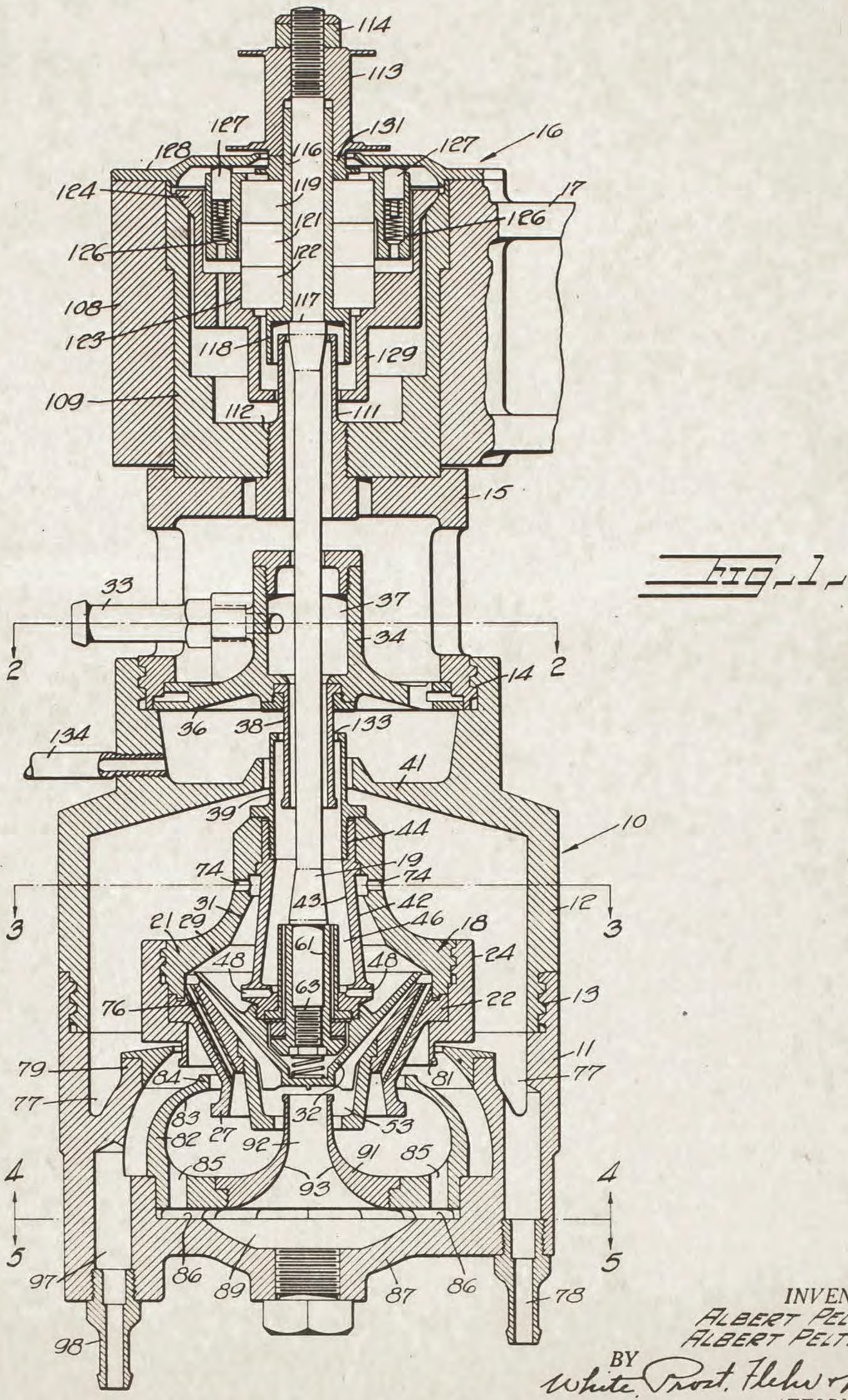
Feb. 6, 1934. A. PELTZER ET AL 1,945,786

CENTRIFUGAL APPARATUS

Filed Sept. 23, 1930 3 Sheets-Sheet 1



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CENTRIFUGAL APPARATUS

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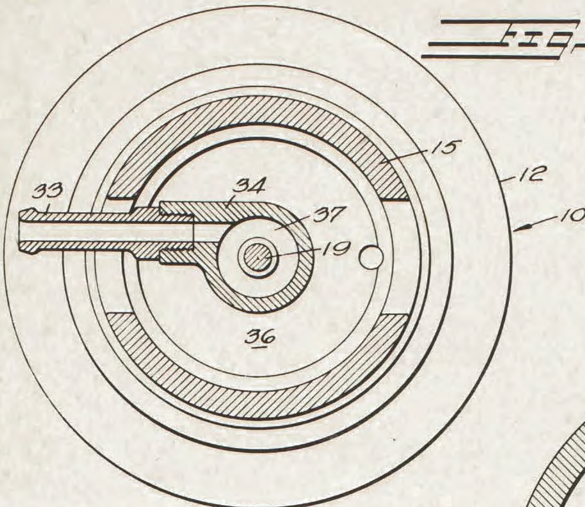
Fig. 2.



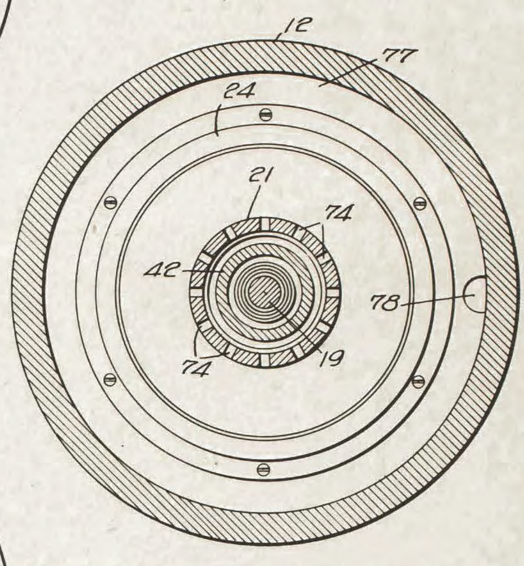


Fig. 3.

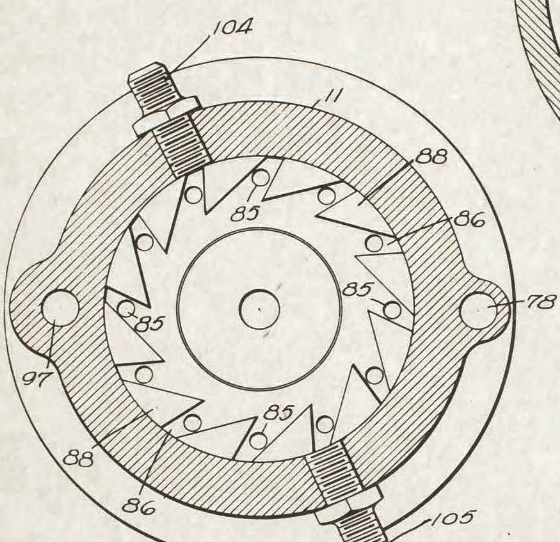


Fig. 4.

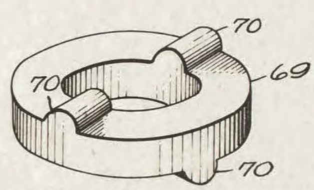


Fig. 10.

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Fig. 5.

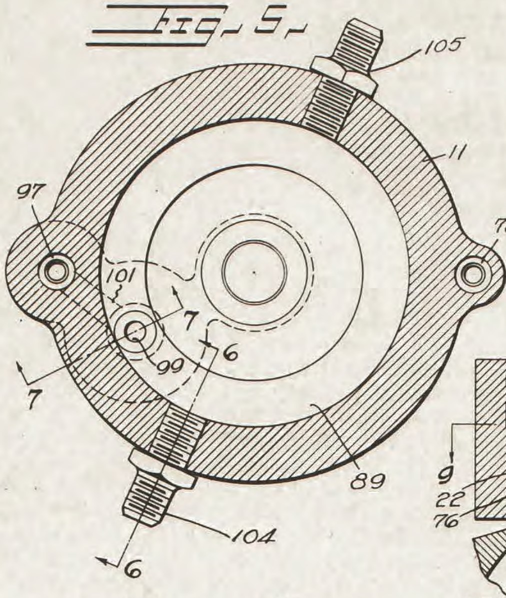
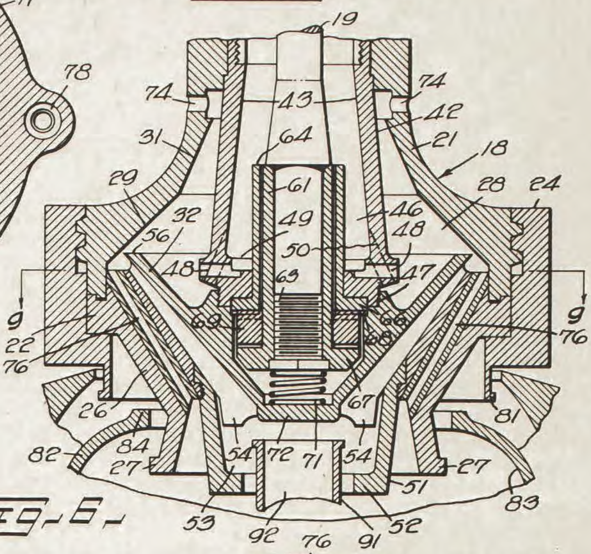


Fig. 8.



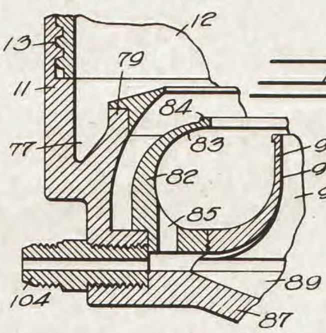


Fig. 6.

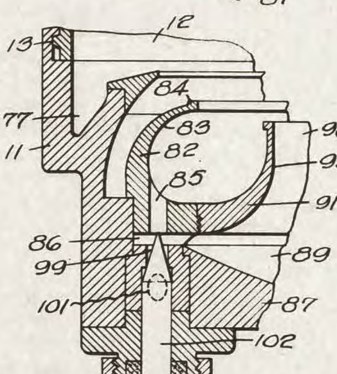


Fig. 7.

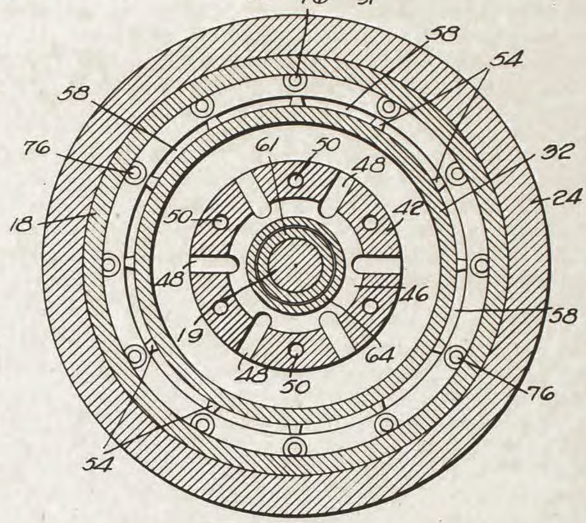


Fig. 9.

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UNITED STATES PATENT OFFICE

1,945,786

CENTRIFUGAL APPARATUS

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Application September 23, 1930
Serial No. 483,874

5 Claims. (Cl. 233—28)

This invention relates generally to centrifuge apparatus and methods such as are utilized for separating components of different specific gravities in fluid feed material.

It is an object of the present invention to devise a centrifuge apparatus and method which will make possible continuous operation without clogging of the centrifuge or of the discharge ports.

It is a further object of the invention to devise a centrifuge apparatus and method which will be efficient in operation with a relatively high speed of rotation of the centrifuge bowl. In this connection the invention is characterized by a minimum amount of slippage between the walls of the bowl and the material being subjected to centrifugal force, thus making possible the use of a centrifuge bowl of relatively small diameter operating at relatively high speed.

Another object of the invention is to devise an apparatus and method of the above character which will make possible a relatively clean separation between heavier and lighter components of a fluid feed. In attaining this object the invention is characterized by the maintenance of a zone of separation substantially free of turbulence, and when the method is practiced as in the preferred form described herein, heavier solid components being separated from feed material are scrubbed with wash liquor to effectively cleanse the same of undesired solubles.

It is a further object of the invention to devise novel means for introducing a suitable material or liquid medium into the centrifuge bowl or chamber in addition to the usual fluid feed.

Further objects of the invention will appear from the following description in which the preferred embodiment of the invention has been set forth in detail in conjunction with the accompanying drawings. It is to be understood that the appended claims are to be accorded a range of equivalents consistent with the state of the prior art.

Referring to the drawings:

Figure 1 is a side elevational view in cross section, illustrating machine incorporating the principles of the present invention.

Fig. 2 is a cross sectional view taken along the line 2—2 of Fig. 1.

Fig. 3 is a cross sectional view taken along the line 3—3 of Fig. 1.

Fig. 4 is a cross sectional view taken along the line 4—4 of Fig. 1.

Fig. 5 is a cross sectional view taken along the line 5—5 of Fig. 1.

Fig. 6 is an enlarged cross sectional detail taken along the line 6—6 of Fig. 5.

Fig. 7 is an enlarged cross sectional detail taken along the line 7—7 of Fig. 5.

Fig. 8 is a detail in cross section and side elevation showing in an enlarged scale the rotary centrifuge bowl and its associated parts.

Fig. 9 is a cross sectional detail taken along the line 9—9 of Fig. 8.

Fig. 10 is a detail perspective illustrating a swivel ring forming a part of the driving connection between the bowl and its driving shaft.

While the apparatus illustrated in the drawings and to be presently described in detail is in a single representative embodiment, it will be apparent that a number of distinct novel features are incorporated which can be utilized independently or in various combinations. Likewise the method of the invention, which can best be understood after a detailed explanation of the apparatus, incorporates various features which can be utilized singly or in various combinations to improve present methods of effecting separation between components of different specific gravities. The machine as illustrated consists of a housing 10 which for ease of manufacture and assembly, has been shown formed of a number of separate parts joined together. Thus the lower sections 11 and 12 of the housing are joined together by a suitable threaded connection 13, and serve to surround the rotary bowl of the apparatus. An upper housing section or neck 15 is connected to section 12 by means of threaded connection 14, and serves in turn to connect the housing to the stationary parts of a bearing assembly 16. This assembly is carried by a suitable support, such as a rigid arm 17. The rotary bowl of the apparatus is designated generally at 18 and is supported centrally within housing 10 by a suitable rotatable shaft 19.

The construction of the centrifuge bowl appears more clearly in the enlarged Fig. 8. For convenience in manufacture this bowl is likewise formed of two principal members or sections 21 and 22, which are secured together by suitable means such as a ring nut 24. Section 22 is formed with a downwardly converging portion 26 and a lower downwardly divergent flange portion 27. Within the bowl sections described above there is formed the centrifuge chamber 28 within which the centrifugal action takes place. The upper walls of chamber 28 are defined by the conical shaped surfaces 29 and 31 of the bowl section 21, while the lower wall is defined mainly by the inverted conical surface of member 32 to be presently described.

To form suitable means for introducing feed material into the chamber 28 of the rotary bowl, an inlet pipe 33 extends into the housing section 15 and communicates at its inner end with a cup 34. The position of cup 34 is fixed by a spider portion 36, which is clamped between housing sections 12 and 13. Cavity 37 in cup 34 surrounds shaft 19, and fluid material introduced into this cavity thru pipe 33 is discharged thru a depending sleeve 38. Sleeve 38 discharges into a lower second sleeve 39 of substantially larger diameter, which is mounted upon the centrifuge bowl as will be presently explained. As is evident from Fig. 1 sleeves 38 and 39 are concentric with respect to shaft 19, whereby the shaft and sleeve 39 can rotate independently of the relatively stationary sleeve 38. It will be noted that housing 10 is provided with an annular portion 41 which surrounds sleeve 39, and which serves as an enclosure for the interior of the housing.

Within the centrifuge chamber there is a member 42 which is annular in cross section, and which preferably is provided with an inner conical or downwardly divergent surface 43. By means of a threaded connection 44 with the lower end of sleeve 39, member 42 is suitably fixed with respect to the centrifuge bowl in order to rotate therewith. The space 46 within member 42 and surrounding the lower portion of shaft 19, can be termed a feed chamber. In order to retain member 32 in proper position, it is shown provided with a suitable threaded connection 47 with the lower end of member 42. For discharging material within the feed chamber 46 into the centrifuge chamber 28, the lower portion of member 42 is provided with a plurality of circumferentially spaced radial ports 48 and 50. In passing from feed chamber 46 thru ports 48, the material must flow over an inner annular wier or lip 49. Material flowing thru ports 50 is delivered into chamber 28 at a plane below the level at which ports 48 discharge, for a purpose to be presently explained.

Mounted concentrically of the lower bowl section 22 there is a collar 51, which is preferably downwardly convergent and is provided with a lower flange 52, to form an inner annular chamber 53. Formed upon the lower face of inverted conical member 32 are a plurality of radially extending ribs or vanes 54 which extend from a point in proximity with the upper edge or lip 56 of member 32, downwardly into chamber 53. As will be apparent from Fig. 9, ribs 54 in conjunction with the lower surface of member 32 and the upper adjacent surface of the lower bowl section 22, form a plurality of radially extending passages 58 for flow of fluid. The upper ends of these passages communicate with the annular space 55 about the lip 56 while the lower ends of the passages communicate with chamber 53. Therefore member 32 can be termed an impeller as it serves in conjunction with its associated parts to pump fluid material from chamber 53 into the space 55, which communicates with the main portion of chamber 28 through the restricted annular orifice between lip 56 and surface 29.

In order to form a suitable driving connection between shaft 19 and the rotary parts of the centrifuge, a sleeve 61 is fitted upon the lower end of shaft 19 and is fixed thereto by suitable means, such as a threaded connection 63. Sleeve 61 is in turn slidingly fitted within an outer sleeve 64, which carries the rotating parts of the centrifuge bowl. For example the lower end of sleeve 64 is shown provided with an enlarged annular portion 66, and this annular portion is shown securely clamped between the lower end of member 42 and the adjacent portion of impeller 32. The lower end of rotary sleeve 61 is formed with an annular surface 67 which is in opposed relationship with the lower annular face 68 of sleeve 64. An annular swivel ring 69 such as shown in detail in Fig. 10, is interposed between surfaces 67 and 68. The faces of ring 69 are provided with lugs 70 which seat in recesses provided in surfaces 67 and 68. A compressing spring 71 interposed between the lower end of shaft 19 and the lower central portion 72 of collar 32, serves to normally bias surfaces 67 and 68 together upon ring 69 with considerable force. Thus a driving connection is formed thru which sufficient torque can be transmitted for effecting normal rotation of the centrifuge bowl, and which will permit relative rotation between the shaft and the centrifuge bowl if the torque is in increased beyond a same value.

It may be noted at this time that an impeller 32 serves as a means for introducing fluid material into the centrifuge chamber 28 in addition to the feed material which is introduced by way of pipe 33. Suitable provision is also made for the separate discharge of the lighter and heavier components. Thus the upper bowl section is provided with a plurality of circumferentially spaced ports 74, which communicate with the centrifuge chamber 28 inwardly from its outer periphery. These ports serve to discharge the overflow or the lighter separated components from the chamber. For discharging heavier separated components the lower bowl section 22 is provided with a plurality of circumferentially spaced ports or ducts 76. The upper ends of these ducts communicate with the outer periphery of chamber 28, while the lower ends communicate with the interior of bowl portion 27.

The housing 10 serves the function of catching both the lighter and heavier discharged components, and as will be presently explained, means is also incorporated in conjunction with the housing for effecting a return of heavier components back into the centrifuge chamber. Thus the overflow or lighter components discharged thru port 74 are collected into annular pocket 77 and can be withdrawn thru pipe 78. Pocket 77 is formed by an annular apron 79, which in turn is formed within the lower housing section 11 and has its inner edge extending immediately beneath the lower surface of bowl ring 23. Depending collar 81 formed upon ring 24 in conjunction with apron 79, effectively isolates the lower portion of the centrifuge bowl from that part of the housing in which the lighter components are discharged, thus preventing intermixing of discharged lighter components with heavier components.

To effect delivery of fluid material to chamber 53 and to the impeller 32, a volute structure 82 is mounted within the lower portion of housing 10. The inner peripheral surface 83 of this volute is curved inwardly, in order to receive fluid material discharged from the lower lip 84 of the centrifuge bowl and to direct this material downwardly. A plurality of circumferentially spaced passages 85 serve to deliver material from surface 83 into a plurality of circumferentially spaced pockets 86. (Fig. 4.) Referring to Fig. 1 it will be noted that pockets 86 are formed between the lower face of volute 82 and the adjacent annular face of the housing bottom wall 87, and that they are formed by vanes 88 carried by and depending from volute 82. Pockets 86 serve to deliver material to a cavity 89 formed between the inner portions of the volute and the housing bottom wall 87. An upstanding portion 91 of the volute 82 forms a passageway 92, communicating with cavity 89, and serving to conduct the material into the bowl chamber 53. It will be noted that pockets 86 are inwardly divergent and that they are faced toward the direction of normal rotation of the bowl. By this construction a swirling movement is imparted to material which is discharged inwardly in to cavity 89, thus minimizing loss of kinetic energy. Likewise the flow resistance of material discharged thru passage 92 is minimized by the upward and inward curving of volute surface 93.

To permit the removal of a portion of fluid material from volute 82 the lower section of housing 10 is provided with a passageway 97, with which a discharge pipe 98 is connected. Cavity 89 is in communication with passageway 97 thru connected passages 99 and 101. An adjustment of the rate of outflow thru pipe 98 is made possible by the provision of a needle valve 102 by means of which flow thru passage 101 can be restricted to a desired degree. Needle valve 102 can of course be adjusted exteriorally of the housing and is shown provided with a suitable packing gland 103. By means of another pipe connection 104 with cavity 89 (Fig. 5), it is possible to introduce varying quantities of additional material into the interior of volute 82, as for example wash water, as will be presently explained. Another pipe connection 105 communicating with cavity 89 can be connected to a suitable manometer or pressure gauge.

It is evident that different types of bearing assemblies 16 can be utilized. The particular type illustrated consists of a collar 108 fixed to the end of support arm 17, and within which a liner 109 is fitted. Sleeve 111 is formed upon and extends upwardly from housing section 15, and has a threaded connection 112 with liner 109. A suitable driving element such as a pulley 113 is engaged upon the upper end of shaft 19, and is retained in position by nut 114 threaded upon the shaft. A sleeve 116 is fitted upon the shaft below pulley 113, and has its lower end engaging a shoulder 117 formed upon the shaft. A collar 118 larger in diameter than the upper diameter of sleeve 111, and extends concentrically about the latter. A plurality of suitable bearing units 119, 121 and 122, surround sleeve 116 within the liner 109. 119 can be a roller bearing unit, 121 a ball bearing unit, and 122 a roller bearing unit similar to unit 119. An annular socket 123 serves as a support for the lower bearing unit 122, and is provided with an upper annular conical portion 124 seated upon the upper edge of liner 109. The upper bearing unit 119 is provided with a socket 126 and is disposed telescopically with respect to socket 123. A plurality of spring pressed plungers 127 are disposed within the socket 126, and press against the lower face of the removable cover plate 128, thus serving to normally urge socket 126 downwardly. The lower bearing unit socket 123 is provided with a depending collar 129 which extends below and which is concentric with collar 118. An oil throw ring 131 is shown disposed about sleeve 116 between the lower face of pulley 113 and the upper bearing unit 119. A bearing assembly of this character will properly journal and support the weight of the rotating centrifuge parts and will permit a high speed of operation.

To explain the mode of operation of the above described machine, it will be presumed that the centrifuge bowl is being rotated at a given speed, as by means of a belt connected to pulley 113. It will also be presumed that feed material is being introduced into the centrifuge bowl thru pipes 33 at a constant rate under the control of the operator. While the apparatus can be utilized with various fluid feeds, it will be presumed that the feed in this instance is "mill starch", from which the solid starch particles are to be separated. The feed material enters the centrifuge chamber 28 thru radial ports 48 and 50, which impart to it considerable rotary energy, and within the centrifuge chamber separation takes place by virtue of the centrifugal force to which the rotating mass of material is subjected. Heavier separated components, which in this instance are the solid starch particles, progress to the outer periphery of chamber 28 and are discharged thru pipes 76 into the volute 82. It is of course understood that this heavier discharge material does not consist solely of solid heavier separated components, but these solid components are mixed with a liquid medium to provide flow characteristics similar to a liquid, as for example water in the case of mill starch. Lighter separated components, which in this specific example will be gluten and water, will flow thru the discharge ports 74. These lighter separated components are collected by pockets 77 and discharged thru pipe 78. The heavier discharge material received by volute 82 flows downwardly thru passages 85, inwardly into cavity 89, and then upwardly thru central passage 92 into the chamber 53. From chamber 53 this discharge material is forcibly introduced into the annular space 55 of the centrifuge chamber 28, by the impeller 32.

Assuming now that the preferred features of our method are to be utilized, the heavier components returned to the centrifuge bowl by volute 82 and impeller 32, are diluted by admixing therewith a suitable liquid medium introduced at a controlled rate thru pipe 104. The nature of this liquid medium will depend upon the conditions under which the apparatus and method are to be utilized, and upon the character of the feed material. Generally speaking it should be such that its contact with the heavier separated components will not be detrimental, and its admixture with the lighter components not undesirable. In the case of a feed material such as mill starch this liquid medium introduced thru pipe 104 can be distilled water. When operating upon feed material such as a spent chemical solution in which solid particles of a metallurgical pulp are suspended, the liquid medium can be spent chemical liquor. As will be presently explained, in the event that the heavier components to be separated from the feed consists of solid particles (as in the example of mill starch) the liquid medium admixed with the material reintroduced into the centrifuge bowl will perform the useful function of scrubbing the heavier separated components within the centrifuge chamber. Therefore this liquid medium will hereafter be termed "wash liquor".

Continuing the above example in which mill starch is being treated, water is introduced thru pipe 104 at a controlled rate to form the wash liquor refered to above. The heavier previously separated components of the material introduced into the centrifuge bowl by way of impeller 32 are redischarged thru pipes 76 together with heavier components directly separated from the feed material. In this connection it should be noted that the discharge passages afforded by pipes 76 are preferably substantially larger in diameter than standard practice. This is made possible by virtue of the fact that the passages carry not only heavier components directly separated from the feed, but also heavier components reintroduced by way of impeller 32. Thus the use of relatively large discharge passages precludes clogging of the centrifuge bowl thru packing of heavier components. While it is possible to introduce the material by way of impeller 32 at such a rate, proportioned with respect to the rate of introduction of the feed material, so that all of this material is discharged immediately thru pipes 76 together with the components separated directly from the feed, it is preferable according to the present method to introduce this material at such a rate that a portion thereof flows inwardly from the outer periphery of chamber 28 thru the zone of separation, to be discharged together with the latter separated components thru ports 74. Thus assuming that the material introduced by impeller 32 consists of heavier previously discharged material mixed with a wash liquor such as water, the rate at which this material is introduced is so adjusted, and the amount of wash liquor contained therein is so controlled, that as the mixture is introduced into the centrifuge chamber it divides or splits into two portions. One portion containing the heavier previously separated components discharges thru pipes 76, and another portion consisting of wash liquor flows inwardly toward the center of rotation thru the separation zone, and is discharged thru ports 74 together with the lighter separated components. This method makes possible several important advantages, one of the most important of which is that it causes an energy exchange within the centrifuge chamber.

To explain what is meant by an energy exchange within the centrifuge chamber, it may be pointed out that in an ordinary centrifuge in which no material is introduced into the bowl in addition to the feed, the heavier components in the mass of material within the centrifuge bowl must accelerate in a rotary direction as they progress toward the periphery of the bowl. Since in the ordinary centrifuge this rotary velocity must be imparted to the mass of material within the bowl and to the heavier components by contact with the mechanical surfaces presented to the material, it is apparent that as a given heavier particle progresses to the outer periphery of the bowl, it lags considerably behind the bowl's actual rotary velocity. Such lagging or slippage within the centrifuge chamber causes eddy currents or turbulence within the separating zones, a condition which is conducive to poor separation. Such slippage may be reduced by vanes or by discs, but vanes augment turbulence while discs are not satisfactory in treating feed materials containing a high percentage of solids. On the other hand if it is assumed that a fluid material is introduced into the centrifuge bowl of the present invention by way of impeller 32, this material at its point of introduction into chamber 28 will have a peripheral velocity substantially equal to the corresponding portion of the centrifuge bowl, by virtue of vanes 54. Assuming now that a portion of this material flows inwardly of the centrifuge chamber over the upper lip 56 of the impeller, it will be apparent that the rotary velocity of each mass of such inwardly flowing material will tend to remain the same. The result will be that such inwardly flowing material will tend to lead the bowl.

From the above it will be understood that when a flow occurs in opposite directions thru the centrifuge chamber, one of a liquid medium introduced with rotary velocity thru the impeller 32, and the other of components of the feed material introduced near the center of the bowl, there will be an interchange of kinetic energy within the centrifuge chamber and within the zone of separation.

Assuming again the above example in which mill starch is being introduced into the centrifuge chamber simultaneously with the return of separated starch together with wash water thru impeller 32, an exchange of kinetic energy will occur between the particles of starch separated from the feed and the wash liquor flowing inwardly from the periphery of the chamber, and if this exchange of energy is properly controlled the result will be that the slippage of the starch particles being separated from the feed will be reduced to substantially zero. Due to the reduction in slippage the disadvantages attendant the same will also be reduced to a minimum; that is, separation will take place in a substantially eddyless zone. Therefore with the preferred method of this invention it is possible to secure remarkably sharp separation between the heavier and lighter components. As it is also possible to operate the centrifuge bowl at relatively high rotative speeds, the immediate transfer of energy from liquid to starch makes possible a compact centrifuge apparatus of high capacity. Another material advantage results from the counter flow of wash liquor, namely that each particle being separated from the feed is received in a zone or bed of wash liquor flowing over lip 56 and is given a thorough scrubbing. Such a scrubbing action is frequently of paramount importance in securing a clean separation of heavier solid components. For example in separating starch particles from mill starch containing gluten, the starch particles are given a thorough scrubbing to remove solubles therefrom.

It is evident that the apparatus must be carefully and intelligently operated and the rates of introduction of various materials properly controlled in order to secure an energy exchange as explained above, with its resulting advantages. The adjustment of needle valve 102 determines the amount of material which is removed from the apparatus thru pipe 98. The amount of wash liquor introduced thru pipe 104 must also be properly adjusted, so that a proper amount of this liquid medium flows inwardly to secure a proper energy exchange. The amount of material being introduced by way of impeller 32 is indicated to a certain extent by the reading of a pressure gauge connected to pipe 105. In operation the pressure as indicated by this gauge may vary over wide limits responsive to different adjustments of needle valve 102, for the same rate of introduction of feed and for the same speed of rotation of the bowl. For certain pressures (assuming a given rate of feed and speed of rotation) the exchange of energy within the centrifuge chamber will be such that the material within the chamber will in general be lagging behind the bowl, for other pressures the material within the chamber will in general lead the bowl, while for a given narrow range of intermediate pressures the material within the chamber is substantially in unison with the bowl. In the preferred method the pressure of fluid in both feed chamber 46 and return chamber 53 is in excess of the pressure in chamber 28, thereby causing a scouring or racing action which will prevent accumulation of separated solids, particularly within the annular space 55. Such scouring or racing action is facilitated because space 55 is substantially unobstructed in its entire circumferential extent.

By experimentation an operator can readily determine the proper adjustments for a given feed material and for a given set of operating conditions. Assuming a given rate of introduction of wash liquor thru pipe 104 it is possible to maintain a control over the specific gravity of the discharge material removed thru pipe 98, by adjustment of needle valve 102. Thus in general a lowered rate of withdrawal of material thru the needle valve will tend to increase the specific gravity of the heavier discharge fraction. Assuming that adjustments are once properly made for a given rate of feed and a feed of given characteristics, the apparatus will continue to operate in a state of equilibrium without further adjustments. It is of course obvious that in general the machine is operated to give a separation as clean as that desired with a capacity which is as great as can be secured under the conditions of operation.

It is to be understood that the term "feed material" or "fluid feed material", as utilized in the present specification and the appended claims, refers to a material having liquid characteristics, as distinguished from gases. This feed material may contain heavier suspended solid particles which are to be removed from the feed in the form of a concentrate, solid particles which are to be separated from various solutions, solid particles of different specific gravities which are to be separated, or liquid components of different specific gravities. The apparatus and method described appear to be particularly adapted for the separation of solid particles in fluid suspension and for the separation of heavier components emulsified with liquid.

In case certain feed material such as mill starch, are being treated by our apparatus, a preliminary classification can take place prior to introducing the material into the centrifuge chamber. Thus referring to Fig. 1 it will be noted that a swirling motion is imparted to the feed material because of the tangential relationship of inflow pipe 33 with respect to chamber 37. Therefore feed material flowing into chamber 46 is swirling in the direction of rotation of the centrifuge bowl, and further swirling movement is imparted by contact with the conical surface 43. The lighter classified material in feed chamber 46 flows over wier 49 and is discharged into the centrifuge chamber 28 while heavier material is discharged into the centrifuge chamber thru ports 50. Such a preliminary centrifugal treatment is advantageous when utilized with feed materials containing components which are detrimentally affected by suddenly applied centrifugal forces, as for example the gluten in mill starch. In the form of the apparatus illustrated, centrifugal force is gradually applied to the feed material. It will also be noted that the paths taken by the materials flowing thru ports 48 and 50 do not intersect or cross within the centrifuge chamber. This is an advantage in handling feed material containing components which readily go over into colloidal form, as for example gluten. If an excess of feed is supplied to chamber 46 an overflow occurs thru opening 133, and can be recovered from pipe 134.

We claim:

1. In a continuously operating centrifuge machine, a rotary bowl having provision for the discharge of lighter separated material and also having ports for the discharge of heavier separated material, means for continually introducing feed material into said bowl, and means for effecting a continuous return flow of a portion of the heavier discharge material back into the centrifuge bowl apart from the feed, said means comprising a closed circuit flow path characterized by the fact that ununiformity in the total discharge from said ports cause automatic compensating control of the heavier material being returned.

2. In a centrifuge machine, a rotor having provision for introducing feed material and for separately discharging heavier and lighter separated components, and means for continuously returning heavier separated components back into the rotor, said last means including an impeller mounted upon the rotor and formed to provide an inlet chamber concentric with the rotor axis, a volute adapted to receive heavier components discharged from the rotor, and means for continuously conducting heavier components from the volute and into said chamber with rotary velocity in the direction of rotation of the rotor.

3. In a continuously operating centrifuge machine, a rotary bowl having provision for the discharge of lighter separated material and also having ports for the discharge of heavier separated material, and means for automatically maintaining stable separating conditions within the bowl, said last means comprising a closed circuit flow path for continuously returning a portion of the heavier separated material discharged from the bowl back into the outer peripheral portion of the bowl, said path being so formed and proportioned that a change in the rate of discharge of heavier material from the rotor is immediately accompanied by a compensating change in the rate of return into the bowl.

4. In a continuously operating centrifuge machine, a rotor, a wall disposed within the rotor serving to divide the interior thereof into an inner separating space and an outer annular space, said spaces being connected by a restricted annular orifice, said outer space being substantially unobstructed for its entire circumferential extent, means for introducing a fluid feed into said inner space, means for discharging lighter separated material from said inner space, means for effecting discharge of heavier separated material from said outer annular space, and impeller means for introducing fluid material into the outer space with substantially rotary velocity.

5. In a continuously operating centrifuge machine, a rotor, a wall disposed within the rotor serving to divide the interior thereof into an inner space and an outer annular space, said spaces being connected by a restricted annular orifice, said outer space being substantially unobstructed for its entire circumferential extent, means for introducing a fluid feed into the inner space, means for discharging lighter separated material from the inner space, means for effecting discharge of heavier separated material from the outer annular space, and means including an impeller for introducing heavier separated material discharged from the rotor back into said outer annular space with substantially rotary velocity.

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Dec. 9, 1941. G. J. STREZYNSKI 2,265,459

CENTRIFUGAL BOWL

Filed March 28, 1939 2 Sheets-Sheet 1

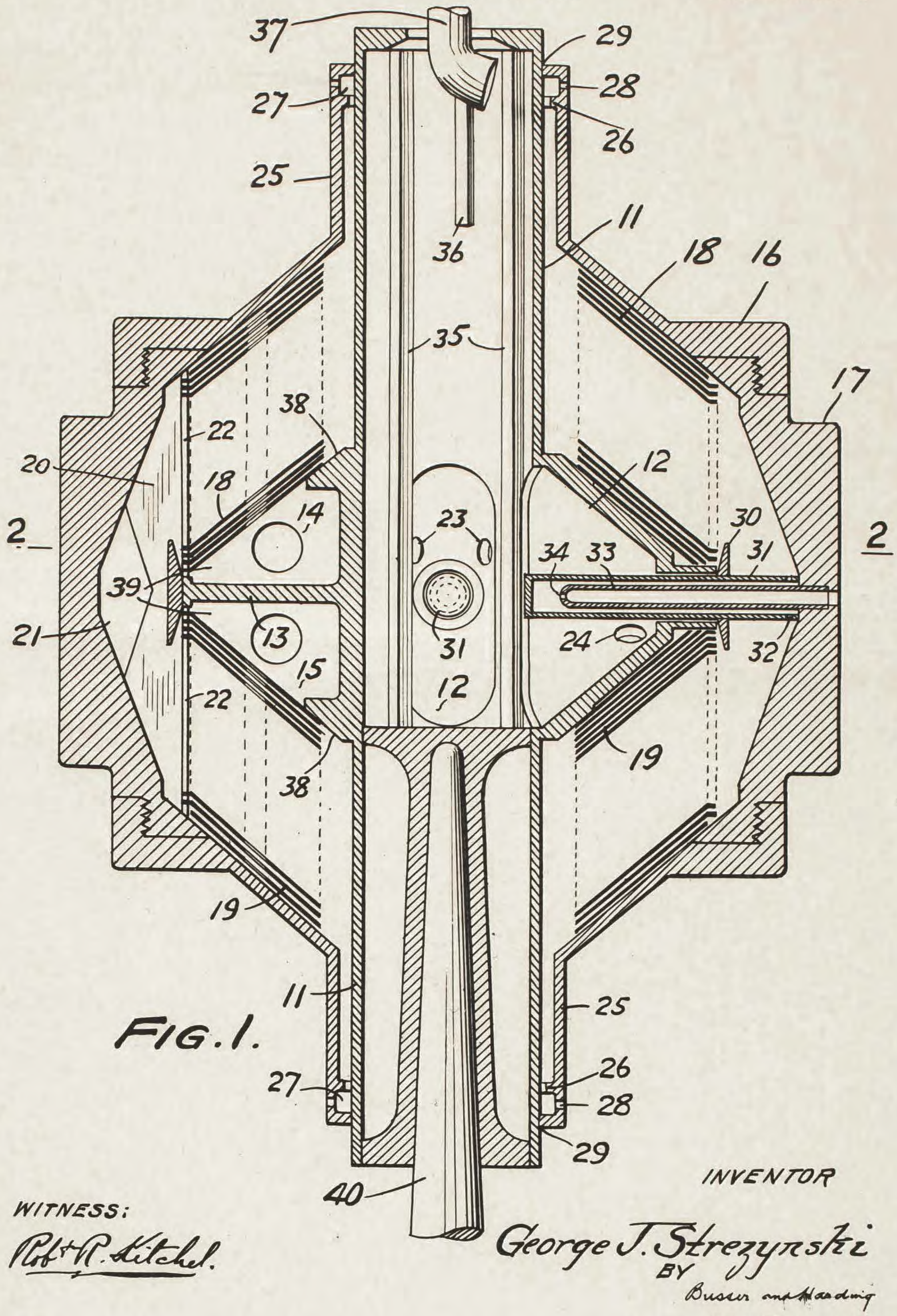

FIG. 1.

WITNESS:
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CENTRIFUGAL BOWL

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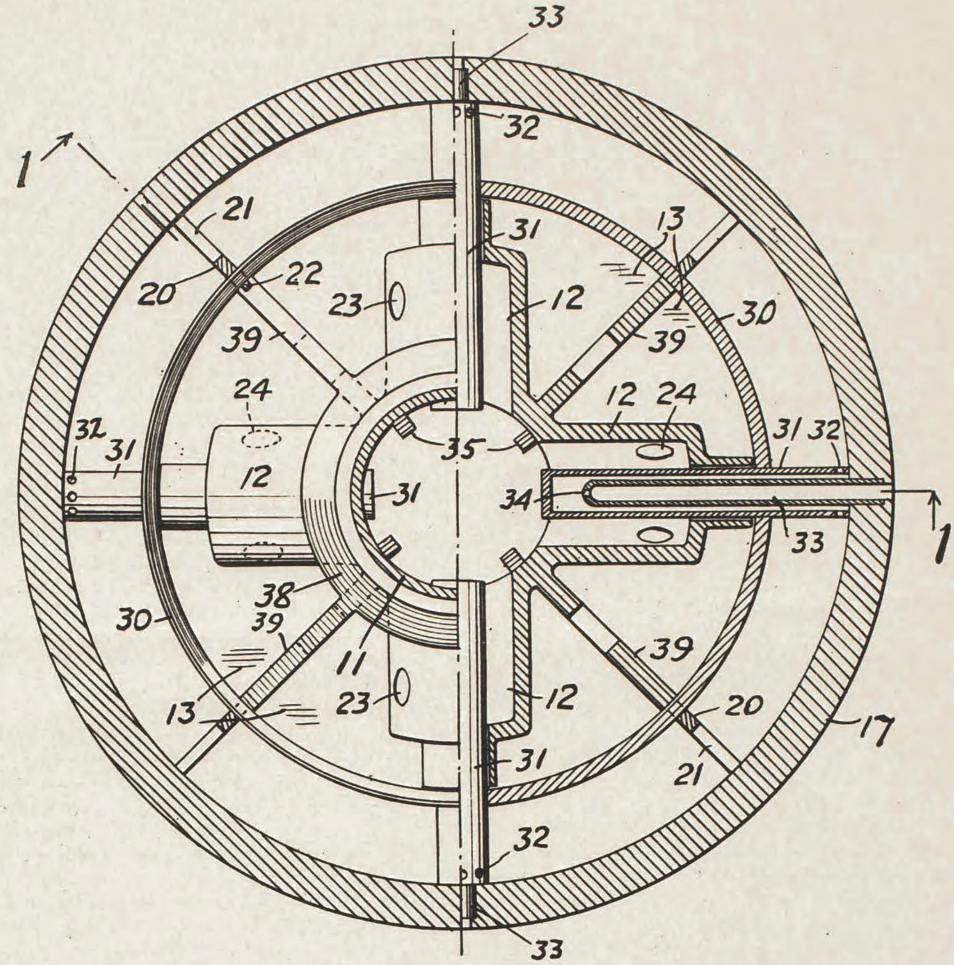

FIG. 2.

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Patented Dec. 9, 1941 2,265,459

UNITED STATES PATENT OFFICE

2,265,459

CENTRIFUGAL BOWL

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Application March 28, 1939, Serial No. 264,523

16 Claims. (Cl. 233—29)

My invention is an improvement in centrifuges for the concentration, from a carrying serum, of materials which have a tendency to coagulate when overconcentrated or when dried. Examples of materials of this class are rubber latex and similar plant juices.

The object of my invention is the provision of a centrifugal bowl which will have a greater capacity than previously made bowls and will consistently continuously discharge the concentrate in a more concentrated condition and at the same time leave a smaller quantity of solids in the discharged serum.

There are two ways of increasing the separating capacity of a centrifugal bowl; one by increasing the diameter and the other by increasing the length. Increase in diameter is limited by the strength of available materials. Increase in length beyond a certain rather short limit results in unequal flow through the different inter disc spaces.

It is known to divide the frusto-conical discs in a bowl into two groups with their large ends together or closely approximating and feed the mixture to be separated to the space between the two groups. One example of such a construction is disclosed in an application filed by me December 2, 1937, Serial No. 177,688. With this construction each group of discs is half the height of the total number and the inequality is much less. I have found, however, that there is a tendency to feed much more mixture to the lower than to the upper group of discs. I have succeeded in overcoming this tendency by providing, on the central feeding member, generally called a tubular shaft, an even number of circumferentially spaced pockets alternately feeding the upper and the lower groups of discs.

Even with short groups of discs there is a tendency to discharge too much liquid from the outer edges of the discs that are nearest the feed end of the group. To overcome this tendency I have provided a taper bored ring around such discs.

If air is allowed to circulate over the surface of the concentrate it has a tendency to dry it and increase its tendency to adhere to any surfaces with which it comes in contact, causing irregularity in flow and non-uniformity in the product. The invention includes means to prevent such drying.

In the accompanying drawings, which illustrate an embodiment of my invention:

Fig. 1 is a vertical longitudinal section on line 1—1 of Fig. 2, and Fig. 2 is a transverse section on line 2—2 of Fig. 1 partly broken away.

Except for a driving and supporting spindle and its connection to the lower part of the bowl, the bowl is symmetrical about its center of length as well as about its axis of rotation.

The central tubular shaft 11 has an equal number (four in the drawings) of radially extensive pockets 12 projecting therefrom and between the pockets a horizontal partition 13 separating the space around the central tubular shaft into an upper chamber 14 and a lower chamber 15.

Above the pockets 12 and clamped to them by the head 16 of the bowl shell 17 is a group of frusto conical members 18, known in the art as "discs." Below the pockets another similar group of discs 19 is clamped against the pockets by the opposite head of the bowl. In each group of discs the one nearest the center of length of the bowl fits tightly against an annular conical surface 38 around the central tubular shaft and is otherwise supported on vertical vanes 39 arranged in the bowl intermediate the pockets 12. These discs are guided at their peripheries by vertical ribs 20 in the bowl shell each of which has a hole 21. One of the ribs 20 has a key 22 that, by fitting notches in the discs, insures their correct circumferential location.

Two of the pockets 12 have holes 23 which feed liquid to the upper chambers 14 from which it flows through conventional distributing holes in the upper discs 18 to the interdisc spaces. The other two pockets have similar holes 24 which, through the lower chambers 15, feed the interdisc spaces of the lower group 19.

The bowl top at each end has a neck 25 with a discharge controlling ring 26 substantially smaller than the neck but substantially larger than the outside of the tubular shaft 11. Beyond the ring 26 is an annular trough 27 with several slots 28 therethrough and, beyond the slots an inturned flange that fits closely around the central tubular shaft at 29.

The central holes in the discs are, as shown, larger than the inside of the bowl neck 25 and much larger than the outside of the central tubular shaft 11 and there are no members extending into the annular space between the discs and said tubular shaft.

A ring 30 around the discs in each group nearest the feed end has its inner surface almost touching the first disc and is distant from the last one that it surrounds by about twice the distance between two discs. The ring may surround the group of discs between about 15% to 30% of the length of the group from its feed end and may be spaced from the group at its outer and larger end a distance equal to somewhat less than twice, to about four times, the space between adjacent discs.

A radial tube **31** resting against the inner surface of the bowl shell **17** at its maximum diameter has several small holes **32** leading to an annular passage between that tube and a smaller tube **33** inside it, having at its inner end, an inlet **34** and, at its outer end, an outlet through the bowl wall.

On the inner side of the central tubular shaft **11**, and located at the back side, in the direction of rotation, of each pocket **12**, is a liquid accelerating rib **35** and between these long ribs there are an equal number of shorter ribs **36**.

A feed tube **37** extends inside the upper end of the tubular shaft and has its end bent toward one side and flattened.

In operation liquid from the tube **37** flows against the inside of the tubular shaft **11** where it is caught by the ribs **35** and **36** and caused to rotate with the bowl. It then flows down and outwardly into the pockets **12**. Because the ribs **35** and pockets **12** are equally and symmetrically spaced and of the same size, the pockets all receive the same quantity of liquid and, because half of them feed the upper part of the bowl and the other half the lower part, the liquid is equally divided between the two ends.

The action is the same in both ends of the bowl and, for simplicity, the description will be confined to the upper end.

From the pockets **12** liquid flows through holes **23** into chambers **14** and thence through the distributing holes in the discs to the spaces between them where the light and heavy constituents are separated. The heavier constituent moves to the outside, passes through the holes **32** in the tube **31**, then along the annular space between that tube and tube **33** to the hole **34** in the end of the tube. The length of the tube **33** is calculated, as taught by Snyder Patent 1,283,343, so that the neutral zone between the heavier and lighter constituents will be at about the center of the distributing holes in the discs. The bowl may be supported and driven in the usual manner by a vertical spindle **40**.

The ring **30** around the outside of the discs nearest the feed end of the group provides a graduated throttling that largely equalizes the flow from the outside of the discs.

The lighter constituent moves toward the center and forms an annular zone which flows out over the ring **26** into the trough **27** then out through the slots **28**.

The inturned flange at the end of the bowl neck **25** fits closely around the tubular shaft **11** at **29** and prevents circulation of air over the concentrate.

While the bowl and especially certain of the described details are more particularly intended for concentrating, from a carrying serum, of materials having a tendency to coagulate if overconcentrated or dried, certain features thereof, such as the means insuring equality of feed to the two groups of discs, are of value and utility when applied to centrifugal separators and purifiers intended and adapted for general or other uses.

What I claim and desire to protect by Letters Patent is:

1. A centrifugal bowl enclosing a space in which the mixture is centrifuged, an axial tubular feed shaft communicating with said space, a group of longitudinally spaced discs within said space and surrounding the feed tube, and means to retard excessive flow from between the discs nearest the feed, said means comprising a ring surrounding the discs nearest the feed and having a tapered bore with its end of smaller diameter only slightly larger than and adjacent to the exterior of the disc nearest the feed end of the group and its end of larger diameter surrounding a disc substantially nearer to the feed end of the group than to the opposite end of the group.

2. A centrifugal bowl as defined in claim 1 in which the larger diameter end of the ring is spaced from the edge of the last named disc a distance substantially greater than the space between two adjacent discs.

3. A centrifugal bowl as defined in claim 1 in which the larger diameter end of the disc surrounds a disc position between 15% and 30% of the length of the group from the feed end thereof and distant from said disc between about two to four times the space between adjacent discs.

4. In a centrifugal bowl for concentrating, from a carrying serum, materials having a tendency to coagulate, an axial tubular feed shaft, two groups of discs in said bowl arranged along different lengths of the axis of the bowl, said bowl having a serum outlet between its ends and provided at opposite ends thereof with necks surrounding and spaced from the tubular shaft and provided with discharge rings of substantially greater diameter than the outside diameter of the tubular shaft and of substantially smaller diameter than the inside diameters of the bowl necks and the group of discs.

5. A centrifugal bowl in accordance with claim 4 comprising also guiding means engaging the groups of discs at their outer edges, the annular spaces between the inner edges of the discs and the tubular feed shaft being unobstructed by any elements projecting through the inner surface of the concentrate.

6. A centrifugal bowl in accordance with claim 4 comprising tight closures between the bowl neck and tubular shaft beyond the discharge rings.

7. A centrifugal bowl in accordance with claim 4 comprising also a trough beyond each discharge ring having peripheral outlets for escape of concentrate but closed against admission of air.

8. In a centrifugal bowl having an axial tubular feed shaft into which the material to be separated is fed, said bowl enclosing two annular separating chambers spaced apart along the axis of the bowl and having midway between them a common discharge for the heavier separated constituent, the improvement which comprises means providing equality of feed from the tubular shaft to the two separating chambers, said means comprising an even number of distributing pockets of similar size arranged symmetrically around the feed shaft and communicating therewith along the same length thereof and at equal distances from the axis one half of which feed only one separating chamber and the other half of which feed only the other separating chamber.

9. A centrifugal bowl in accordance with claim 8 in which the pockets are not less than four in number and in which the pockets communicating with one chamber alternate with the pockets communicating with the other chamber.

10. In a centrifugal bowl having an axial tubular feed shaft and enclosing two annular separat-

ing chambers spaced apart along the axis of the bowl, and two sets of annular frusto-conical discs in the respective chambers having distributing orifices between their inner and outer edges, one set of discs being inverted relatively to the other, all the discs of both groups being of uniform diameter with their inner and outer edges in alignment in the direction of the axis of the bowl, the orifices of the discs of each group being in alignment along lines extending parallel to the axis of the bowl, the improvement which comprises means providing substantial equality of feed from the feed shaft to the two separating chambers, said means including pockets of similar size located symmetrically around the feed shaft betwen the two separating chambers and communicating therewith along the same length thereof, and one of which communicates with the disc orifices of only one separating chamber and the other of which communicates with the disc orifices of only the other separating chamber.

11. A centrifugal bowl in accordance with claim 10 in which the pockets are not less than four in number and in which the pockets communicating with one chamber alternate with the pockets communicating with the other chamber.

12. A centrifugal bowl in accordance with claim 8 in which the width of the communicating openings between the feed tube and the pockets, measured circumferentially of the feed tube, substantially exceeds the distance, similarly measured, between adjacent pockets.

13. A centrifugal bowl in accordance with claim 8 in which the width of the communicating openings between the feed tube and the pockets, measured circumferentially of the feed tube, substantially exceeds the distance, similarly measured, between adjacent pockets, and longitudinally extending accelerating ribs on the inside of the tubular shaft corresponding in number to said pockets and extending adjacent to corresponding edges thereof.

14. A centrifugal bowl in accordance with claim 8 in which the width of the communicating openings between the feed tube and the pockets, measured circumferentially of the feed tube, substantially exceeds the distance, similarly measured, between adjacent pockets, and longitudinally extending accelerating ribs on the inside of the tubular shaft corresponding in number to said pockets and extending adjacent to corresponding edges thereof, and additional longitudinally extending accelerating ribs on the inside of the tubular shaft shorter than and arranged between the first named ribs.

15. A centrifugal bowl in accordance with claim 10 having at opposite ends necks and control rings extending inward therefrom, the inner edges of each ring having a radius substantially greater than that of the outside of the feed shaft and the inner edges of the pocket walls and substantially less than that of the central holes in the annular discs, said necks beyond said rings forming troughs closed at their ends provided with discharge orifices.

16. A centrifugal bowl in accordance with claim 10 and comprising also means to retard excessive flow from between the discs of each chamber nearest the feed thereto from the pockets, said means comprising a ring surrounding only that minor proportion of the discs which is nearest the feed from the pockets to the disc orifices.

G. J. STREZYNSKI.

No. 888,685. PATENTED MAY 26, 1908.

C. E. ARNOLD.

LIXIVIATING APPARATUS.

APPLICATION FILED MAY 21, 1907.

2 SHEETS—SHEET 1.

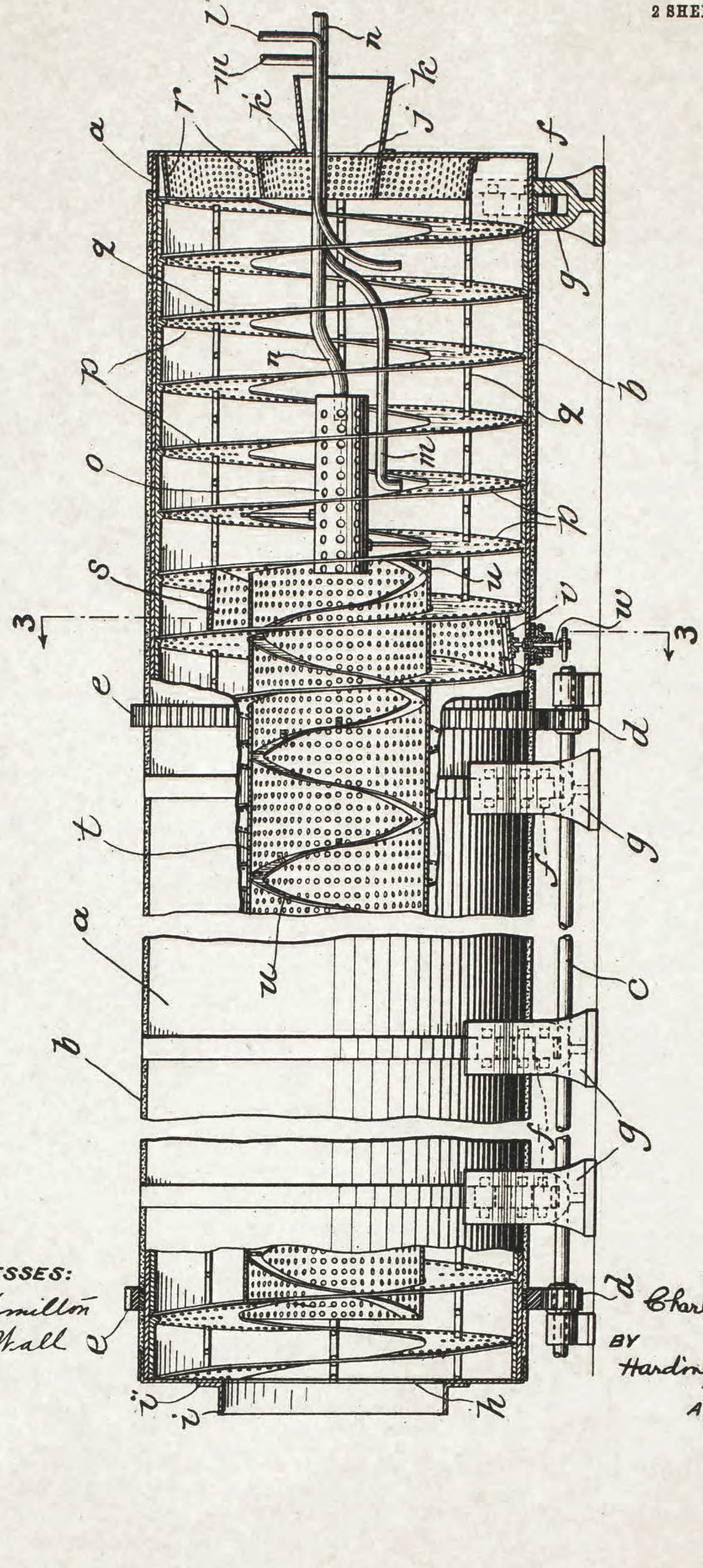

FIG. 1.

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No. 888,685. PATENTED MAY 26, 1908.

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LIXIVIATING APPARATUS.

APPLICATION FILED MAY 21, 1907.

2 SHEETS—SHEET 2.

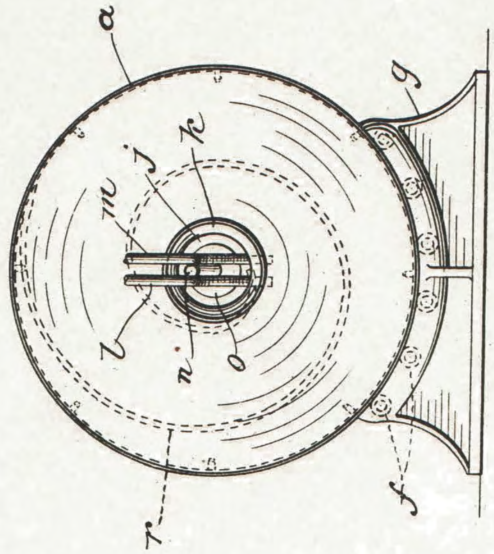

FIG. 2.

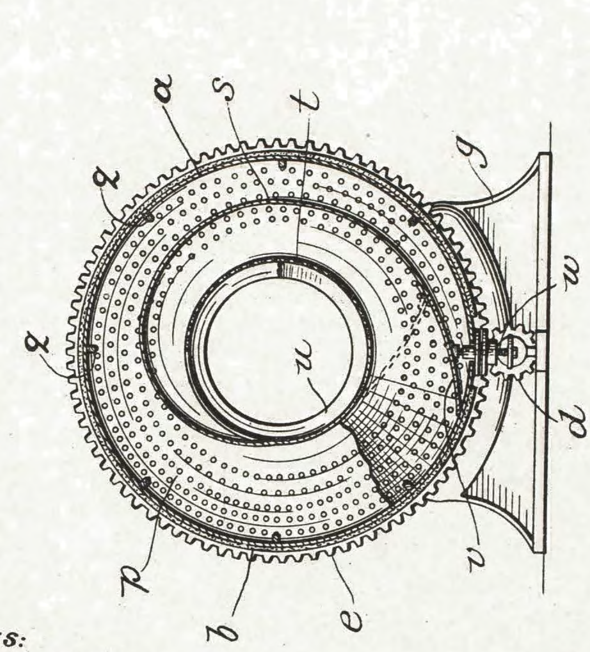

FIG. 3.

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UNITED STATES PATENT OFFICE.

CHARLES E. ARNOLD, OF WILMINGTON, DELAWARE, ASSIGNOR TO THE E. I. DU PONT DE NEMOURS POWDER COMPANY, OF WILMINGTON, DELAWARE, A CORPORATION OF NEW JERSEY.

LIXIVIATING APPARATUS.

No. 888,685. Specification of Letters Patent. Patented May 26, 1908.

Application filed May 21, 1907. Serial No. 374,834.

To all whom it may concern:

Be it known that I, CHARLES E. ARNOLD, a citizen of the United States, residing at Wilmington, county of Newcastle, and State of Delaware, have invented a new and useful Improvement in Lixiviating Apparatus, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, which form a part of this specification.

The object of my invention is to produce an apparatus capable of extracting nitrate of soda from caliche. The known processes are always attended with a loss of a certain proportion of the available nitrate, the loss being due partly to the carrying away of nitrate in solution by the "ripios" or waste. The percentage of loss varies with the process or apparatus employed, and amounts to from one-third to one-half of the available nitrate in the methods of extraction most commonly used.

The more specific object of my invention is to produce an apparatus capable of extracting nitrate of soda from caliche without loss of substantially any of the available nitrate and to carry out the extracting process continuously and automatically.

While the apparatus is designed with especial reference to the requirements attending the extraction of nitrate of soda from caliche, it will be understood that it is not intended to imply that the apparatus is not useful for operating upon other substances. It will also be understood that whether applied to the particular use that I have more especially in view, or whether used for other purposes, the detailed construction and arrangement of parts may be modified, it being understood that the specific apparatus hereinafter described is intended to represent a preferred embodiment of my invention for the particular purpose specified.

In the drawings:—Figure 1 is a side-elevation, partly in section. Fig. 2 is an end view. Fig. 3 is a section on the line 3—3 of Fig. 1.

a is a long tube or cylinder of one-quarter inch iron plate. The diameter of the cylinder may be about six feet, and its length about one hundred feet. The entire tube is covered with heavy insulating material *b* to prevent radiation of heat. The cylinder is rotated from the shaft *c*, on which are gears *d* engaging annular gears *e* encircling the cylinder. The cylinder rests and turns on sets of rollers *f* journaled in standards *g*. In operation, the cylinder is turned at the rate of not more than two or three revolutions per minute.

One end of the cylinder is provided with a central circular opening *h*, of less diameter than the cylinder; and registering with this opening is the annular throat *i* having flanges *i'* bolted to the end plate of the cylinder. Through the opening *h*, the caliche or other material is introduced and the saturated solution discharged. The opposite end of the cylinder is provided with a central opening *j* of less diameter than the opening *h*; and registering with the opening *j* is a funnel shaped throat *k* having flanges *k'* bolted to the end plate. Through the opening *j* are inserted the pipes *l* and *m*, the pipe *l*, through which fresh water is introduced, opening into the cylinder near the latter's extreme end, while the pipe *m*, through which the mother liquid is introduced, opens into the cylinder at a point more remote from the latter's extreme end.

n is a third pipe extending into the cylinder through the opening *j* and connecting with a perforated cylinder or heater *o*, supported from the helix *p* hereinafter described. The fuel supply, which may be crude oil or coal dust, is introduced through the pipe *n* into the heater *o* and is burned there. The heater *o* always being hot, the ignition of the fuel is insured should the supply be momentarily stopped. The perforated helix *p* extends the entire length of the cylinder *a*, the function of the helix being to propel the caliche, while the perforations permit the solution to flow in the opposite direction to that of the caliche.

q, *q*, represent ribs extending longitudinally of the cylinder and secured to its inner wall, their function being to increase the rubbing action of the caliche and at the same time serve as supports for the helix *p*.

r is an elevating spiral adjoining the outlet *j*, the spiral extending from the inner wall of the cylinder to the edge of the outlet *j*, its function being to carry the ripios or waste out at *j*.

s is a perforated elevating spiral extending between successive convolutions of the helix *p* and merging into one end of the perforated tube *t*. This tube is provided with a helix *u* whose convolutions extend in the opposite direction to those of the helix *p*. The function of the spiral *s* is to carry any lumps, too large to pass its (spiral *s*) perforations, up to and into the tube *t*, whence the lumps are conveyed, by the helix *u*, back to the starting point for retreatment.

v is a gate, hinged to and forming part of, the spiral *s*, the gate being operated by means of a screw shaft *w*, extending through the wall of the cylinder *a*.

To put the apparatus into operation, fire is started in the heater *o*, air for the combustion entering through the pipes *l*, *m*, and *n*. The cylinder is revolved at the rate of one or two revolutions per minute. Fresh water is run in at pipe *l* and mother liquor at pipe *m*. At the same time a continuous supply of caliche is fed in through the opening *i*. The water flows gradually along, extracting the nitrate from the caliche during its progress and, becoming saturated therewith, flows out of the cylinder at *h*. At the same time the caliche is carried in the opposite direction by the helix *p*. When it reaches the spiral *s*, if it is finely disintegrated, it will pass through the perforations of the spiral *s* at this point and continue on; but any lumps remaining will be elevated by the spiral *s* and conveyed to the tube *t*, whence the helix *u* conveys them back to the starting point. The finely disintegrated "ripios" is elevated by the spiral *r* and discharged through the outlet *j*. The nitrate is recovered from the saturated solution escaping at *h* by crystallization of the nitrate, as is well known, and the mother liquor, containing more or less nitrate in solution, is fed in through the tube *m* as described. Should a large amount of rock containing no nitrate accumulate in the apparatus, the gate *v* is opened for a time, and the rock passes out with the finer insoluble materials.

It will be observed that the extracting process is carried on continuously and automatically. The action of the apparatus is such as to entirely disintegrate the caliche, and the ripios or waste is discharged wet with fresh water and not wet with the nitrate solution. Further, it is impossible for any lumps containing nitrate to be discharged, and it is also impossible for the waste to carry away nitrate in solution. Moreover, maximum efficiency is secured in the utilization of heat, every unit of heat from the fuel being absorbed by the liquid.

Having now fully described my invention, what I claim and desire to protect by Letters Patent is:

1. In a lixiviating apparatus, the combination with a cylinder and means for rotating the same, of a perforated helix therein and rotating therewith for conveying the material from one end to the other, an outlet at the latter end for the solid residue, means to introduce liquid at the end of the cylinder at which the solid residue is discharged, and means to allow the saturated solution to escape at the opposite end of the cylinder.

2. In a lixiviating apparatus, the combination with a cylinder and means for rotating the same, of means at one end permitting the material to be introduced and the saturated solution to be discharged, means at the opposite end permitting liquid to be introduced and the solid residue to be discharged, and a helix within and rotating with the cylinder for conveying the material from one end to the other.

3. In a lixiviating apparatus, the combination with a cylinder, of a perforated helix therein for conveying the material from one end to the other, an outlet at the latter end for the solid residue, means to introduce liquid at the end of the cylinder at which the solid residue is discharged, means to allow the saturated solution to escape at the opposite end of the cylinder, a heater within the cylinder, and means to introduce fuel to the heater.

4. In a lixiviating apparatus, the combination with a cylinder, of a perforated helix therein for conveying the material from one end to the other, an outlet at the latter end for the solid residue, means to introduce liquid at the end of the cylinder at which the solid residue is discharged, means to allow the saturated solution to escape at the opposite end of the cylinder, a heater near the end of the cylinder at which the water is introduced and the solid residue discharged, and a fuel-supply pipe extending through the discharge opening and connected with the heater.

5. In a lixiviating apparatus, the combination with a cylinder, of a perforated helix therein for conveying the material toward the end at which the solid residue is discharged, a centrally disposed outlet at said end to permit the solid residue to escape, and an elevating spiral to convey the solid residue from the bottom of the cylinder to said outlet.

6. In a lixiviating apparatus, the combination with a cylinder, of a perforated helix therein for conveying the material toward the end at which the solid residue is discharged, a tube within the cylinder, a helix within the tube conveying material in the opposite direction, and an elevating spiral to arrest lumps of material and convey them from the bottom of the cylinder to the tube.

7. In a lixiviating apparatus, the combination with a cylinder, of a perforated helix therein for conveying the material toward the end at which the solid residue is discharged, a waste outlet at said end at which the solid residue is discharged, means at said end to introduce liquid into the cylinder, means at the opposite end permitting the saturated solution to escape and the material to be introduced, a tube within the cylinder, a helix within the tube conveying material in the opposite direction, an elevating spiral extending between successive convolutions of the first named helix, from the inner wall

of the cylinder to the end of the tube nearest said outlet, the opposite end of the tube terminating near the end of the cylinder at which the solid material is introduced and the saturated solution escapes.

8. In a lixiviating apparatus, the combination with a cylinder, of a perforated helix therein for conveying the material toward the end at which the solid residue is discharged, a tube within the cylinder, a helix within the tube conveying material in the opposite direction, and an elevating spiral to arrest lumps of material and convey them from the bottom of the cylinder to the tube, a gate closing an opening in the elevating spiral, and means to open said gate and permit lumps of material to be fed by the helix into that part of the cylinder beyond the elevating spiral.

9. In a lixiviating apparatus, the combination with a cylinder having a relatively large central opening at one end and a relatively small central opening at the other end, of a perforated helix therein for conveying the material from the first opening to the second opening, and means to introduce liquid near the end of the cylinder containing the second opening.

10. In a lixiviating apparatus, the combination with a cylinder, of a perforated helix therein for conveying the material from one end to the other, means to introduce liquid at the end of the cylinder toward which the solid material is conveyed, means allowing the saturated solution to escape at the opposite end, and ribs on the inner wall of the cylinder.

11. In a lixiviating apparatus, the combination with a cylinder, of a perforated helix therein for conveying the material from one end to the other, means to introduce liquid at the end of the cylinder toward which the solid material is conveyed, means allowing the saturated solution to escape at the opposite end, and longitudinally extending ribs on the inner wall of the cylinder.

12. In a lixiviating apparatus, the combination with a cylinder, of means allowing the introduction of the solid material and the escape of the saturated solution at one end of the cylinder, a discharge opening for the solid residue at the other end of the cylinder, means to introduce liquid at the last named end of the cylinder, a perforated helix in the cylinder to convey the material from one end to the other, an elevating spiral at the last named end of the cylinder to convey the solid residue to the discharge opening, an inner tube within the cylinder, a helix therein to convey material in the opposite direction from that in which it is conveyed by the helix in the cylinder, an elevating spiral to convey the solid material from the cylinder to the inlet end of the tube, and a heater within the cylinder.

13. In a lixiviating apparatus, the combination with a cylinder, of means allowing the introduction of the solid material and the escape of the saturated solution at one end of the cylinder, a discharge opening for the solid residue at the other end of the cylinder, means to introduce liquid at the last named end of the cylinder, a perforated helix in the cylinder to convey the material from one end to the other, an elevating spiral at the last named end of the cylinder to convey the solid residue to the discharge opening, a perforated inner tube within the cylinder, a helix therein to convey material in the opposite direction from that in which it is conveyed by the helix in the cylinder, a perforated elevating spiral to convey the solid material from the cylinder to the inlet end of the tube, a heater within the cylinder, a gate forming part of, and hinged to, the last named elevating spiral, and longitudinally extending ribs on the inner wall of the cylinder.

14. In a lixiviating apparatus, the combination with a cylinder, of a feeding device therein to carry the same in one direction, and means to introduce a liquid therein and cause it to flow in the opposite direction in contact with the solid material.

15. In a lixiviating apparatus, the combination with a cylinder, of a feeding device therein to carry the same in one direction, means to introduce a liquid therein and cause it to flow in the opposite direction in contact with the solid material, and a second feeding device in the cylinder to carry partly disintegrated solid material in the direction of the flow of the body of liquid but out of contact therewith.

16. In a lixiviating apparatus, the combination with a cylinder, of a feeding device therein to carry the same in one direction, and means to introduce a liquid therein and cause it to flow in the opposite direction in contact with the solid material, and devices to arrest the feed of partly disintegrated solid material and convey it in the direction of the flow of the liquid and reintroduce it into the cylinder.

17. In a lixiviating apparatus, the combination with the cylinder, of a perforated helix therein for conveying the material from one end to the other, an outlet at the latter end for the solid residue, a pipe, opening into the interior of the cylinder near the last named end, for introducing water into the cylinder, a second pipe, opening into the interior of the cylinder more remote from the last named end, for introducing mother liquor into the cylinder, and means allowing the saturated solution to escape at the opposite end of the cylinder.

18. In a lixiviating apparatus, the combination with a feeding device to carry the material in one direction, means to cause a flow of liquid in the opposite direction in contact

with said material, and a second feeding device to carry partly disintegrated solid material in the direction of the flow of the liquid.

19. In a lixiviating apparatus, the combination with a feeding device to carry the material in one direction, means to cause a flow of liquid in the opposite direction in contact with said material, a second feeding device to carry partly disintegrated solid material in the direction of the flow of the liquid, and means to arrest the feed of partly disintegrated solid material and convey it to the second feeding device.

In testimony of which invention, I have hereunto set my hand, at Wilmington, Del., on this eleventh day of May, 1907.

CHARLES E. ARNOLD.

Witnesses:
HENRY E. MEAD,
S. W. NEWELL.

Jan. 13, 1942. H. SCHULZ **2,270,173**

CENTRIFUGE FOR SEPARATING SOLIDS FROM LIQUIDS

Filed July 19, 1939 3 Sheets-Sheet 1

Fig.1

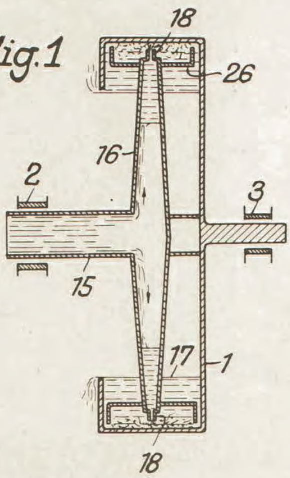
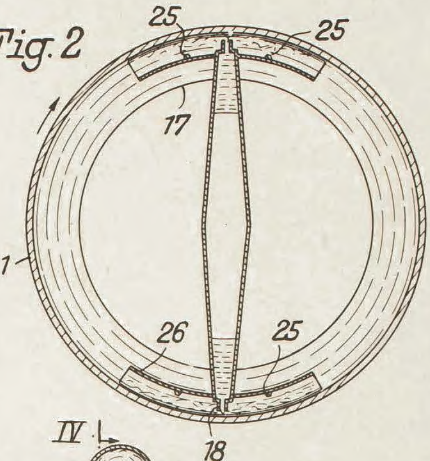


Fig.2



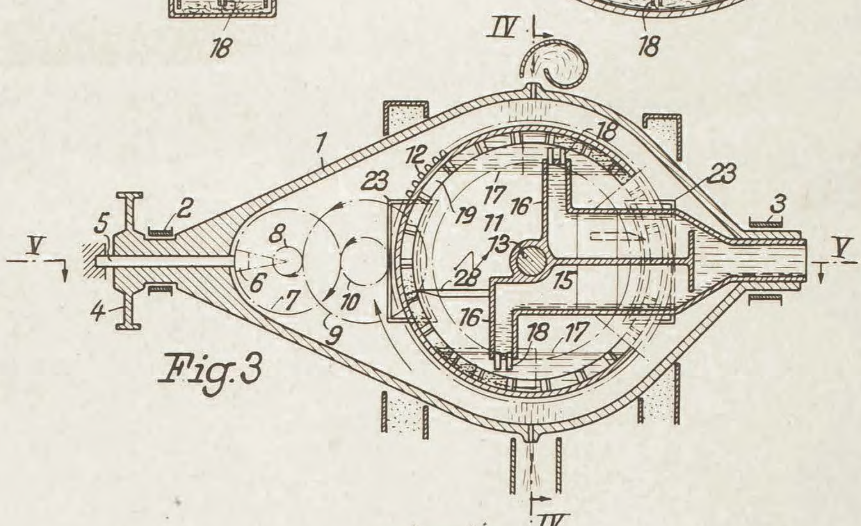


Fig.3

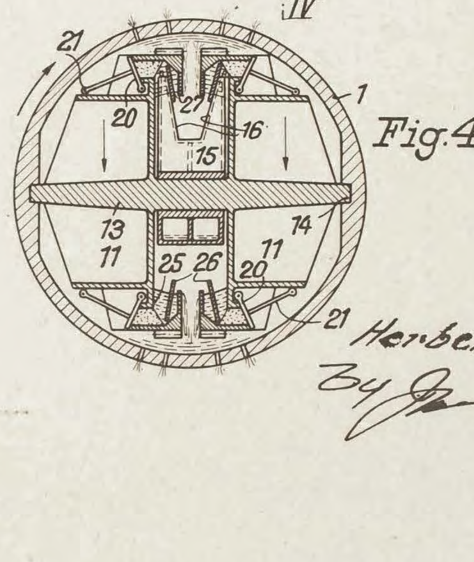


Fig.4

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CENTRIFUGE FOR SEPARATING SOLIDS FROM LIQUIDS

Filed July 19, 1939 3 Sheets-Sheet 2

Fig. 5

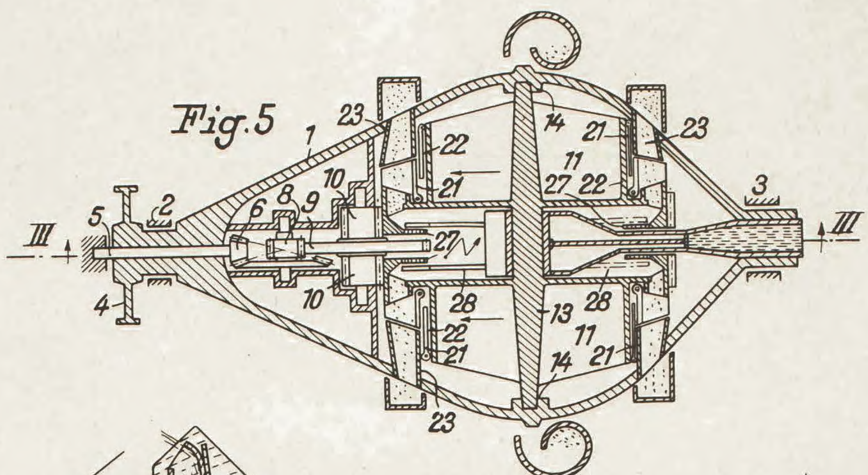


Fig. 8

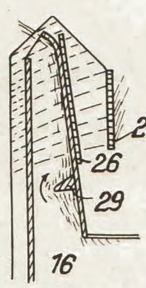


Fig. 6

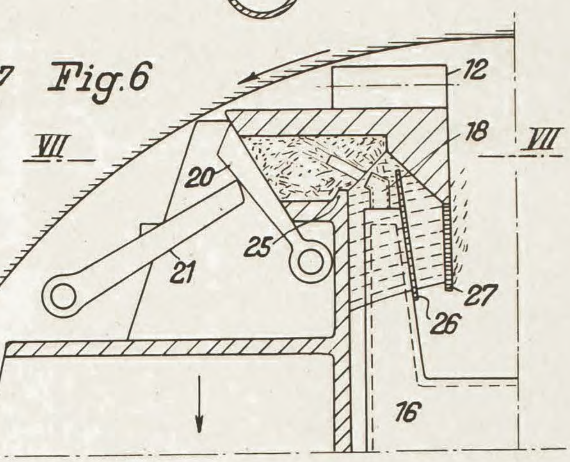
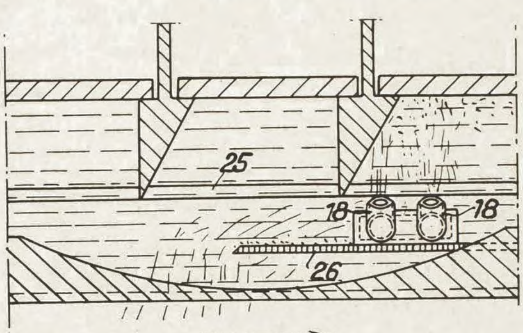


Fig. 7



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CENTRIFUGE FOR SEPARATING SOLIDS FROM LIQUIDS

Filed July 19, 1939 3 Sheets-Sheet 3

Fig. 9

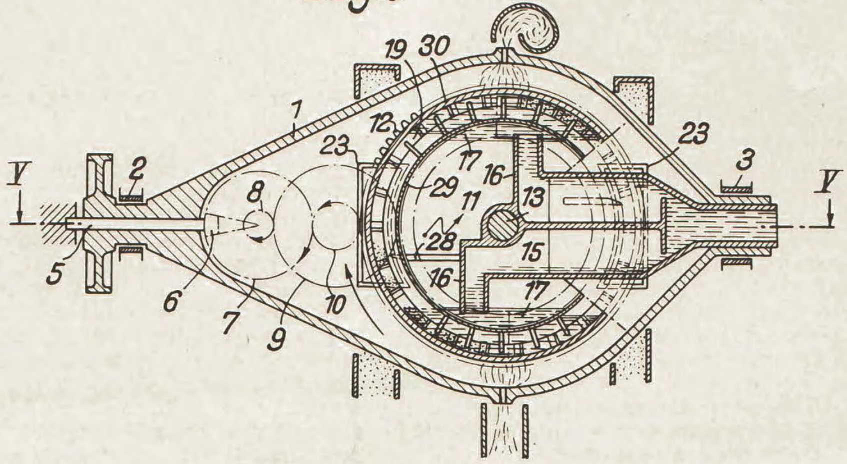
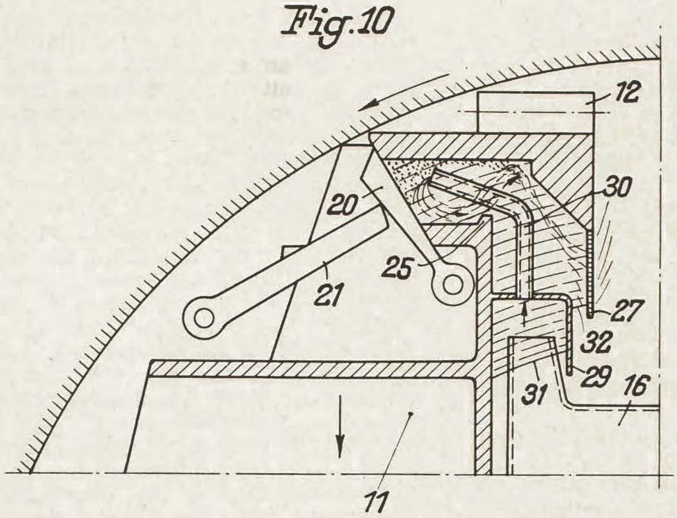


Fig. 10



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Patented Jan. 13, 1942 **2,270,173**

UNITED STATES PATENT OFFICE

2,270,173

CENTRIFUGE FOR SEPARATING SOLIDS FROM LIQUIDS

Herbert Schulz, Berlin-Tempelhof, Germany

Application July 19, 1939, Serial No. 285,426
In Germany April 29, 1938

3 Claims. (Cl. 233—28)

This invention relates to centrifuges for separating the solid matter from mixtures of solids and liquids, such centrifuges being of the type in which there is produced a rotary liquid ring into which extend conduits admitting the mixture to be acted upon.

An object of the invention is to provide a centrifuge of the type stated in which the solid matter is separated by ejection at high speed and with great pressure into a separation zone, so that the time required for separation is reduced and the output is improved as regards quantity and dryness.

Another object of the invention is to attain a high discharge speed and impact pressure of the fluid mixture admitted to the centrifuge by building-up in said mixture a high pressure in opposition to a lesser back pressure.

Another object of the invention is to make use of constricted fluid-mixture discharging orifices which assist the building-up under centrifugal force of the requisite excess pressure in the mixture by producing a difference in effective level, or pressure head, between the surface of the admitted mixture and the surface of the liquid ring into which said mixture is discharged.

Another object of the invention is to effect the requisite separation by impact of the high-speed fluid mixture against a rotary separation or deposition surface.

Another object of the invention is to effect separation impact of the high-speed fluid mixture almost perpendicularly to the rotary separation surface.

Yet another object of the invention is to provide a centrifuge comprising a rotatable separation drum arranged in a housing which also is rotatable but about an axis transverse to the axis of rotation of the drum.

Other objects of the invention will be apparent from the following specification and claims.

Examples embodying the invention will now be described with reference to the accompanying drawings, in which:

Figs. 1 and 2 are sections at right angles to one another of a simple form of centrifuge.

Fig. 3 is a longitudinal section of a centrifuge comprising two drums having mutually transverse axes, Fig. 3 being a section on line III—III of Fig. 5.

Fig. 4 is a section on the line IV—IV of Fig. 3.

Fig. 5 is a section on the line V—V of Fig. 3.

Fig. 6 is a detail sectional view to a larger scale of a deposition pocket already shown in Fig. 4.

Fig. 7 is a section to a larger scale on the line VII—VII of Fig. 6.

Fig. 8 is a fragmentary sectional view showing an enlarged inlet discharge suitable for thickly fluid mixtures.

Fig. 9 is a view similar to Fig. 3, but showing a modified form of centrifuge in longitudinal section, the centrifuge according to Fig. 9 having an arrangement of constricted spraying discharges separate from the inlet conduits.

Fig. 10 is a view similar to Fig. 6, but showing the modification according to Fig. 9 to an enlarged scale.

The centrifuge according to Figs. 1 and 2 includes a centrifugal drum 1 rotatably mounted in bearings 2 and 3. The right-hand end wall of the drum 1 is closed, while the left-hand end wall has the form of a ring. The inlet for the mixture to be separated is a conduit 15 which is journalled in the bearing 2 in the manner of a trunnion. The inlet conduit 15 merges into radial outlets 16 which extend into the ring 17 of liquid in the drum 1 at the inner peripheral surface 17 of the liquid. The mixture, in consequence of an accumulation of pressure in the outlet conduits 16, is discharged through nozzles 18 at high speed to the inner deposition or separation zone in the drum 1. The accumulation of pressure is in effect due to the difference in radius from the axis of rotation, or virtual difference in "level" or pressure head, between the surface of the greater depth of liquid in the outlets 16, with their constricted discharges 18, and the surface 17 of the liquid in the liquid ring confined by the drum. The resultant impact of the high speed streams with the separation surface of the drum, in co-operation with the effect of centrifugal force, ensures a strong separation or deposition effect, whilst recoil of the solid matter is counteracted by the centrifugal force. The impact of the high-speed discharge streams takes place almost perpendicularly to the deposition surface presented by the internal periphery of the drum. While the solid matter is separated and deposited on the separation surface and is discharged from time to time by any known means, the excess of liquid flows over the inner circular edge of the left hand ring wall, as shown in Figure 1.

Deflecting projections 25 throw the liquid stream back again towards the periphery, in order to obtain as complete deposition as possible due to impact. The liquid streaming back is guided as far as possible along the internal periphery of the drum by deflecting plates 26 surrounding the nozzles 18 so that any solids which may be entrained are given time for deposition.

Referring to Figs. 3 to 7, the centrifuge therein shown includes an outer housing constituted as a drum 1 which is rotatably supported by bearings 2 and 3 and which can be driven by a wheel or pulley 4. There extends through one of the journals of the drum 1 a shaft 5 which is connected through transmission gearing 6, 7, 8, 9 and 10 to a second drum 11. The drum 11 is arranged internally of the drum 1 with its axis perpendicular to the axis of the drum 1, the drum 11 having a shaft 13 which is journalled in bearings 14 in the drum 1. The drum 11 has a peripheral ring of teeth 12 which mesh with the last element 10 of said gearing. The shaft 5 is held fast externally of the drum 1. Thus, in the rotation of the drum 1, the internal drum 11 is caused to rotate more or less slowly as determined by the transmission ratio of the gearing.

As shown in Figures 4 and 5 the drum 11 is formed in two similar halves, being arranged with an axial distance or space. Into this space extends the end piece or mouth of an inlet conduit 15 which is supported by the shaft 13 and the bearing 3 respectively. This inlet-conduit 15 for the mixture to be separated extends into the middle of the inner drum 11, the discharges 16 of said conduit being offset from the axis of the shaft 13 (see Fig. 3) and being provided at their outer ends with exchangeable nozzles 18 of constricted cross-section. Pockets or cells 19 are arranged at the internal periphery of the drum 11, and pivotal valve flaps 20 are adapted to close them. Pivotal props 21, which are urged outwards under centrifugal force, serve to maintain the flaps in closed position during the deposition or separation stage. Pivotal pressers (not shown) serve to force the props away in order that the flaps 20 will adopt their open position during the discharge stage, at which stage the solid materials pass outwards through convergent funnels 23 into fixed receptacles (see Fig. 5).

In view of the fact that the structure 15, 16 does not rotate with the inner drum 11, the nozzles 18 do not enter the pockets 19, but simply extend closely thereto.

Due to the accumulation of pressure in the discharges 16 of the inlet conduit 15, the mixture is forced to pass at great speed through the nozzles 18 into the pockets 19. Fig. 3 illustrates the difference, or effective pressure head, between the surface of the pressure-accumulating liquid in the outlets 16 and the surface 17 of the liquid ring in the drum 11. It is due to this difference that the requisite discharge-stream speed through the nozzles 18 is obtained. The excess of liquids overflowing the annular inner edges of the halves of the drum 11 (see Fig. 4) and passing through the sieves 27 is expelled outwards by the centrifugal force through holes of the outer drum 1 into a fixed receiver surrounding the drum 1 (see Figs. 3 and 5).

Fig. 6 illustrates a suitable flow of the stream into a pocket and shows how the stream flowing in the direction of the arrows impinges against several surfaces and is thus forced to deposit its solid materials. The stream impinges almost perpendicularly on the internal periphery of the drum, but only after an initial circuitous passage during which it impinges against other faces or walls of each pocket.

The stream is again led back towards the outer peripheral surface of the pockets by deflection projections 25. Fig. 6 shows also the pivoted flap 20 and the pivotal prop 21 in the closing position.

A further deflection and deposition action is brought about by extending the exit path by means of a baffle plate 26, which is connected to and rotates with the discharges 16 and may be made as a sieve (see Figs. 4, 6 and 7). A drum-end ring 27 connected to the inwardly directed side surface of the half of the drum 11 (see Figs. 4 and 6) may also be made as a sieve, and in this event the outgoing liquid, which but for the sieving perforations would have to pass over said ring, ultimately leaves some of the entrained solid materials deposited on the ring to be forced outwards towards the outer periphery of the pockets under centrifugal force. Scrapers 28 (see Fig. 5) continuously maintain the sieve 27 cleaned in proximity to the discharge zone.

Where the centrifuge has to deal with thickly fluid mixtures, the arrangement of deflecting projections 29 (see Fig. 8) in the converged discharges 16 can be used with advantage instead of nozzles. These projections present inclined faces which propel the liquid radially outwards at increased speed.

In the modification according to Figs. 9 and 10, the constricted outlets for discharging the fluid mixture supplied to them through the inlet conduit are arranged on a separate channelled ring 29. The ring 29 is fixed to and rotates with the inner drum 11. The outlets 16 of the structure 15, 16 are wider mouthed than in the former construction and they project to a short extent into the channel of the ring 29. The liquid discharged into the ring 29 accumulates in the form of a liquid ring 31 and produces an excess pressure sufficient to produce the increased liquid-speed necessary in the small-bore discharge tubes 30 connected to the ring 29. Where as in the example the inner drum periphery is divided into deposition or separation pockets 19, there is one tube 30 for each pocket. These tubes 30 may extend as shown well into the pockets 19 seeing that the tubes and pockets rotate in unison. Thus, the discharged streams have to penetrate only a comparatively thin layer in order to reach the impingement faces, and so the disadvantage of discharging the streams into the pockets through a thick layer of liquid is obviated. Indeed, in large machines such a layer of liquid readily becomes so thick that the discharge-stream speed necessary to penetrate it would produce erosion and wear effects, with the result that enlargement of the discharges would take place and reduction of the discharge-stream speed would result. Another disadvantage obviated by the modification according to Figs. 9 and 10 is due to the feature that the discharge stream, in its initial circuitous passage in each pocket or cell preparatory to almost perpendicular impact with the internal periphery of drum 11, does not become braked or thrown back for a short time when flowing past the walls of the pocket. Such a disadvantage carries with it the danger that a proportion of the solid matter would be entrained with backwardly flowing liquid.

The excess pressure necessary for production of the increased discharge-stream speed in the tubes 30 is obtained by virtue of the difference, or effective pressure head, between the liquid surfaces 31 and 32 in the channel of ring 29 and in the liquid ring, respectively. The liquid accumulated in the channeled ring 29 tends to remain, under the action of centrifugal force, as far as possible from the axis of rotation. Thus, the ring 29 can turn in unison with the drum 11 without thereby causing the segmental form of the accumulated liquid to alter (see Fig. 9).

The fluid mixture to be separated can be supplied to the inlet conduit under pressure, especially in any case where the mixture is thickly fluid or viscous.

I claim:

1. A centrifuge comprising an annular hollow rotor defining an inwardly facing separation area having inwardly directed side surfaces, said side surfaces under rotor rotation enclosing a centrifugally produced ring of liquid, a hollow rotatable structure coaxial to said rotor and provided with a hollow radial part to supply said liquid, the end of said radial part extending into said liquid ring closely towards the inside of said separation surface, and means for rotating said rotor and structure, the radial part being provided at its end with a sudden constriction of its cross section to maintain a radially inner surface of an accumulation of a mixture of liquid and solid matters supplied by said hollow coaxial structure, said inner surface being at a lesser radius than the inner periphery of said ring of liquid, to effect separation of the solid matter from the liquid matter of said accumulated mixture by high-speed ejection thereof through said constriction and against said separation surface through said ring of liquid.

2. A centrifuge according to claim 1, wherein said hollow radial part is provided with a projection on its inner surface, the rear side of said projection being inclined with respect to the axis of rotation, whereby to give an additional drive to said mixture in said hollow radial part in the radial direction.

3. A centrifuge according to claim 1, wherein said hollow radial part is subdivided by a hollow ring provided on said rotor open on its inwardly facing circumference, a first hollow radial part leading from said hollow rotatable coaxial structure and submerging into the open circumference of said ring and a second hollow radial part leading from the outward circumference of said ring and submerging into said annular hollow rotor, the cross section of said second hollow radial part being constricted with regard to the cross section of said first hollow radial part.

HERBERT SCHULZ.

Nov. 10, 1931. H. O. LINDGREN 1,831,500

PROCESS OF SEPARATING RUBBER LATEX

Filed July 2, 1928

FIG. 1.

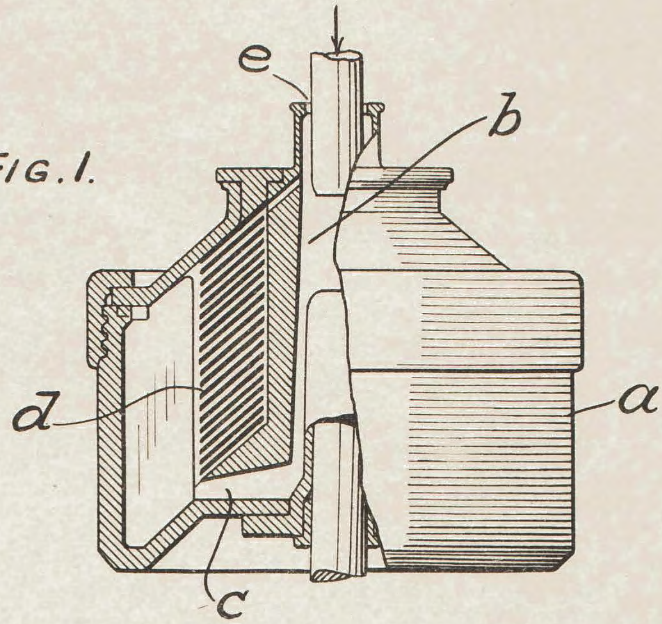
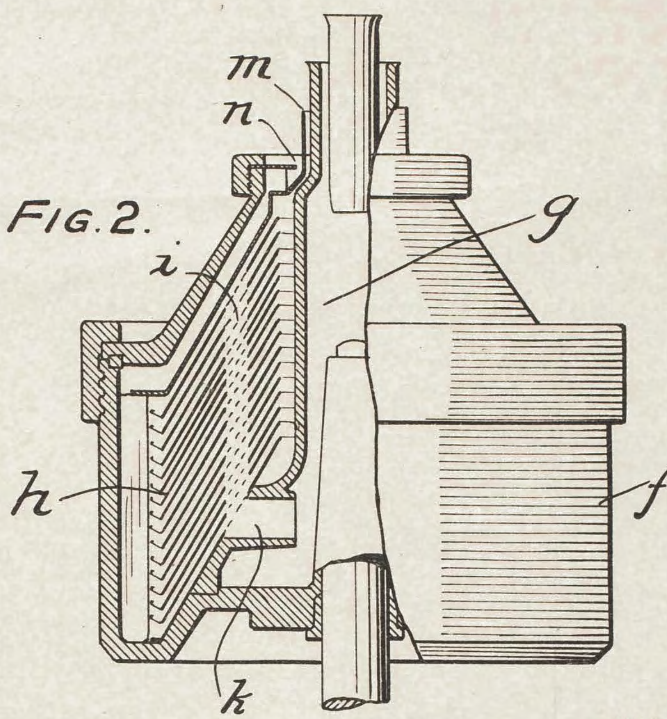


FIG. 2.



WITNESS:

Robt. R. Kitchel.

INVENTOR

Hans Olof Lindgren

BY

Busser and Harding

ATTORNEYS

Patented Nov. 10, 1931 1,831,500

UNITED STATES PATENT OFFICE

HANS OLOF LINDGREN, OF APPELVIKEN, SWEDEN, ASSIGNOR TO THE DE LAVAL SEPARATOR COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY

PROCESS OF SEPARATING RUBBER LATEX

Application filed July 2, 1928, Serial No. 289,872, and in Sweden July 12, 1927.

Rubber latex usually contains between 30 and 40 per cent. of rubber. It has been found possible, by centrifuging, to obtain, from 100 litres of rubber latex, about 50 litres of concentrate containing about 60 per cent. rubber and about 50 litres of skimmed latex containing about 10 per cent. rubber. In order to effect such separation it has been found necessary to use a separator of maximum efficiency. For this reason it is almost imperative to use separator bowls provided with conical "discs". With certain kinds of latex it has been found that the discs quickly become coated with slime, which, after a few minutes' separation, accumulates to such an extent as to substantially fill the spaces between the discs. The bowl must then be dismantled and the slime removed. It has been therefore found commercially impracticable to effect the purification of rubber latex by centrifugation.

The object of the present invention is to provide an efficient and commercially practicable centrifugal process for the purification of rubber latex that will remove the impurities and also effect the separation of the rubber latex into a concentrate of a very high degree of purity and a skimmed latex that is of a lower, but yet comparatively high, degree of purity.

The process comprises two centrifugal separating processes of different character in the first of which are removed the impurities, or the great bulk of them, including impurities that are liable to stick to the separator bowl as well as relatively non-adherent solids, and in the second of which the latex is separated into two parts one containing more, and the other containing less, rubber than in the original latex.

While the process is not dependent for its execution on the use of centrifuges of any specific construction, it is practically imperative to use centrifuges of quite different types in the two centrifugal steps of the complete process, and as illustrative of centrifuges that have been found efficient, vertical sectional views of two centrifuges are shown in the drawings: Fig. 1 being a vertical sectional view of a centrifuge in which the first step of the process may be carried out and Fig. 2 a similar view of a centrifuge in which the second step of the process may be carried out.

The centrifuge shown in Fig. 1 comprises a bowl *a*, a tubular feed shaft *b*, a passage *c* through which the latex is admitted to the separating space of the bowl, discs *d* sleeved on the tubular feed shaft, and a liquid outlet *e* from the central part of the bowl.

In this centrifuge, all the latex passes through a part of the bowl which has a strong centrifugal action and, from a purifying point or view, is extremely effective. It is not necessary that the bowl should be equipped with conical discs, but it is distinctly preferred to use such discs. It is preferred, however, that the discs should extend at a wider angle to the bowl's axis than is customary in separators of this type so as to facilitate the sliding outward along the discs of such of the solid impurities as are separated out between the discs. It is preferred that the discs shall not extend out close to the periphery of the bowl, but shall extend out only so far as to leave a surrounding chamber of substantial radial dimensions. Nor need the discs, if discs are used, be positioned as close together as in the ordinary disc separator.

In this centrifuge, the solids and slime constituents are to a substantial extent separated out in the open space surrounding the discs and accumulate on the bowl wall. That part of the latex that flows between the discs *d* has a reduced content of impurities and the remaning impurities that are removed in the constricted separating chambers between the discs slide outwardly comparatively freely along the discs and do not tend to accumulate thereon or clog the separating compartments.

The centrifuge shown in Fig. 2 comprises a bowl *f*, a tubular feed tube *g*, discs *h* extending outward from the feed tube comparatively close to the bowl wall and provided with vertically aligning holes *i*, a passage *k* through which the entering liquid is fed to the holes *i*, a light liquid outlet *m* and a heavy liquid outlet *n*.

When the purified rubber latex discharged from bowl *a* is admitted to the feed tube of the central bowl, it flows up through the disc orifices i and distributes itself through the separating spaces between the discs, where a separation occurs similar to that characterizing the separation from whole milk of skim milk and butter fat. The discs should extend at a comparatively small angle to the axis of rotation, they should be quite close together and should extend radially to near the periphery of the bowl. The separation that occurs therein is one of maximum efficiency. Any part of the solution that, reaching the separating spaces, flows directly inward and thence upward to the light liquid discharge m and that therefore escapes passing through that part of the bowl that has the maximum separating effect, cannot carry with it any substantial amount of heavy solid impurities, since these have been removed in the first separator. The result is that, of each 100 litres of rubber latex admitted to the centrifuge, there are discharged from the light liquid discharge m (say) 50 litres of a purified concentrate comprising (say) 60 per cent rubber and from the heavy liquid discharge n (say) 50 litres of a purified skimmed latex comprising (say) 10% rubber. These proportions are merely illustrative and may be controlled by regulating the comparative rate of discharge from the two outlets.

Having now fully described my invention, what I claim and desire to protect by Letters Patent is:

1. The process of purifying rubber latex and separating it into two portions each of a high degree of purity and containing, respectively, more and less rubber than in the original latex which comprises subjecting the latex to such centrifugal action as will substantially separate impurities from the latex and then subjecting the separated purified latex to such centrifugal action as will separate it into a purified latex having a relatively high rubber content and a purified latex having a relatively low rubber content.

2. The process of purifying rubber latex and separating it into two portions each of a high degree of purity containing, respectively, more and less rubber than in the original latex, which comprises feeding the latex to a relatively spacious open compartment wherein it is subjected to a relatively strong centrifugal action and then into a series of relatively constricted separating compartments, in which it is subjected to a relatively weak centrifugal action and from which the latex is delivered in a substantially purified state, and then feeding the purified latex to a number of constricted separating compartments and to loci between the zones of maximum and minimum centrifugal action and in said compartments separating purified latex having a high rubber content from purified latex having a low rubber content and continuously removing the two separated components from the loci of centrifugation.

3. The process of purifying rubber latex and separating it into two portions each of a high degree of purity and containing, respectively, more and less rubber than in the original latex which comprises subjecting the latex to such centrifugal action as will substantially separate impurities from the latex and continuously removing from the locus of separation the purified latex, and then subjecting the purified latex to such centrifugal action as will separate it into a purified latex having a relatively high rubber content and a purified latex having a relatively low rubber content.

4. The process of purifying rubber latex and separating it into two portions each of a high degree of purity containing, respectively, more and less rubber than in the original latex, which comprises subjecting the latex to such centrifugal action as will subject substantially the entire body of the latex to a relatively strong centrifugal action and remove a portion of the impurities and then to such relatively weak centrifugal action as will remove substantially the remainder of the impurities, and then subjecting the purified latex to such centrifugal action as will separate it into a purified latex having a relatively high rubber content and a purified latex having a relatively low rubber content.

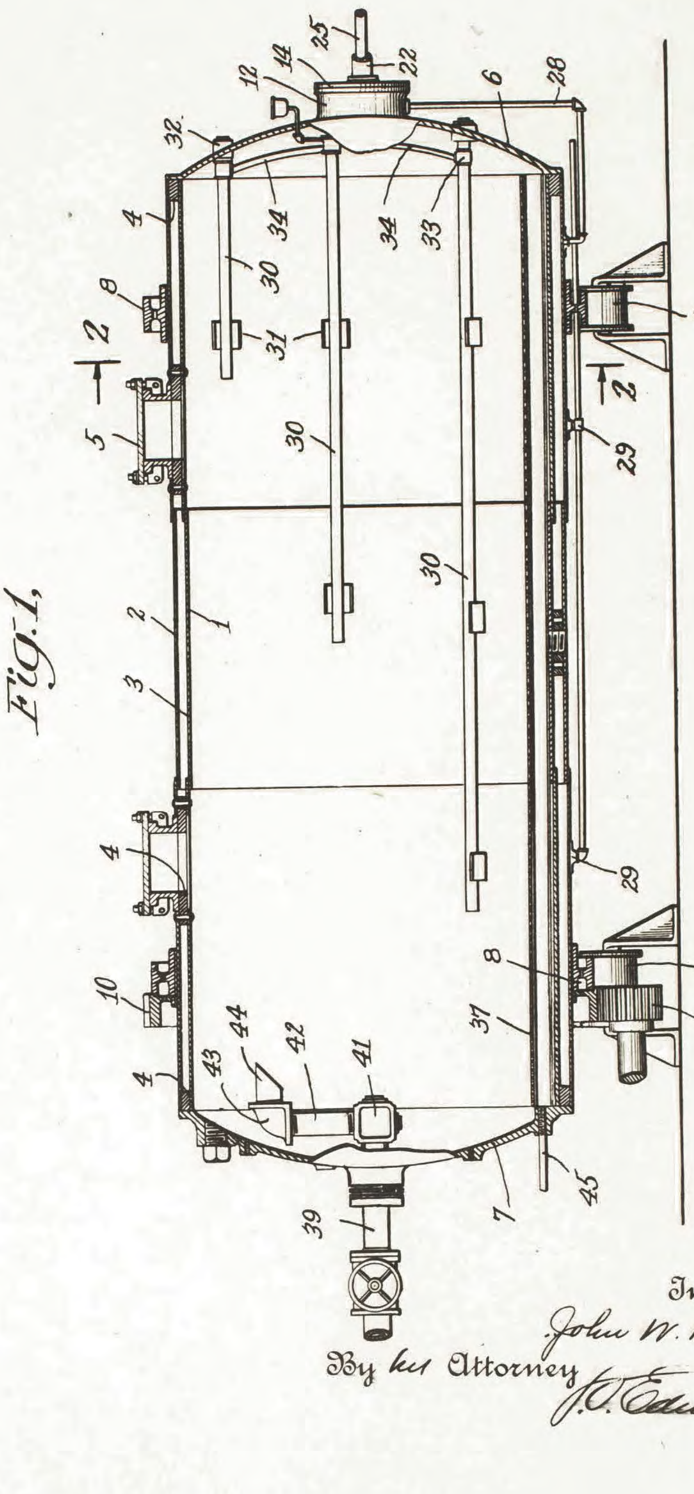
In testimony of which invention, I have hereunto set my hand at Stockholm, Sweden, on this thirteenth day of June, 1928.

HANS OLOF LINDGREN.

J. W. BODMAN.
ROTARY EXTRACTING APPARATUS.
APPLICATION FILED JAN. 13, 1921.

1,424,335. Patented Aug. 1, 1922.

2 SHEETS—SHEET 1.



Inventor
John W. Bodman
By his Attorney
[signature]

J. W. BODMAN.
ROTARY EXTRACTING APPARATUS.
APPLICATION FILED JAN. 13, 1921.

1,424,335. **Patented Aug. 1, 1922.**
2 SHEETS—SHEET 2.

Fig. 2,

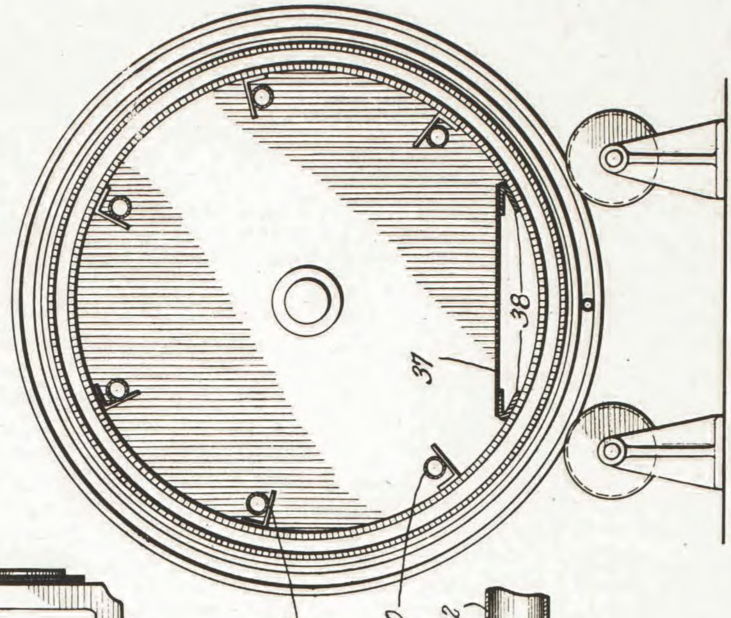


Fig. 3,

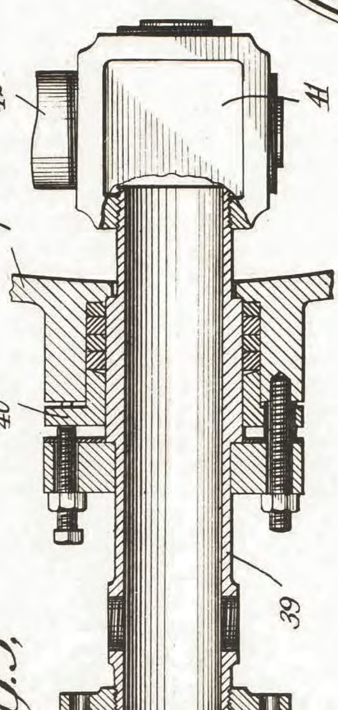
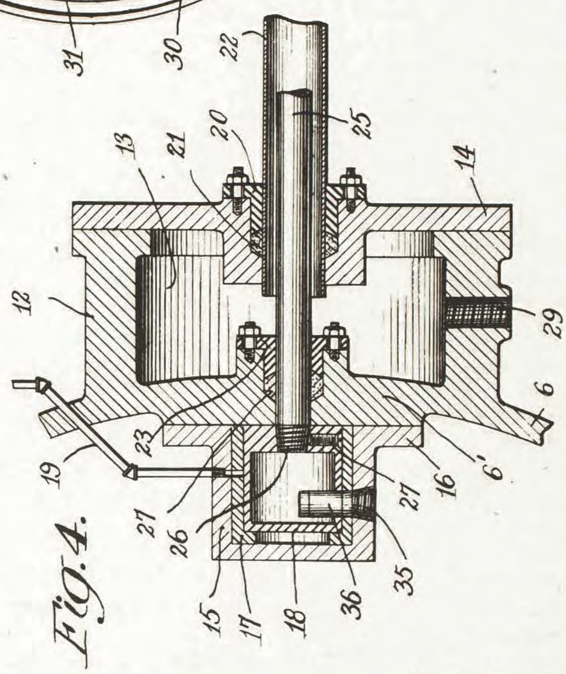


Fig. 4.



Inventor
John W. Bodman
By his Attorney
P. C. Edmonds

UNITED STATES PATENT OFFICE.

JOHN W. BODMAN, OF WESTERN SPRINGS, ILLINOIS, ASSIGNOR TO WILLIAM GARRIGUE & COMPANY, INC., OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

ROTARY EXTRACTING APPARATUS.

1,424,335. Specification of Letters Patent. Patented Aug. 1, 1922.

Application filed January 13, 1921. Serial No. 437,015.

To all whom it may concern:

Be it known that I, JOHN W. BODMAN, a citizen of the United States, residing at Western Springs, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Rotary Extracting Apparatus, of which the following is a specification.

My invention relates to apparatus for extracting soluble substances, such as grease, from various materials containing the same, by means of suitable solvents such as gasoline or naphtha, and recovering the solvent. My invention is in some respects an improvement upon the apparatus described and claimed in Patent Number 1,282,407, issued October 22, 1918, to William E. Garrigues.

In the said patent there is described a horizontal rotary drum in which the material containing the soluble substance and the solvent are agitated together and the solvent with the soluble substance drawn off as fully as possible. This may be accomplished by drawing off the solution through a filter. A certain amount of the solvent, however, remains within the mass of material. A feature of the construction disclosed in the said patent consists in means enabling the introduction of hot gas, specifically steam, during the rotation of the drum, only within that portion of the drum which is at any moment lowermost, the steam being thus used for the recovery of the solvent remaining in the mass. By thus introducing steam into the mass of material in the bottom portion of the drum, and not at all into the space within the drum above the material, the pressure within the mass will be greater than that in the space above the same. Accordingly, the hot gas or steam with the volatilized solvent and any particles of the same which may remain liquid, entrained therein, will rapidly rise from the mass and pass out through an axial outlet, to the condenser.

My construction provides various improvements on the type of apparatus referred to. In the construction of the patent referred to steam was introduced in the lower portion of the drum through perforated pipes, and the drum was heated by steam which was circulated through series of closed pipes, to prevent condensation within the drum of the steam injected into the material through the perforated pipes. The entering steam for both series of pipes and the return connection for the closed series of pipes, all passed through the valve construction at one end of the drum. I have found with this construction that wet steam, returning from the closed heating system, is likely to mingle with the entering dry steam which is to be injected within the material, which is undesirable.

With my present construction I keep the steam which is to be injected into the material separated at all times from the steam which is intended for maintaining the temperature of the drum, and so arrange the rotating and stationary parts at and adjacent to the steam passages as to prevent the mixture of wet and dry steam. I accomplish this by providing a heating jacket surrounding the drum in place of the closed pipes within the drum referred to, and providing an enclosed pocket within the head of the drum into which steam passes by an axial opening and from which it is led into the jacket. A smaller inlet pipe carries the dry steam for injection within the material in the drum through the interior of the other pipe referred to and into the interior of a suitable valve construction within the drum, both pipes passing through suitable stuffing boxes which may readily be adjusted to take up wear.

My improved construction also preferably provides improvements in regard to the means by which the dry steam is passed into the mass of material, the filtering means provided within the drum, and the manner in which the volatilized solvent and steam are led from the drum, as will more fully hereinafter appear.

In order that a clearer understanding of my invention may be had attention is hereby directed to the accompanying drawings forming part of this application and illustrating one embodiment of my invention. In the drawings Fig. 1 represents a sectional longitudinal view through a horizontal rotary extractor, embodying my invention, certain parts being shown in elevation, Fig. 2 is a cross section taken on line 2—2 of Fig. 1, Fig. 3 is an enlarged sectional detail showing the outlet of the drum, partly shown in elevation and Fig. 4 is an enlarged vertical section through the steam head and valve at the entrance end of the drum, partly shown in elevation.

Referring to the drawings the horizontal rotary drum is illustrated at 1, an outer shell 2 surrounding the same to provide a heating jacket 3, the cylindrical shells 1 and 2 being spaced apart by means of suitable rings such as those shown at 4. Suitable man holes are provided as is indicated at 5 for the introduction of the material containing the soluble substance which is to be extracted.

The drum is provided with heads 6 and 7 at the entrance and exit ends of the same. The drum may be provided with peripheral rails 8 which rest in contact with rollers 9, the extractor having a drive gear 10 which meshes with a driving pinion 11.

The head 6 of the drum is preferably divided in the form of a casting having an outwardly extending annular flange 12 enclosing a space or pocket 13. This is covered by an outer plate 14 which may be removably secured in any suitable way to the flange 12.

A suitable valve structure is provided on the inner face of head 6. This preferably comprises a rotating member 15 which takes the form of a box-like structure having a flange or flanges 16 secured to the inner face of head 6. This may have a bearing member 17 secured within the same to rotate therewith. A stationary member 18, preferably of box-like construction, is mounted within the rotating bearing member 17, this stationary member being secured in position by means presently to be described. Lubricants may be conducted by a suitable pipe 19 to the adjacent surfaces of members 17, 18 and 6 at which relative rotation occurs. Member 18 may suitably be formed of brass or other suitable bearing material.

The outer plate 14 is provided with an opening extending axially through the same in which a stuffing box is mounted comprising the gland 20 and a packing material 21. A tube 22 extends through this stuffing box into the inner pocket 13.

An axial opening extends through the inner portion 6′ of the head 6 in alignment with the opening through plate 14 and a stuffing box is mounted in this opening, comprising a gland 23 and packing material 24. A pipe 25 of smaller diameter than pipe 22 extends through the interior of pipe 22 and through the stuffing box in the portion 6′ of head 6. The inner end of pipe 25 is securely fastened to member 18 of the valve, to hold the latter stationary, pipes 22 and 25 both being fixed in position. Preferably the inner end of pipe 25 is threaded as is indicated at 26 and is screwed into a suitably threaded opening in the outer wall of member 18. If desired a set screw 27 may also be provided to extend through the wall of member 18 into binding contact with the threaded end of pipe 25, after the latter has been screwed into position.

The heating jacket 3 of the drum is connected by a suitable pipe or pipes 28 with the pocket 13 of head 6. The pipe 28 indicated connects with a tapped opening 29 which extends through flange 12 into pocket 13, pipe 28 at its other end opening in a similar manner into the jacket 3. As stated a plurality of pipes 28 may thus be provided to lead from various points on the periphery of pocket 13 to various points around the steam jacket.

Heating fluid, preferably steam, flows through the pipe 22 into pocket 13 and thence through pipe or pipes 28 into the jackt 3 so as to maintain the drum in a heated condition to prevent the condensation of steam within the drum. When steam condenses in jacket 3 to a sufficient extent, the drum may be stopped and the jacket drained through connections 29.

The pipes for injecting the heating fluid, preferably dry steam, into the mass of material in the drum, preferably takes the form of a plurality of spaced pipes 30, 30 which are secured in parallel spaced relation around the periphery of the drum, by means of the supporting angle members indicated at 31. These pipes are preferably open at their ends which are farthest removed from head 6 and are of varying length as is indicated in Fig. 1 so that the steam delivered thereby will enter the material in the drum at different points lengthwise of the latter. I consider this construction to be preferable to the perforated pipes specifically described in the Garrigues patent referred to for the reason that the latter tend to become clogged.

The various pipes 30 may be secured at their outer ends in bosses 32 provided in head 6.

Each pipe 30 is provided with a T connection 33 from which extends a pipe 34, pipes 34 extending radially inward, their inner ends extending into tapped openings in the member 15 of the rotary valve, one of such tapped openings being indicated at 35 in Fig. 4.

The stationary valve member 18 has a slot or opening 36 through its bottom surface. The tapped openings 35 through the outer member 15 are equally spaced around the periphery of the latter and correspond in number to the pipes 30, pipe connections 34 screwing into each of the same, bearing member 17 also having openings in alignment with the tapped openings 35. As the drum revolves, there will only be communication between the interior of valve member 18 and a pipe 30, when the latter is adjacent to the bottom of the drum, during rotation of the latter, so that the connection 34 of the pipe 30 referred to will be in alignment with slot

36. The latter may extend for a distance sufficient to enable one or two of the pipes 30, for example, to register therewith at a time. Dry steam continuously enters the space within the valve through pipe 25, during the rotation of the drum, and passes through the pipes 30 which are lowermost at any moment into the mass of material within the drum. The solvent which is to be used within the extractor may similarly be introduced through pipe 25.

It will be noted that with the arrangement described the steam which is used in jacket 3 is kept at all times apart from the steam which is to be injected through pipes 30 into the interior of the drum. Glands 20 and 23 may readily be tightened to take up any wear between the same and the pipes 22 and 25.

I also find it advisable to use a longitudinal screen or filter in place of the vertical filter which is illustrated as extending across the exit end of the drum in the Garrigues patent referred to. Such a vertical filter cuts off the end portion of the drum and therefore decreases the space within the drum which is effective for containing the material to be treated. Furthermore, difficulty sometimes arises because of the clogging of the vertical screen in the prior construction referred to.

Accordingly I have provided a longitudinal screen indicated at 37 as secured upon parallel longitudinal angular members 38 secured to the inner curved surface of the drum. The filter thus extends the length of the drum and across the curved surface of the drum, so as to form a chord of a small arc of the periphery of the drum.

The space between the filter and the adjacent curved surface of the drum is quite small and accordingly the greater portion of the interior of the drum is available for containing the material to be operated upon. With this construction the vapor outlet through head 7 of the drum takes the form of a stationary pipe 39 which extends through a stuffing box 40 in the head 7 of the drum. At its inner end pipe 39 is provided with a suitable connection 41 into which extends the upwardly directed pipe 42 having an elbow 43 at its upper end with an inwardly directed open end portion 44. With this construction the end 44 of the outlet is always above the upper surface of material being treated in the drum. During the solvent recovery operation, the vapor tension within the mass of material causes the steam to rise with a considerable portion of volatilized solvent and to pass out through pipes 44, 42, and 39, to a suitable condenser.

In the operation of the apparatus the extractor is partly filled with a material containing the soluble substances to be extracted, and the solvent, preferably preheated, is continuously run in through pipe 25 while the extractor is rotated. The rotation is then stopped, a pipe or tube connected to the draw off connection indicated at 45, leading to the space between filter 37 and the adjacent peripheral surface of the drum, and the solvent with dissolved soluble substance drawn off as fully as possible. Connection 45 is then closed, the pipe leading therefrom being removed, the extractor again rotated, and steam allowed to flow through pipes 22 and 25, with the recovery of solvent remaining in the mass, as above described.

What I claim is:

1. In extracting apparatus, the combination of a horizontal rotary drum having a head at one end with an enclosed pocket therein, a jacket surrounding said drum, connecting pipe means leading from said pocket to said jacket, a valve comprising a rotary and a stationary member and having an interior space, at the inner side of said head, spaced steam delivery pipes secured within said drum, connected to said valve to open into said space only when they occupy the lower portion of the drum, during the rotation thereof, an axial pipe leading through the outer portion of said head into said pocket, and a pipe of smaller diameter extending through said first pipe and into said space within said valve.

2. In extracting apparatus, the combination of a horizontal rotary drum having a head at one end with an enclosed pocket therein, a jacket surrounding said drum, connecting pipe means leading from said pocket to said jacket, a valve comprising a rotary and a stationary member and having an interior space, at the inner side of said head, spaced steam delivery pipes secured within said drum, connected to said valve to open into said space only when they occupy the lower portion of the drum, during the rotation thereof, said pipes having open ends at varying distances from said head, a pipe leading from the exterior into said pocket, and a pipe leading from the exterior into said space within said valve.

3. In extracting apparatus, the combination of a horizontal rotary drum having a head at one end with an outwardly opening pocket therein, an outer plate secured thereto to cover said pocket, a jacket surrounding said drum, connecting pipe means leading from said pocket to said jacket, axially disposed stuffing boxes mounted in openings through said plate and the inner portion of said head, a pipe extending through said plate stuffing box into said pocket and a smaller pipe extending through said first pipe and through said inner stuffing box, a valve within said drum having a member rotating with said head

and a stationary member and having an interior space into which said last named pipe extends, and spaced delivery pipes within said drum, connected to said valve to open into said space only when they occupy the lower portion of the drum during the rotation thereof.

This specification signed and witnessed this 6th day of December, 1920.

JOHN W. BODMAN.

Witnesses:

GUY S. BURTIS,

W. E. SANGER.

Dec. 19, 1933. P. L. FAUTH 1,940,585

CONTINUOUS EXTRACTION AND FILTRATION APPARATUS

Filed May 29, 1930 2 Sheets-Sheet 1

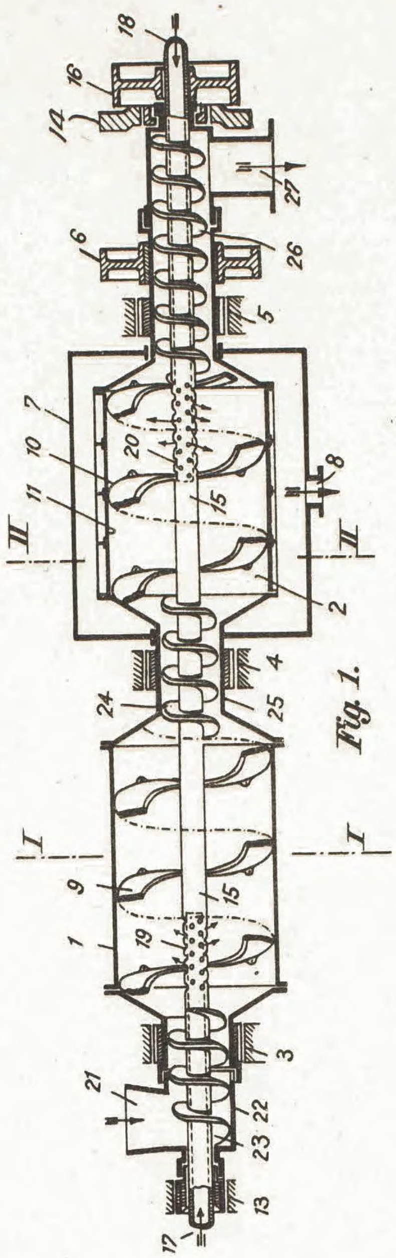


Fig. 1.

Fig. 3

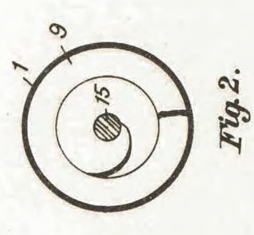


Fig. 2.

Inventor,
Philipp L. Fauth,
By [signature] Attys.

CONTINUOUS EXTRACTION AND FILTRATION APPARATUS

Filed May 29, 1930 2 Sheets-Sheet 2

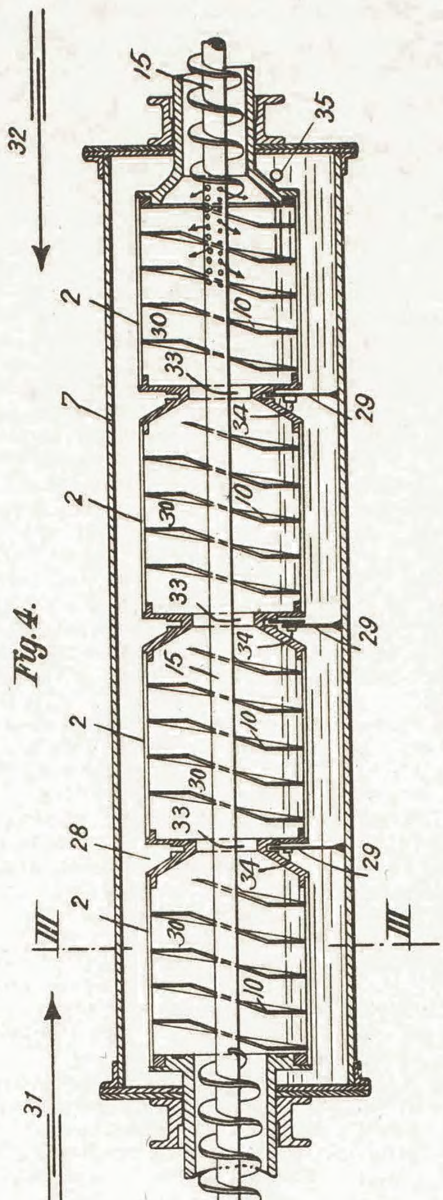


Fig. 4.

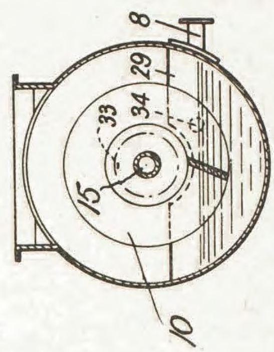


Fig. 5.

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Philipp L. Fauth,
By Henry Orth Jr.
Atty.

Patented Dec. 19, 1933 1,940,585

UNITED STATES PATENT OFFICE

1,940,585

CONTINUOUS EXTRACTION AND FILTRATION APPARATUS

Philipp Lorenz Fauth, Wiesbaden, Germany

Application May 29, 1930, Serial No. 457,224, and in Germany June 14, 1929

4 Claims. (Cl. 87—6)

Heretofore valuable extracts of oil-containing material, such as seeds or the like, and miscellaneous filtration has generally been effected in a special apparatus. In prior practice, however, there has been the defect that the extraction has taken place in a continuous manner while it has not been possible to carry out continuous filtration because the filter used always remained entirely operable only for a limited time and it was necessary to renew it from time to time. This, however, considerably lowers the practicability of the process.

Apparatus for this purpose having drum bodies which rotate in a cylinder which is partially filled with solvent have been known. Here, however, there is a washing without a continuous operation because a simultaneous removal of the extracted material does not occur.

It has already been proposed to conduct the extraction material to the solvent by means of screw conveyors. Here it has been shown that the material conveyed in a stationary spiral trough clogs the stationary filter bottom of the trough after a short period of operation.

On the other hand, filter cloths, tin sieves, porous stone, etc., heretofore used cannot be employed for continuous filtration, because, for example, cloths absorb moisture in a short time and become impenetrable, while sieves, although remaining penetrable, cannot give a clear filtrate, and rotating porous stones permit the passage only of liquids, when they are so coarsely porous that a clear filtrate cannot be obtained. If the grains, however, are so fine that a clear filtrate is possible, a rotating stone permits passage of nothing at all.

The new apparatus according to this invention, consists of a rotating drum divided into two subdivisions by means of a restriction. In the first part of the drum the material to be treated is saturated with solvent, while in the second part of the drum it is filtered and washed.

Longitudinally of the drum extends a rotary partially hollow shaft which serves as an inlet for the solvent to the interior of the drum. The shaft supports screw conveyors which move the extraction material from a stationary trough provided with an inlet hopper first to the saturating or enriching drum and then to the filtering and washing drum, from which it reaches the outlet of the apparatus.

On the inner walls of the drum body, according to the invention, spirals are mounted which intimately mix the material and move it through the drums.

The shaft and two part drum body have separate drives, the relative speeds of which can be adjusted as required. In this way regulation of the period of saturation of the extraction material with solvent, as well as of the extraction, is made possible.

Use of a saturating drum, as opposed to known feeding spirals, affords the important advantage that the extraction material comes into intimate contact with the solvent, whereby solution of the oil or fat is favored.

The restriction at the junction of the two drums results in maintaining a certain condition of solvent in the enriching drum such that a continued repeated soaking of the material with solvent occurs. This is not possible with a screw conveyor, because its helical trough must always have its outlet on the bottom.

In addition, according to the invention, the casing of the filter drum is covered with an anti-moisture impregnated silk for filtering. This filter covering absorbs no moisture whatever and therefore need not be changed, whereby an entirely continuous operation is made possible.

The filter drum is surrounded by a stationary casing which catches the filtered miscellaneous matter and conveys it through an outlet to the distilling means.

The modified form of filtering and extracting drum, as shown in Figs. 4 and 5, is subdivided into several compartments by constrictions and the insertion of partitions. The successively articulated drum compartments makes possible repeated washing of the material in the individual compartments and to appreciably raise the efficiency of the filtration. The solvent and extraction material can thus be exposed to each other in a counter current.

In this modification of the drum, the material being treated (seeds or the like) and the solvent remain in intimate contact for a considerable period, which tends to increased economy.

The invention is hereinafter described, by way of example, with reference to the accompanying diagrammatic drawings in which:—

Figure 1 is a longitudinal section illustrating one construction of apparatus according to the invention. Figures 2 and 3 are sections along the lines I—I, and II—II respectively of Figure 1.

Figure 4 is a longitudinal section illustrating a modification, and Figure 5 is a section on the line III—III of Figure 4.

In carrying the invention into effect and with reference to Figures 1 to 3 of the accompanying diagrammatic drawings, the rotating member consisting of the two drums 1 and 2 is mounted in the bearings 3, 4 and 5, and is driven by the driving pulley 6. A stationary casing 7 having a discharge pipe 8 surrounds the drum 2. Helical blades 9 and 10 are fixed to the inner walls of the drums 1 and 2. The circumference of the drum 2 is constructed in the form of a filter 11, which consists of separate frame parts, for example of four parts, 12a to 12d, as shown in section in Figure 3, covered with silk impregnated against moisture.

A partially hollow rotatable shaft 15 is disposed co-axially with the rotating members 1 and 2, and is mounted in the bearings 13 and 14, which shaft 15 is driven by the driving pulley 16. The solvent necessary for the extraction enters the hollow shaft 15 at 17 and 18, from which points it is conveyed through perforations 19 and 20 in the shaft into the interior of the drum in contact with the extraction material.

The extraction material introduced through the inlet funnel, a hopper 21 falls into the trough 22, where it is caught up by the screw conveyor on the shaft 15, and is thereby conveyed into the impregnating drum 1. The material is here continuously impregnated to the point of complete saturation with the solvent entering at 19, in such a way that the rotating drum 1 with its helical blades 9 constantly kneads the material under treatment and conveys the same to the second screw conveyor 24, situated on the shaft 15. This screw conveys the material through the constriction 25 between the drums 1 and 2 to the filtering and washing drum 2. The material is here also again worked up by the helical blades 10, and is subjected to further repeated washing by the solvent issuing from the perforations 20.

The drum wall 2 constructed in the form of a filter 11 allows the solvent saturated with oil and fat (miscella) to flow into the casing 7, from which it passes through the discharge pipe 8 to the distillation apparatus. Owing to the continuous rotation of the drum, the surface of the filter 11 as it comes to the top, is constantly freed afresh from the adhering extraction material, because the latter falls downwards owing to its own weight and the moisture contained therein is not absorbed by the impregnated silk. In this way constant and uniform permeability of the filter and a continuous operation are ensured.

The helical blades 10 pass the filter residue remaining in the drum 2 on to the screw conveyor 26 of the shaft 15, which conveys it to the discharge pipe 27. The residue leaving the apparatus at this point can, if desired, be again introduced into the extraction apparatus or to a further apparatus operating in the same manner in order to obtain as clear a filtrate as possible. Further several drums 2 may be connected one behind the other.

According to the modification illustrated in Figures 4 and 5, the drum 2 is divided into drum cells 30 by constrictions 28, into which the partitions 29 interlock. The material under treatment is introduced in the direction of flow of the arrow 31, whilst the solvent is introduced into the filter drum in the direction of the arrow 32. The apparatus therefore operates on the counter-current principle. The screw conveyor 10 of the individual cells conveys the material, in the manner hereinbefore described, from one cell to another through the constricted openings 33 between the cells. The solvent, which enters through the hollow shaft 15, fills the external drum 7 to a definite height, and flows through the overflows 34 situated in the partition walls 29 from one cell to the other, and finally passes through the discharge pipe 8 attached at 35 to the distillation plant in the form of a highly saturated filtered miscella. By means of this modification the extraction material comes into particularly intimate contact with the solvent and consequently thorough washing is effected.

In a further modification the apparatus may consist only of a filter and washing drum such as the drum 2. In this case, the material must be introduced into the drum in a state of complete saturation with the solvent. The above described filtering and washing drum is then in itself a continuous operating filter.

After the extraction has been completed the discharged material may be subjected in known manner to pressure in order to remove the greater portion of the solvent. The expulsion of the residual solvent is then effected in a continuous process by means of a suitable expelling apparatus which follows immediately on the former. If desired a pressing out process may be inserted between the individual drum systems, so that repeated pressing is effected in known manner in combination with the extraction by means of the above described drum system.

What I claim is:—

1. Apparatus for continuously extracting and filtering material containing a soluble substance by means of a solvent, comprising a rotatable impregnating drum wherein the material to be treated is impregnated with solvent and a rotatable washing and filtering drum rigidly connected in axial alignment with the impregnating drum, separate means for passing the raw material and solvent into said drums, and separate means for removing the resulting filtrate and residue from said drums, said filtering drum having a covering formed of impregnated moisture-proof silk.

2. Apparatus for continuous extraction and filtration of material containing a soluble substance comprising a rotatable drum provided with transverse constrictions forming compartments in series, at least one of said compartments being perforated, an independently rotatable conveyor means within said drum, means for producing a continuous flow of material under treatment through said compartments, means for continuously removing said material from the drum, and means for continuously directing solvent through said material in the opposite direction to its flow.

3. Apparatus for continuously extracting and filtering material containing a soluble substance by means of a solvent, comprising an impregnating drum wherein the material to be treated is impregnated with a solvent and a rotatable washing and filtering drum rigidly connected with the impregnating drum, spiral conveyors fixed to the inner walls of said drums, said filtering drum having a wall pervious to the solvent and extract and a rotatable shaft extending through the drums, conveyor means on said shaft, means to rotate said shaft, separate means to rotate said drums, and means to regulate the speed of rotation of said shaft and drums.

4. An extracting and filtering apparatus comprising a rotatable impregnating drum for impregnating a material with a solvent, a rotatable washing and filtering drum rigidly connected in axial alignment with said impregnating drum, a constriction in said rigid connection, separate means for feeding the raw material and the solvent into said drums, and separate means for withdrawing the resulting filtrate and residue from said drums, said filtering drum having a wall pervious to the solvent and extract.

PHILIPP LORENZ FAUTH.

March 14, 1939. A. OLIER 2,150,608

EXTRACTION COLUMN

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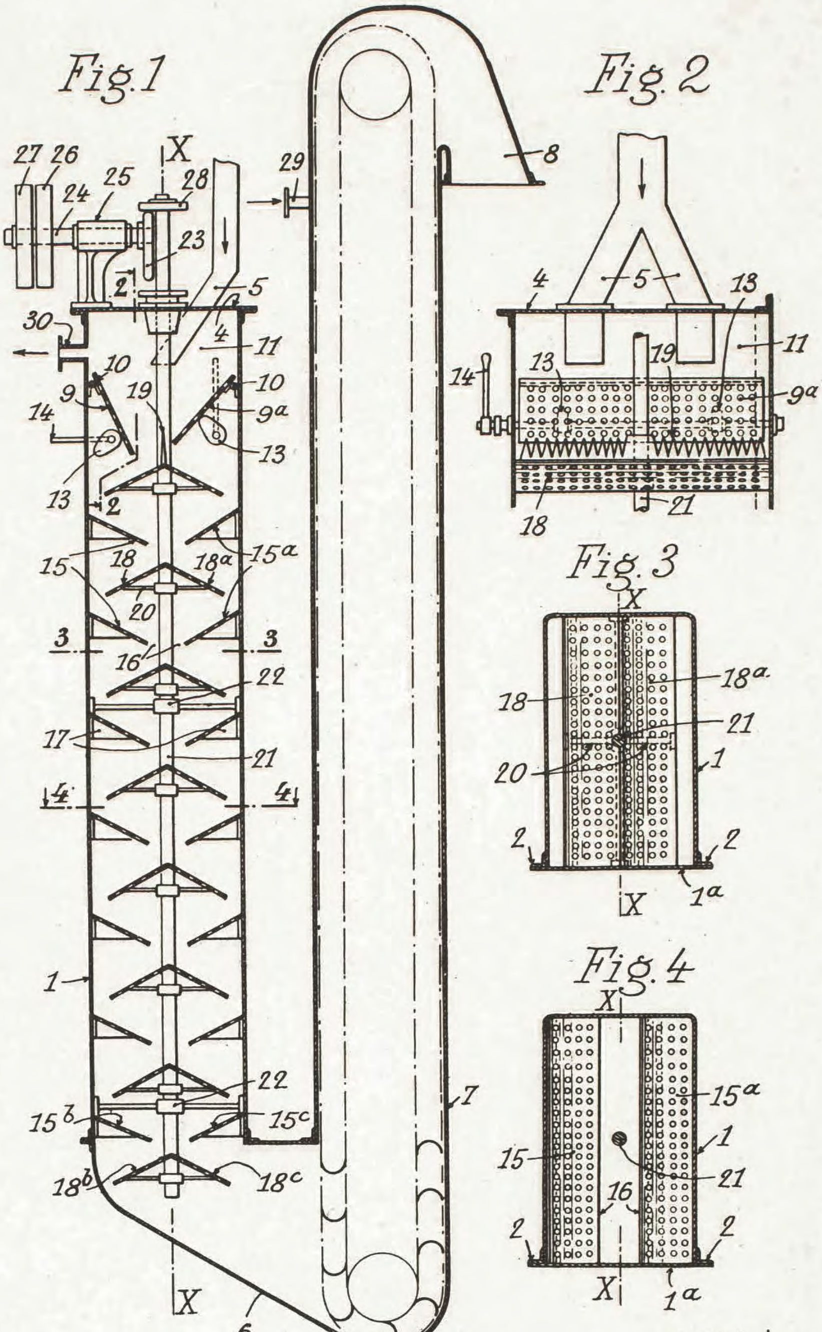

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EXTRACTION COLUMN

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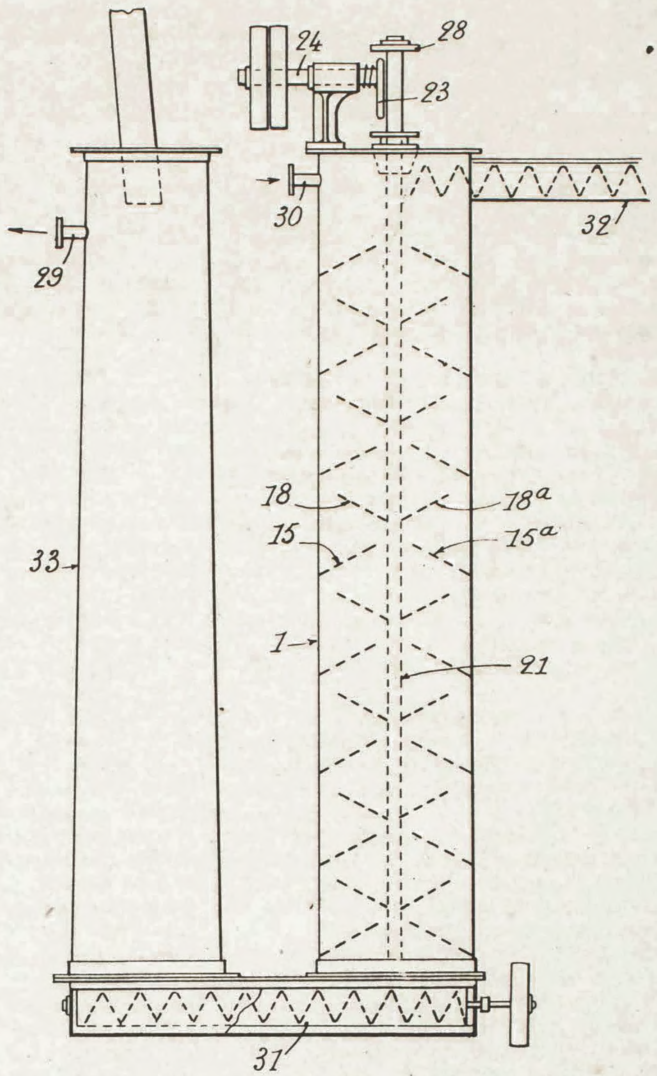
Fig. 5



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Patented Mar. 14, 1939 2,150,608

UNITED STATES PATENT OFFICE

2,150,608

EXTRACTION COLUMN

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Application November 12, 1937, Serial No. 174,260
In France November 18, 1936

6 Claims. (Cl. 87—6)

The present invention has for its object a reaction column, which also provides, in particular, for the continuous extraction by one or more solvents or reagents, of one or more substances which are contained in solution or combination in solid bodies or material, such as oleaginous material (ground seeds and oil-cake) in the case of the oil industry.

The said column is chiefly characterized by the fact it comprises, disposed one below the other and separated by a suitable space, planes or surfaces which are perforated and have the inclined position, and whose lines of greatest slope are all situated in the same plane and are arranged in zigzag, so that the material under treatment will move on a zigzag path and in thin sheets along the said planes or surfaces, whilst the solvent or solvents, or other liquid or gaseous fluids used for the treatment will traverse the said planes or surfaces in the contrary direction to that of the material, and pass through their perforations.

According to the density of the material to be exhausted, the direction of such material may be either upward or downward, while the solvent or solvents will always move in a contrary direction to the material.

In a preferred embodiment, there are employed, side by side, two sets or perforated surfaces which are mounted in zigzag in each set, the adjacent surfaces of the two sets being preferably inclined in contrary directions.

According to another characteristic, in the single set or in each set of perforated surfaces mounted in zigzag, the surfaces inclined in contrary directions have a relative alternate movement of translation, parallel with the axis of the column, the surfaces inclined in one direction being for example stationary, while the surfaces inclined in the other direction are vertically movable.

Thus in the above-mentioned embodiment comprising two sets of perforated surfaces, the adjacent surfaces of the two sets may be vertically movable and may be mounted, for instance, upon a shaft which is given an alternate vertical movement, whilst the other surfaces are fixed and are mounted on the walls of the column.

Further characteristics will be set forth in the following description.

In the accompanying drawings, which are given solely by way of example:

Fig. 1 is a vertical lengthwise section of an extraction column which is improved according to the invention and provides for the downward circulation of the material to be exhausted, which has a greater density than the solvent or solvents. The said figure also shows an elevator arranged at the outlet of the column for the purpose of taking up the exhausted material.

Fig. 2 is a partial vertical section on the line 2—2 of Fig. 1.

Figs. 3 and 4 are horizontal sections on the lines 3—3 and 4—4 of Fig. 1.

Fig. 5 is diagrammatic view of a column adapted for material which is lighter than the solvent or solvents, this material circulating in the column in the upward direction.

In the embodiment represented in Figs. 1 to 4, the extraction column comprises a vertical receptacle 1 consisting of metal or other material. The said receptacle, which is represented as having a single wall, may obviously have a double wall. The cross-section of the said receptacle may be as desired, but it is preferably of a square or rectangular form as shown (Figs. 3 and 4). The receptacle may be formed, for instance, by the longitudinal bending, in U-shape, of a sheet-metal piece (or a double wall) which thus forms three sides, the fourth side 1ª (Figs. 3 and 4) being removable and secured for instance to angle-iron members 2 mounted on the edges of the two adjacent faces.

The said receptacle 1 is closed at the top by a cover 4 (Figs. 1 and 2), traversed by one or more conduits 5 which are connected with a feeding chute, not shown, and serve for the supply of the material under treatment to the upper part of said receptacle 1 and practically in its vertical longitudinal plane of symmetry X—X.

The lower part of the receptacle 1 is joined by a connecting part 6 to a bucket elevator 7 at whose upper end is a discharge conduit 8 which opens downwardly.

On the inner faces of the receptacle 1, and parallel with the plane X—X, are located at a certain distance from the cover 4, two perforated plates 9 and 9ª which are pivotally mounted on the said faces by means of hinges 10. The plates 9, 9ª, which form above them a chamber 11 termed "maceration chamber", may be more or less inclined by any suitable means, for instance by means of oscillating cams 13 rotated by levers 14 arranged outside of the receptacle 1.

Below the said pivoted plates 9, 9ª, the same faces of the receptacle 1 are provided, at stated distances, with perforated plates 15, 15ª (Figs. 1 and 4), which are downwardly inclined from the wall of the receptacle 1 towards the middle plane X—X, but without reaching this plane, thus providing, for each pair, between their adjacent central edges, a middle opening 16 (Figs. 1 and 4).

The said plates 15, 15ª, which are removable or not, are mounted on the walls of the said receptacle, by any suitable means, in a fixed inclined position, for instance by the use of angle-irons 17 or like members.

Between the stationary plates 15, 15ª are respectively mounted additional perforated plates 18, 18ª (Figs. 1, 2, 3) which are inclined in the contrary direction to the corresponding plates 15, 15ª, the lines of greatest slope of all such plates being situated in a vertical plane which is perpendicular to the plane X—X. The plates 18 and 18ª form by pairs roof-shaped devices, whose upper ridges are situated in the plane X—X. The ridge of the first roof section located at the top, carries a comb 19 with vertical teeth.

All of the plates 18, 18ª which stop at a certain distance from the inner faces of the receptacle 1 are secured by brackets 20 to a vertical shaft 21 of circular, square or any polygonal section. The said shaft 21 is mounted in bearings 22 (Fig. 1) which are secured, at stated distances apart, to the walls of the receptacle 1, and is vertically slidable along its longitudinal axis, in the said bearings. The said shaft is given a vertical reciprocating movement whose amplitude is such that the plates 18, 18ª which move with the same, will not make contact with the plates 15, 15ª between which they are located. The reciprocating motion of the shaft 21 may be obtained by any suitable means, and for instance, as shown in Fig. 1 by the use of an eccentric cam 23, which is keyed to a horizontal shaft 24 which rotates in a bearing 25 mounted on the cover 4, and carries a loose pulley 26 and a driving pulley 27. The cam 23 acts upon the lower face of a disc 28 which is mounted on the upper end of the shaft 21. The said cam has such outline and angular setting that it will rapidly lift the shaft 21, but will only allow it to descend very slowly by gravity.

The elevator 7 is provided at the upper part with an inlet pipe 29 for the supply of the solvent or solvents, and the receptacle 1 is provided, below the cover 4, in the maceration chamber 11, with a neck 30 for the discharge of the solvent or solvents loaded with the substance or substances to be extracted.

The material to be treated is delivered by the conduit or conduits 5 to the upper part of the receptacle 1, i. e. into the maceration chamber 11.

It is discharged by gravity through the central adjustable opening formed between the lower edges of the two plates 9, 9ª. In this opening, it is divided into two parts by the vertical comb 19. One of these parts slides down by gravity on a zigzag path, successively upon the set of plates 15—18 which are alternately inclined in contrary directions; the other part descends in a similar manner upon the second set of plates 15ª—18ª which are also alternately inclined in contrary directions. The descent of the material is facilitated by the reciprocating vertical movements imparted to the plates 18—18ª carried by the shaft 21, by the action of the rotating cam 23, the upward movements being very rapid and the downward movements very slow.

The exhausted material is directed by the inclined conduit 6 into the bottom of the elevator 7 which discharges it through the upper opening 8, from which it is brought, for instance, to a drying device, not shown, in order to remove the solvent or solvents with which it is saturated.

As concerns the said solvent or solvents, these are supplied to the apparatus through the neck 29 of the elevator 7, and are discharged through the maceration chamber 11 and the neck 30 after circulating in the upward direction in the whole of the receptacle 1, thus passing through the various perforated plates 15—15ª and 18—18ª. Said solvent or solvents will thus circulate in counter-current with reference to the material, and they traverse the thin sheets of moving material. As concerns these sheets, a certain number are spread upon the various perforated plates 15, 15ª and 18, 18ª; the others have the vertical position, and form, as it were, curtains of material which drop respectively from the lower edges of the plates 15, 15ª and 18, 18ª upon the upper parts of the plates 18, 18ª and 15, 15ª.

It should be noted that the last two perforated plates 18ᵇ, 18ᶜ which are mounted on the lower end of the shaft 21 may be located at a distance from the lower edges of the last two stationary perforated plates 15ᵇ, 15ᶜ, which is less than the distance between the other sets of fixed and movable plates. In consequence, a given upward movement of the shaft 21 which exceeds the normal movement but will not allow the contact between all of the other sets of plates, will provide for the closing of the space between the two fixed plates 15ᵇ, 15ᶜ by means of the two lower movable plates 18ᵇ, 18ᶜ which now serve as a check-valve, thus cutting off the material in case the elevator 7 should stop its action.

A like result may be obtained by pivotally mounting the two lower panels 15ᵇ and 15ᶜ so that their lower central edges may be brought in contact.

In the embodiment above described, it is supposed that the material under treatment has an absolute density which exceeds the density of the solvent or solvents.

In the contrary case, the operation will be modified, as well as the extracting apparatus, as shown in Fig. 5, and herein the fixed plates 15, 15ª and the movable plates 18, 18ª which are mounted on the shaft 21, are inclined in contrary directions to the corresponding plates shown in the preceding embodiment. The solvent is supplied through the neck 30, which served as the exit of the mixture in the preceding case, and the material is delivered by pressure to the lower part of the column by a screw conveyor 31, or the like, which receives the material from a column 33 which now serves as the maceration column. The discharge of the solvent mixture and of the extracted product or products will take place through the neck 29. The exhausted material is removed for instance by a screw conveyor 32, and may be brought to a drying apparatus, as in the preceding case.

Obviously, the said invention is not limited to the embodiments herein described and represented, which are given solely by way of example.

Thus the movable plates 18, 18ª may, if necessary, be mounted upon several vertical shafts 21 whose axes would be situated in the plane X—X, and all of these shafts would be vertically movable in synchronism, for instance by cams similar to each other and having the same angular position, or by a rigid connection between the said shafts.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:

1. An extraction column comprising a casing, two sets of inclined, perforated surfaces arranged in zigzag above each other at a suitable distance from each other, means for delivering at one end of the casing the material to be treated, means for delivering the extracting medium at the opposite end of the casing and means for imparting an axial reciprocating motion to one set of perforated surfaces.

2. An extraction column comprising a casing, two sets of inclined, perforated surfaces arranged in zigzag above each other at a suitable distance from each other, means for delivering at one end of the casing the material to be treated, means for delivering the extracting medium at the opposite end of the casing and means for imparting rapid motion to one set of perforated surfaces in one direction and a slower motion to the same in the reverse direction.

3. An extraction column comprising a vertical casing, means for delivering at one end of the casing the material to be treated, means for delivering the extracting medium at the opposite end of the casing, inclined, perforated surfaces fixed in the casing at a suitable distance above each other, a shaft extending axially in the casing, roof shaped perforated surfaces mounted on said shaft in the spaces between the surfaces carried by the casing and inclined in the contrary direction to said surfaces and a rotating cam adapted to impart an axial reciprocating motion to said shaft.

4. An extraction column comprising a vertical casing, means for delivering, at the top of the casing, the material to be treated and means for delivering the extracting medium at the bottom of the casing, a discharge outlet at the upper part of the casing, inclined perforated surfaces mounted in an angularly adjustable position in the casing substantially below the said discharge outlet, and converging towards the axis of the casing, inclined, perforated surfaces fixed in the casing at suitable distance above each other, a shaft extending axially in the casing, roof shaped perforated surfaces mounted on said shaft in the spaces between the surfaces carried by the casing and inclined in the contrary direction to said surfaces, and means for imparting an axial reciprocating motion to the shaft.

5. An extraction column according to claim 4 and further comprising a vertical comb provided on the ridge of the upper most inclined roof shaped surfaces carried by the shaft.

6. An extraction column according to claim 4 in which the lowest roof shaped device and the lowest inclined surfaces carried by the casing are so arranged that the distance between them is smaller than the distance between anyone of the surfaces carried by the shaft and the surfaces carried by the casing immediately above the latter.

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Oct. 24, 1939. G. THAYER 2,176,982

CENTRIFUGAL COUNTERCURRENT CONTACTING MACHINE

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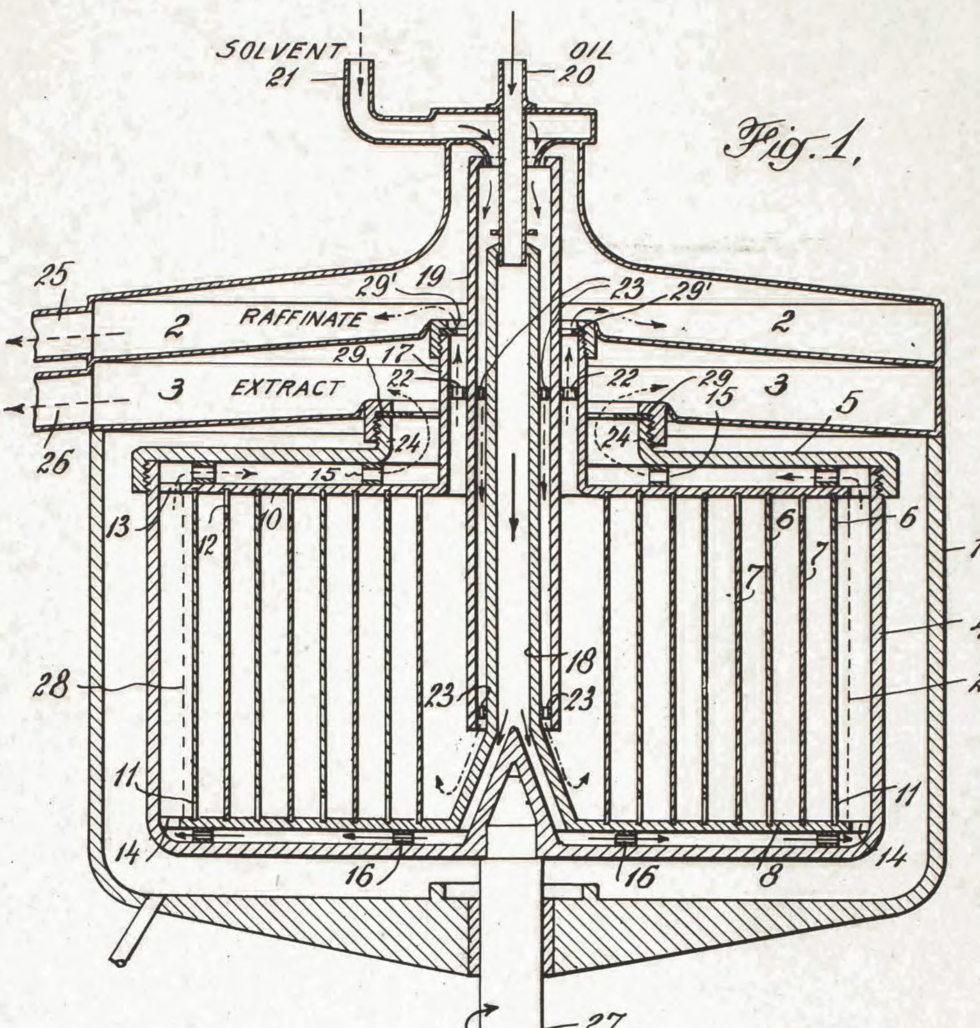

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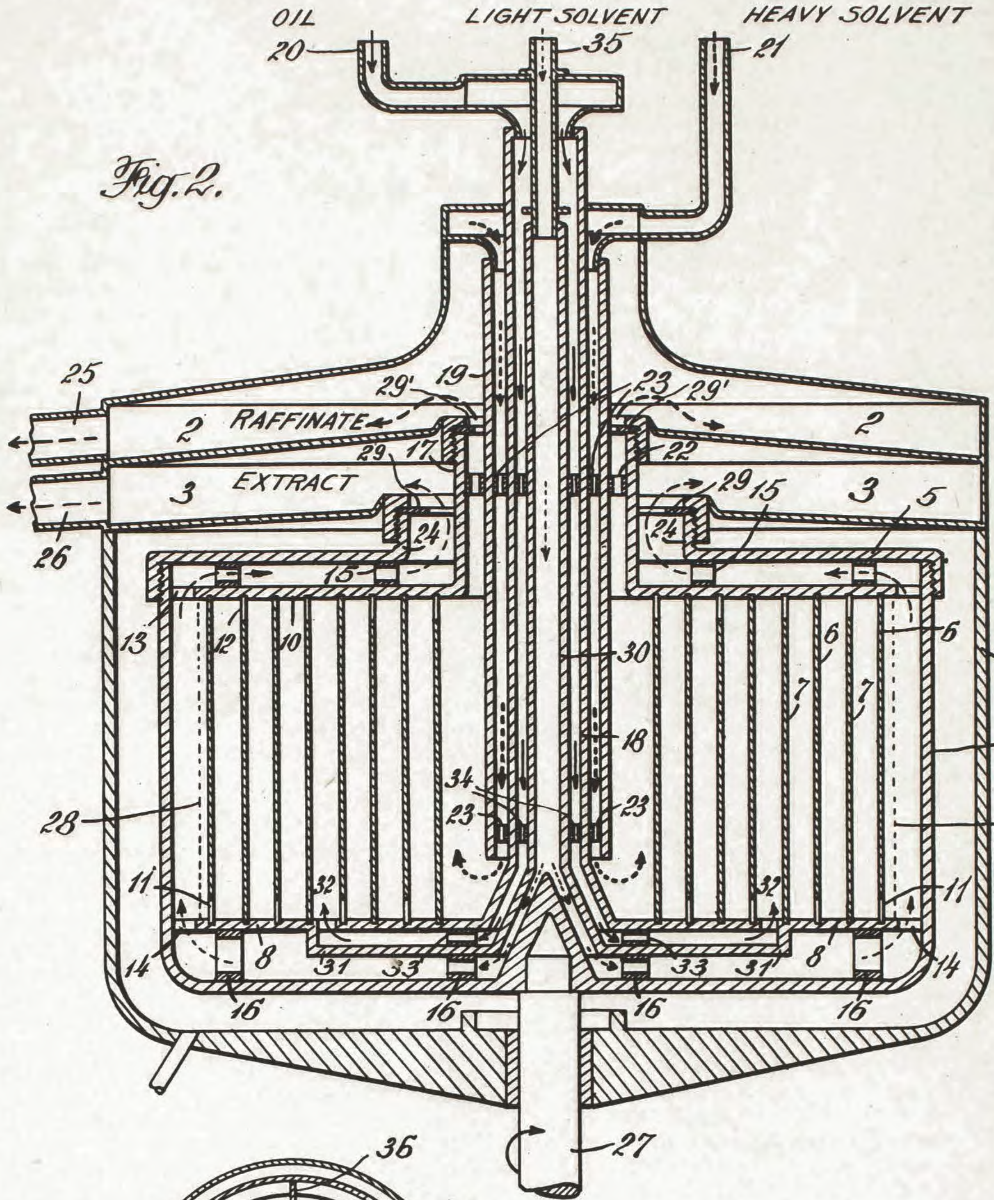
CENTRIFUGAL COUNTERCURRENT CONTACTING MACHINE

Filed Aug. 6, 1937 2 Sheets-Sheet 2

Fig. 2.



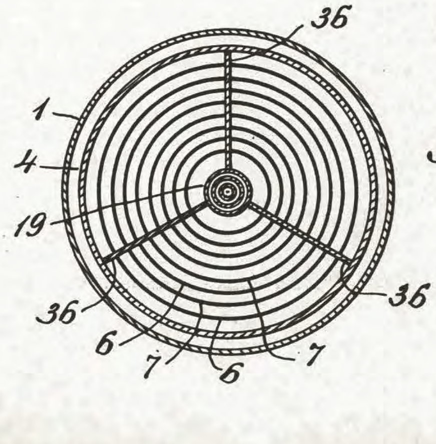


Fig. 3,

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2,176,982

CENTRIFUGAL COUNTERCURRENT CONTACTING MACHINE

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Application August 6, 1937, Serial No. 157,747

5 Claims. (Cl. 261—83)

This invention relates to apparatus for contacting partially immiscible fluids of substantially different densities and more particularly to apparatus for use in the solvent extraction of lubricating oils. The apparatus of this invention provides improved and efficient means for countercurrently contacting partially immiscible fluids and more particularly for contacting hydrocarbon lubricating oils with selective solvents.

In the solvent extraction of hydrocarbon lubricating oils, for example, extraction has been effected by thoroughly agitating the oil and solvent under suitable conditions of temperature and pressure in a mixing chamber and subsequently separating the extract and raffinate phases in a separate operation. Such a process as this has necessitated a large amount of apparatus for mixing the oil and solvent and for separating the extract and raffinate phases.

It has also been proposed to effect solvent extraction of lubricating oils by introducing the solvent and untreated oil into the top and bottom, respectively, of a baffled tower. As a further modification, solvent extraction of the oil has been effected by introducing the oil into the central portion of a vertical tower and introducing a heavy solvent into the top and a light solvent into the bottom of the tower. In such operations the mixture of oil and solvent or solvents completely fills the entire space within the tower, and contact between oil and solvent is effected by countercurrent flow of the oil and solvent or solvents due to their relative difference in gravity. Where gravity towers such as these have been used it has usually been necessary for satisfactory results that a plurality of towers be arranged in series in order that the final raffinate be sufficiently refined. Whenever it has been necessary to repair or to clean any one of the gravity towers the operation of the entire series has been discontinued, thus resulting in an obviously uneconomical use of a large amount of equipment.

The apparatus of my invention provides simple and extremely compact apparatus whereby satisfactory separation may be effected in a single stage of operation. By the use of the apparatus of my invention, a solvent extraction plant constructed with a number of these compact machines operating in parallel would not have its capacity seriously handicapped if one or even more of the machines were shut down for cleaning.

This apparatus which is adapted for contacting partially immiscible fluids of different densities comprises a rotatable bowl, means for introducing a relatively heavy fluid into the central portion of the bowl, means for introducing a relatively light fluid into the outer portion of the bowl, means for withdrawing the heavy fluid from the outer portion of the bowl, and means for withdrawing the lighter fluid from the central portion of the bowl. The rotatable bowl is provided with a plurality of cylinders substantially coaxially aligned within the bowl, the alternate cylinders being provided with openings disposed adjacent the upper portions thereof, and the intervening cylinders being provided with openings disposed adjacent the lower portions thereof.

More particularly, the apparatus of my invention comprises a centrifugal machine which may be used with advantage for subjecting a hydrocarbon oil and a suitable solvent or solvents to the action of centrifugal force to produce an extract and a raffinate phase, and for withdrawing the extract and raffinate phases. The oil and the solvent or solvents may be separately introduced into the apparatus. The extract and raffinate phases produced within the apparatus by the contact between the oil and solvent upon subjection to centrifugal force may be separately withdrawn from the apparatus.

The details of the apparatus of my invention will be clearly understood by consideration of the apparatus shown in the accompanying drawings.

Figure 1 comprises a sectional view of a centrifuge in which an unrefined oil may be subjected to selective extraction;

Figure 2 comprises a sectional view of a modified form of centrifuge; and

Figure 3 comprises a horizontal sectional view of the stationary and revolving bowls of the centrifuges.

The centrifuge shown in Figure 1 comprises a stationary bowl 1 provided with a cover divided radially into two non-communicating chambers 2 and 3. A rotatable or revolving bowl 4 provided with a cover member 5 is positioned coaxially within the stationary bowl and is rotatably mounted therein. Two sets of concentric cylinders 6 and 7 are placed within the revolving bowl 4 and substantially coaxially aligned therewith. These sets of concentric cylinders are positioned so as to alternately overlap each other, thus forming a series of annuluses. One end of one set of cylinders is rigidly mounted in the false bottom 8 of the revolving bowl and one end of the other set of cylinders is rigidly mounted in the false cover 10 of cover member 5. Suitable means may be provided on the inner surface of false cover 10 and false bottom 8 of the revolving bowl for removably holding the unmounted ends of each set of concentric cylinders securely in position. The unmounted ends of the cylinders are provided with suitable perforations 11 and 12 to allow passage of a fluid therethrough. Perforations 13 and 14 are provided in the false cover and false bottom, respectively, of the revolving bowl to permit passage of a fluid from the interior of the revolving bowl into the space between the false cover and false bottom, respectively, and the outer shell of the revolving bowl, which space is maintained by perforated spacer rings 15 and 16, respectively. The centers of the false cover and false bottom terminate in concentric cylinders 17 and 18, respectively, which extend into the cover portion of the stationary bowl. An additional cylinder 19 extends coaxially from within the cover portion of the stationary bowl between cylinders 17 and 18 to a position well within the interior of the revolving bowl. Cylinder 17 communicates with the upper section 2 of the cover portion of the stationary bowl while cylinders 18 and 19, respectively, communicate with suitable supply pipes 20 and 21. The desired space between concentric cylinders 17 and 19 and between concentric cylinders 18 and 19 is provided by perforated spacer rings 22 and 23, respectively. The collar 24 of cover member 5 extends within section 3 of the stationary bowl cover portion and provides a communicating space, together with cylinder 17, for fluid to pass from the space maintained by spacer rings 15 into section 3. Discharge spouts 25 and 26 are provided for the removal of fluid from each of sections 2 and 3 of the cover portion of the stationary bowl. Supply pipes 20 and 21 may be provided with valves (not shown) for controlling the rate of flow of fluid through these pipes. Suitable means may be provided with advantage for draining from the space between stationary bowl 1 and rotatable bowl 4 any fluid which may have leaked thereinto.

In using the apparatus of my invention shown in Figure 1 for the selective extraction of hydrocarbon lubricating oil, the oil to be treated is introduced into the centrifuge through supply pipe 20 into cylinder 18, thence through spacer rings 16 and perforations 14 into the outer portion of the interior of the revolving bowl. The solvent or suitable solvent mixture with which the oil is to be treated, and usually heavier than the oil, is introduced into the centrifuge through supply pipe 21, thence into the space between cylinders 18 and 19 through spacer rings 23 and into the central portion of the interior of the revolving bowl. The revolving bowl is rotated by means of shaft 27 thus exerting centrifugal force on the oil and solvent. The solvent, being heavier than the oil, displaces the oil at the outer portion of the revolving bowl and forces the oil toward the center of the bowl. As the oil is forced toward the center of the bowl, it passes through a tortuous path as it flows through the annuluses and perforations 11 and 12 alternately positioned at the top and bottom, respectively, of adjacent concentric cylinders 6 and 7. Thus, the oil being forced toward the center of the bowl and the solvent being forced toward the outer edge of the bowl come into contact as they pass through the annuluses. The solvent, as it approaches the outer edge of the revolving bowl, comprises a solution of the extract in the solvent (extract phase), while the oil forced toward the center of the bowl comprises the refined oil (raffinate phase). The position of the interface, which is indicated by the dotted line 28, between the oil and the extract phase in the outer portion of the revolving bowl is controlled with advantage by the internal diameter of replaceable ring dams 29 and 29'. The position of the interface is moved toward the center of the bowl by decreasing the internal diameter of ring dam 29, or, conversely, is moved toward the outer portion of the bowl by increasing the internal diameter of ring dam 29. Variation in the internal diameter of ring dam 29' has a diametrically opposite effect upon the position of the interface to that of ring dam 29. The position of the interface may, therefore, be controlled by changing the internal diameter of ring dam 29 or 29', or by the combined effect of both. The oil being forced toward the center by the extract phase tends to fill the greater portion of the bowl. The heavier solvent, or extract phase as it soon becomes, flowing counter-currently outward with respect to the oil flows upward or downward, as the case may be, on the outer edge of each annular space seeking its way to the outer portion of the bowl. At the lip of each cylinder, formed by the perforations 11 and 12, the outflowing solvent (or extract) phase and the in-flowing oil (or raffinate) phase undergo instantaneous mixing and are separated again by centrifugal force in the next succeeding annular space. As a result of this countercurrent flow and instantaneous mixing, each annular space together with the lip of the cylinders within the revolving bowl comprises a stage in a countercurrent contacting system. The extract phase collected at the outer portion of the revolving bowl passes through perforations 13 through spacer rings 15 into section 3 of the cover portion of the stationary bowl. The raffinate phase forced toward the center of the bowl flows upwardly through spacer rings 22 into section 2 of the cover portion of the stationary bowl. Thus, the operation of the apparatus comprises separately introducing the oil and solvent into the apparatus and separately discharging the extract and raffinate phases from the apparatus.

The modified form of apparatus shown in Figure 2 is adapted for use where it is desired that the oil to be treated is subjected to the action of two individual selective solvents or solvent mixtures. The apparatus itself is substantially the same as that shown in Figure 1. The modified apparatus, however, is provided with an additional cylinder 30 extending coaxially within cylinder 18 and conforming generally to the shape of cylinder 18 and false bottom 8 of the revolving bowl. The lower extension 31 of the cylinder 30 engages at its outermost end the false bottom 8 at a point substantially half way between the center and outer portion of the revolving bowl. The false bottom is further provided with perforations 32 to permit the passage of a fluid into the interior of the revolving bowl from the space between the lower extension 31 and false bottom 8. This space between lower extension 31 and false bottom 8 is maintained by perforated spacer rings 33, while the space between concentric cylinders 18 and 30 is maintained by suitable spacer rings 34. The upper portion of cylinder 30 communicates with a suitable supply pipe 35 which may be provided with a suitable valve (not shown).

In using the modified form of apparatus shown in Figure 2, the oil to be treated is introduced into the centrifuge through supply pipe 20 into the space between cylinders 18 and 30, thence through spacer rings 34 and 33 and perforations 32 into the bowl substantially half way between the center and outer portion thereof. A heavy solvent such, for example, as phenol may be introduced through supply pipe 21 and spacer rings 23 into the central portion of the revolving bowl. A suitable light solvent such, for example, as a light naphtha is introduced through supply pipe 35 into cylinder 30, thence through spacer rings 16 and perforations 14 into the outermost portion of the revolving bowl. Upon rotation of the revolving bowl by means of shaft 27, a centrifugal force of considerable magnitude may be exerted upon the oil and solvents within the bowl. The heavy solvent is forced toward the outer portion of the revolving bowl together with the heavy extract obtained from the oil by contact between the oil and the solvents. The lighter solvent is displaced from the outer portion of the revolving bowl and is forced toward the center of the bowl together with the refined oil as a raffinate produced by contact of the oil and solvents. The extract flows through perforations 13 and spacer rings 15 into section 3 of the cover portion of the stationary bowl, while the raffinate is forced upwardly through spacer rings 22 into section 2 of the cover portion. If desired, the entire apparatus may be maintained under a superatmospheric pressure by enclosing the apparatus in a suitable pressure chamber. Thus, the modified operation carried out in the apparatus shown in Figure 2 comprises a process in which the oil to be treated and two individual solvents are introduced separately into a centrifuge and separate extract and raffinate phases are discharged from the apparatus.

If it is found desirable to maintain a substantially uniform rotational speed of fluid within the apparatus shown in Figures 1 and 2, the rotatable bowl may be provided with a plurality of vertical radial partitions 36 as shown in Figure 3. These vertical radial partitions may extend substantially the entire distance between false bottom 8 and false cover 10 of the revolving bowl and also extend substantially the entire distance between cylinder 19 and the outer shell 4 of the revolving bowl.

Many advantages are realized from the use of the apparatus of my invention. An efficient and complete separation of the extract and raffinate phases is produced by the centrifugal force set up within the centrifuge. Inasmuch as the greater bulk of the fluid substantially completely filling the entire revolving bowl comprises the oil (or raffinate), a thin film of the heavy solvent (or extract) is maintained at the outer edge of each annular space. The thin film thickness of the extract at the outer portion of each annular space together with the forceful mixing at the lip of each of the concentric cylinders within the bowl produces a highly efficient mixing of oil and solvent.

The compactness and simplicity of the centrifuge conserves space and simplifies the operation as well as cleaning of the apparatus. Moreover, inasmuch as the apparatus of my invention thoroughly mixes the oil and solvent and efficiently separates the extract and raffinate phases, the treatment with a single machine may constitute with advantage the complete treatment of the oil. A solvent plant using the apparatus of this invention carried out in a number of machines operating in parallel, therefore, would not be seriously handicapped with respect to its overall capacity if one or even several machines were shut down for cleaning or repair.

While the apparatus of my invention has been described with respect to its use in the selective extraction of hydrocarbon lubricating oils, it should be noted that the apparatus may be used with advantage for other similar operations wherein it is desired to contact a plurality of partially immiscible fluids and separately withdraw from the operation a plurality of fluid products produced by this contact. By partially immiscible fluids, as used herein, I means fluids which are not substantially completely miscible or soluble in one another but which are sufficiently miscible to effect a selective extraction of one of the fluids by contact with one or more other fluids.

The method of refining as carried out by the above described apparatus is claimed in my copending application 157,748, filed on the same date as this application.

I claim:

1. Apparatus for contacting partially immiscible fluids of different densities which comprises a rotatable bowl, means for introducing a relatively heavy fluid into the central portion of the bowl, means for introducing a relatively light fluid into the outer portion of the bowl, means for introducing a fluid having a density substantially intermediate that of the heavier fluid and that of the lighter fluid at a point substantially intermediate the central and outer portions of the bowl, means for withdrawing the heavier fluid from the outer portion of the bowl, and means for withdrawing the lighter fluid from the central portion of the bowl.

2. Apparatus for contacting partially immiscible fluids of different densities which comprises a rotatable bowl, a plurality of cylinders substantially coaxially aligned within the bowl, the alternate cylinders being provided with openings disposed adjacent the upper portions thereof, the intervening cylinders being provided with openings disposed adjacent the lower portions thereof, means for introducing a relatively heavy fluid into the central portion of the bowl, means for introducing a relatively light fluid into the outer portion of the bowl, means for introducing a fluid having a density substantially intermediate that of the heavier fluid and that of the lighter fluid at a point substantially intermediate the central and outer portions of the bowl, means for withdrawing the heavier fluid from the outer portion of the bowl, and means for withdrawing the lighter fluid from the central portion of the bowl.

3. Apparatus for contacting partially immiscible fluids of different densities which comprises a rotatable bowl having a false cover and a false bottom, a plurality of cylinders substantially coaxially aligned within the bowl attached to and depending from the false cover, a plurality of cylinders substantially coaxially aligned within the bowl attached to and extending upwardly from the false bottom and adapted to be disposed in spaced relationship intermediate adjacent cylinders of the cylinders depending from the false cover, means for introducing into the bowl a plurality of fluids of different densities, and means for withdrawing said fluids from the bowl.

4. Apparatus for contacting partially immiscible fluids of different densities which comprises a rotatable bowl provided with a cover and having a false cover and a false bottom providing a

space at the top and bottom of the bowl with each space communicating with the interior of the bowl adjacent the outer portion thereof, a plurality of cylinders substantially coaxially aligned within the bowl attached to and depending from the false cover, a plurality of cylinders substantially coaxially aligned within the bowl attached to and extending upwardly from the false bottom, means for introducing a relatively heavy fluid into the central portion of the bowl, means for introducing a relatively light fluid into the space provided by the false bottom, means for withdrawing the heavier fluid from the outer portion of the bowl through the space provided by the false cover, and means for withdrawing the lighter fluid from the central portion of the bowl.

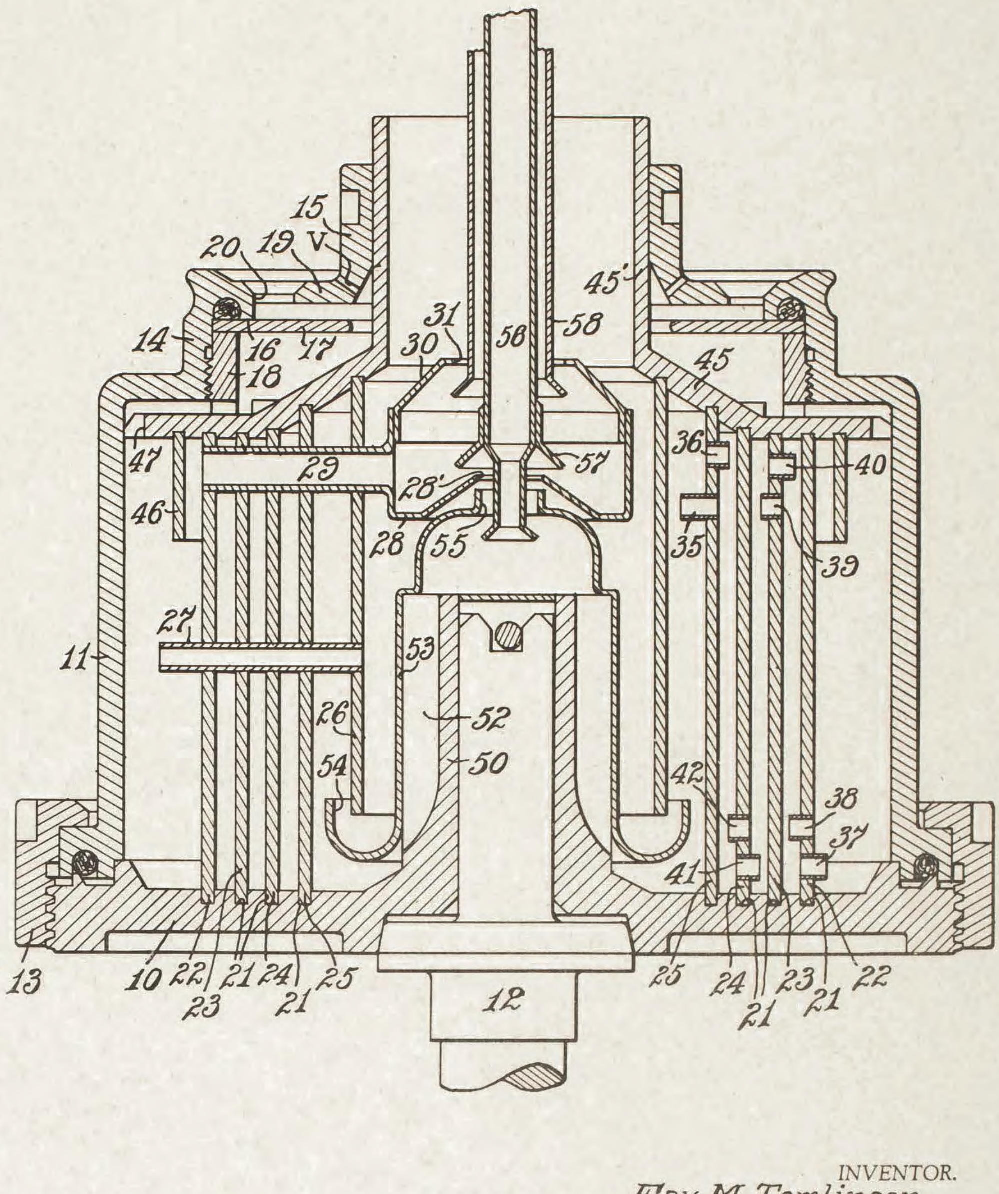
5. Apparatus for contacting partially immiscible fluids of different densities which comprises a rotatable bowl provided with a cover and having a false cover and a false bottom providing a space at the top and bottom of the bowl with each space communicating with the interior of the bowl adjacent the outer portion thereof, a plurality of cylinders substantially coaxially aligned within the bowl depending from the false cover, a plurality of cylinders substantially coaxially aligned within the bowl attached to and extending upwardly from the false bottom, means for introducing a relatively heavy fluid into the central portion of the bowl, means for introducing a relatively light fluid into the space provided by the false bottom, means for introducing a fluid having a density substantially intermediate that of the heavy fluid and that of the light fluid at a point substantially intermediate the central and outer portions of the bowl, means for withdrawing the heavier fluid from the outer portion of the bowl through the space provided by the false cover, and means for withdrawing the lighter fluid from the central portion of the bowl.

GEORGE THAYER.

Aug. 4, 1942. F. M. TOMLINSON 2,291,849

COUNTER-FLOW CENTRIFUGE AND METHOD OF TREATING ONE LIQUID WITH ANOTHER LIQUID OF DIFFERENT SPECIFIC GRAVITY

Filed April 18, 1934



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COUNTERFLOW CENTRIFUGE AND METHOD OF TREATING ONE LIQUID WITH ANOTHER LIQUID OF DIFFERENT SPECIFIC GRAVITY

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18 Claims. (Cl. 233—15)

In certain arts it is desirable to contact and wash the surface of one liquid with another liquid, subsequently separating the resultants into two or more well-defined and individualized liquids, rather than to produce an intimate mixture of such two liquids followed by separation and individualization.

For instance, in the purification of lubricating oil certain steps of purification involve treatment of the oil with a liquid such as phenol which has the capacity of absorbing undesirable impurities contained in the oil. Such purification has heretofore been obtained by admixing the phenol with the oil, but too long and too intimate contact of the phenol with the oil produces undesirable results and it has been recently discovered that desired purification, while avoiding most of the deleterious effects heretofore produced, may be obtained by contacting a film of the oil with a film of phenol followed by a separation of the treated oil and the treating phenol.

An object of my present invention is to provide a mechanism by which two liquids, differing in specific gravities, may be brought into surface contact only and continued in a relative sliding contact in such association for a predeterminable period of time and under predeterminable pressures, and subsequently separated one from the other.

A further object of my invention is to provide an improved method of surface treating one liquid by another liquid of different specific gravity.

The accompanying drawing is an axial vertical section of an apparatus embodying my invention.

In the drawing **10** indicates a base flange and **11** indicates a main body flange which, together form a centrifugal bowl which may be rotated at desired speeds by means of a carrying spindle **12**. The body flange **11** is preferably readily separable from the base flange **10** and is conveniently held in association therewith by the ring nut **13**. The body flange **11** at its upper end is provided with a reduced-diameter intermediate neck **14** and a further-reduced neck **15**. Near its upper end the intermediate neck **14** is provided internally with a downwardly-presented shoulder **16**, upon which may be seated any one of a number of ring dams **17** by means of a nut **18**, said ring dams varying in internal diameter.

Necks **14** and **15** are connected by radial flange **19** provided with a plurality of heavy-liquid outlets **20** and a plurality of air vents V.

Removably seated in a plurality of circular grooves **21**, of different diameters, formed in the upper face of base flange **10**, is a plurality of annular partitions **22**, **23**, **24**, **25** conveniently cylindrical. These partitions may be varied in number and spacing in accordance with the particular liquids which are to be associated.

Within the smallest partition **25** is an annular partition **26** and projected radially through the several partitions **22** to **25** is a pressure-balancing tube **27** which forms a pressure-balancing conduit between the interior of partition **26** and the exterior of partition **22**, the outer end of said tube **27** extending toward but not to the inner face of wall **11**. There may be several of these tubes **27** circumferentially spaced from each other.

Nested within the upper end of partition **26** is a cup **28** provided with a radial conduit **29** which is projected through the several partitions **22** to **26** to form a conduit from the interior of cup **28** to the exterior of the largest diameter partition **22**. There may be several of these conduits **29**, circumferentially spaced. The bottom of cup **28** is medially elevated, as shown, and is axially perforated at **28'**. Cup **28** is capped by an annular cap **30** having an axial perforation **31**.

The smallest-diameter partition **25** near its upper end is pierced by a circumferentially spaced series of conduits **35**, the inlet mouths of which are arranged about half way between partition **26** and partition **25**. Partition **25** is also pierced, near its upper end by a circumferentially-spaced series of conduits **36**, the inlet mouths of which lie closer to the inner face of partition **25** than the inlet mouths of conduits **35**, and the outlet mouths of which lie at a point intermediate between partition **25** and partition **24**.

The largest-diameter partition **22** is pierced near its bottom with a plurality of circumferentially-spaced conduits **37**, the inlet mouths of which are arranged at or close to the inner face of the largest-diameter partition **22** and the outlet mouths of which are spaced outwardly beyond the outer face of said partition **22**. Partition **22** is also pierced near its bottom with a plurality of conduits **38**, the inlet mouths of which are arranged closer to the outer face of partition **22** than are the outlet mouths of conduits **37**, and the outlet mouths of which are arranged intermediate between the inner face of partition **22** and the outer face of the next smaller partition **23**.

Partition **23** near its upper end and conveniently in the plane of conduits **35**, is pierced by a plurality of circumferentially-spaced conduits **39**, the inlet mouths of which are arranged intermediate the inner face of partition **23** and the outer face of partition **24**. The upper end of partition **23** is also pierced by a plurality of circumferentially-spaced conduits **40**, the inlet mouths of which are arranged closer to the inner face of partition **23** than are the inlet mouths of conduits **39**, and the outlet mouths of which are arranged intermediate the outer face of partition **23** and the inner face of partition **22** and preferably a little closer to the inner face of partition **22** than are the outlet mouths of conduits **38**.

Partition **24** near its bottom is pierced by a plurality of circumferentially-spaced conduits **41**, preferably in the plane of the conduits **37**, the inlet mouths of which are arranged close to the inner face of partition **24** and the outlet mouths of which are arranged at an intermediate point between partitions **24** and **23** and preferably as close to the inner face of partition **23** as are the outlet mouths of conduits **39**.

Partition **24** is also pierced by a circumferentially-spaced series of conduits **42**, the inlet mouths of which are arranged at an intermediate point between the inner face of partition **24** and the outer face of partition **25** and the outlet mouths of which are arranged closer to the outer face of partition **24** than are the outlet mouths of conduits **41**.

The piercing conduits of any partition may be arranged in substantially the same plane and conveniently are circumferentially alternated. The conduits **36**, **40** are shown at a higher level than conduits **35**, **39** and **38**, **42**, at a higher level than **37**, **41** for convenience of illustration.

For convenience in handling, the parts **22** to **42**, inclusive, are secured together into a unitary structure.

Surmounting the aforesaid unitary structure is a separator bell **45** having in its lower face a plurality of circumferential grooves adapted to receive the upper ends of the aforesaid cylindrical partitions and this bell carries, beyond the largest-diameter partition, a depending annular skirt **46**, the lower end of which is extended below the outer mouths of conduits **29**. The diameter of this skirt **46** lies within the outer ends of the balancing tubes **27**. Bell **45**, at its outer diameter, conveniently has a sliding fit with the inner face of the bowl wall **11**, but is radially notched as indicated at **47**. Instead of the notches **47** the bell **45** may have a maximum diameter somewhere between the inner face of the bowl wall **11** and the outer face of skirt **46**. Bell **45** is provided at its upper end with a tubular neck **45′** which extends up through and fits neck **15**.

Base flange **10** is provided with an upwardly-projecting hub **50** bored to receive the upper end of spindle **12** and this hub is externally longitudinally slotted to form a plurality of circumferentially-spaced conduits **52**. Sleeved over the upper end of hub **50**, so as to define the outer sides of conduits **52** for a major portion of their lengths, is a thimble **53** which, at its lower end, is outwardly and upwardly flared as indicated at **54**, so that its upper edge lies between partitions **25** and **26** above the lower end of partition **26**. The upper end of thimble **53** projects into the raised central portion of the bottom of cup **28** and is axially perforated as indicated at **55**.

Projected down through perforations **31**, **28′** and **55** is a supply conduit **56** for the heavier liquid, which, in the case of oil treatment, would be the phenol solvent. This tube **56** is provided with an outwardly and downwardly flaring skirt **57** which serves as a guard for perforation **28′**.

Sleeved over the supply conduit **56** is a second supply conduit **58** the lower end of which projects down through perforation **31** but lies short of skirt **57**. The supply conduit **58** is for delivery of the lighter liquid to be handled which, in the case of oil treatment, would be the oil to be treated.

The operation is as follows, the bowl being set in rotation at high speed and the light liquid delivered through supply conduit **58** until it starts to discharge through perforations **20**, whereupon the supply of light liquid is temporarily suspended and the heavy liquid supplied through conduit **56**. This heavy liquid will flow through conduits **52** into the lower end of the space defined by the smaller diameter partition **25**, thence upwardly along the inner face of that partition, out through conduits **36**; thence downwardly along the inner face of partition **24**, thence outwardly through conduits **41**; thence upwardly along the inner face of partition **23** and outwardly through conduits **40**; thence to and down the inner face of partition **22** and outwardly through conduits **37**; and thence upwardly along the inner face of bowl wall **11** and upwardly through passages **47**; thence upwardly over the inner edge of dam **17** and thence through perforations **20** and out over the upper edge of the intermediate bowl neck **14**. Thereupon the supply of lighter liquid will be resumed and will pass from cup **28** out through conduits **29** where it will be deflected downwardly by skirt **46**, and will flow down along the outer face of partition **22**, the stream of lighter liquid being held against partition **22** by reason of the accumulation of heavier liquid adjacent the inner face of bowl wall **11**. At the bottom of partition **22** the lighter liquid flows inwardly through conduits **38** between the outer face of partition **23** and the film of heavier liquid on the inner face of partition **22**; thence upwardly to and through conduits **39** to the outer face of partition **24**, thence downwardly between said outward face and the heavier-liquid film on the inner face of partition **23** to and through conduits **42** to the outer face of partition **25**; thence upwardly in surface contact with the film of heavier liquid on the inner face of partition **24** to and through conduits **35** to the outer face of partition **26**; thence downwardly in surface contact with the heavier-liquid film on the inner face of partition **25** to the lower end of partition **26** and thence upwardly within partition **26** to flow upwardly past cup **28** and thence upwardly through neck **45′** to be discharged from the upper end of said neck. The two liquids will, of course, fill the annular spaces between the several partitions, but the arrangement of the several conduits through the partitions maintains these two liquids in annular strata between the several partitions and between the largest diameter partition and the bowl wall, so that, instead of an intimate mixture of the two liquids there are maintained a plurality of oppositely flowing annular streams of the two liquids having sliding surface contact with each other, the centrifugal force developed by the rotation of the bowl constantly pressing the lighter liquid against the immediately adjacent outer heavier liquid. The lighter liquid flows from outer regions of the bowl toward inner regions of the bowl and the heavier liquid flows from inner regions of the bowl to outer regions of the bowl so that the two liquids (modified by the chemical or other reaction which has occurred within the bowl as a result of the aforesaid surface contact) are finally separated and flow, respectively, over the upper end of the intermediate neck **14** and the upper end of neck **45'**.

It will be noted that, when two liquids of different specific gravities are delivered to a rotating bowl such as has been described, the heavier liquid is formed into a series of annular stream sections which flow along the inner faces of the perforated partitions and finally along the inner face of the bowl wall to exit through perforations **20**, and at the same time the lighter liquid is formed into a series of annular stream sections which flow along the outer face of each partition and in surface contact with the inner annular surface of each heavy-liquid stream in a direction opposite to the direction of flow of the heavy liquid, to exit through the bore of the inner partition **26** and neck **45**. It will also be noted that, due to the centrifugal forces which are set up in the two liquids, the light-liquid stream is pressed against the adjacent portion of the heavy-liquid stream.

One stream therefore acts upon the other by reason of impressed surface contact, as distinguished from intermixture.

My improved method therefore comprises the establishment and maintenance of a stream of relatively heavy liquid and a stream of relatively light-liquid in surface contact, one with the other and one stream moving longitudinally relative to the other so that successive portions of one stream are brought into surface contact with successive portions of the other stream.

I claim as my invention:

1. The combination with a centrifugal bowl, of a dividing bell arranged within the bowl defining two outlet passages from inner and outer pressure regions of the bowl, a plurality of nested annular perforated partitions arranged axially within the bowl and within the bell region to form a nested series of annular chambers, the smallest diameter chamber and the largest diameter chamber communicating respectively with independent outlets from the bowl, a pair of flow-guide means perforating alternate partitions near one end, one defining inward flow from adjacent the outer face of its partition to a zone spaced from the inner face of said partition and the other defining outward flow from adjacent the inner face of its partition to a zone spaced from the outer face of said partition, a pair of flow-guide means perforating the other alternate partitions near the ends opposite the first-mentioned flow-guide means, one of said second-mentioned flow-guide means defining outward flow from adjacent the inner face of its partition to a zone spaced from the outer face of said partition and the other of said second-mentioned flow-guide means defining inflow from adjacent the outer face of its partition to a zone spaced from the inner face of said partition, an inlet conduit and flow-guide means leading from the exterior of the bowl to a zone adjacent the inner face of the smaller diameter perforated partition, and a second inlet and flow-guide means leading from the exterior of the bowl to a zone adjacent the outer face of the largest-diameter perforated partition.

2. The combination with a centrifugal bowl, of a dividing bell arranged within the bowl defining two outlet passages from inner and outer pressure regions of the bowl, a plurality of nested annular perforated partitions arranged axially within the bowl and within the bell region to form a nested series of annular chambers, the smallest diameter chamber and the largest diameter chamber communicating respectively with independent outlets from the bowl, a pair of flow-guide means perforating alternate partitions near one end, one defining inward flow from adjacent the outer face of its partition to a zone spaced from the inner face of said partition and the other defining outward flow from adjacent the inner face of its partition to a zone spaced from the outer face of said partition, a pair of flow-guide means perforating the other alternate partitions near the ends opposite the first-mentioned flow-guide means, one of said second-mentioned flow-guide means defining outward flow from adjacent the inner face of its partition to a zone spaced from the outer face of said partition and the other of said second-mentioned flow-guide means defining inflow from adjacent the outer face of its partition to a zone spaced from the inner face of said partition, an inlet conduit and flow-guide means leading from the exterior of the bowl to a zone adjacent the inner face of the smaller diameter perforated partition, a second inlet and flow-guide means leading from the exterior of the bowl to a zone adjacent the outer face of the largest-diameter perforated partition, and a pressure-balancing conduit between inner and outer pressure regions of the bowl.

3. The combination, with a centrifugal bowl having an open upper end, a dividing bell in the upper end of the bowl having a discharge orifice leading to the top of the bowl and a skirt with an effective diameter adjacent but short of the bowl wall, an annular partition subtending the bell to a low region of the bowl, a second annular partition subtending the bell to the bowl bottom and spaced outwardly from the first-mentioned partition, a third annular partition subtending the bell to the bowl bottom and spaced outwardly from the second partition, a flow passage perforating the second partition near its upper end with its inlet end adjacent the outer face of said partition and its outlet end spaced inwardly from the inner face of said partition, a second flow-passage perforating said second partition near its upper end with its inlet end adjacent the inner face of said partition and its outer end spaced outwardly from the outward face of said partition, a flow passage perforating the third partition near its lower end with its inlet end adjacent the outer face of the third partition and its outlet end spaced from the inner face of the third partition and the outer face of the second partition, a second flow passage perforating the third partition near its lower end with its inlet end adjacent the inner face of the third partition and its outlet end spaced from the outer face of the third partition and from the bowl wall, a fluid-supply conduit leading into the upper region of the bowl and through the several partitions to that region of the bowl beyond the third partition, a skirt depending from the bell to a region below the outlet of said last-mentioned conduit and spaced between said outlet and the bowl wall, a second fluid-supply conduit leading into the lower region of the bowl within the second partition and below the lower end of the first partition, and flow-defining means arranged between said last-mentioned conduit and the lower end of the first partition and

spaced between the first and second partitions to cause flow from the space surrounding the lower end of the first partition to the lower region within the first partition.

4. A structure of the character specified in claim 3 having a pressure-balancing conduit extending through the several partitions from the interior of the first partition to a region outside the third partition and skirt and short of the bowl wall.

5. A structure of the character specified in claim 3 having two annular partitions subtending the bell to the bowl bottom and radially spaced from each other and adjacent partitions, a flow-passage perforating the smaller of said partitions near its lower end with its inlet end adjacent the outer face of its partition and its outlet end intermediate the inner face and the next smaller partition, a second flow-passage perforating the smaller of said partitions near its lower end with its inlet end adjacent the inner face of said partition and its outlet end spaced from the outer face of said partition and the inner face of the next larger partition, a flow-passage perforating the larger of said partitions near its upper end with its inlet end adjacent the inner face of its partition and spaced from the outer face of said partition and the inner face of the next larger partition, and a flow-passage perforating the larger of said two partitions near its upper end with its inlet end adjacent the outer face of its partition and its outlet end spaced from the inner face of its partition and the outer face of the next smaller partition.

6. A structure of the character specified in claim 3 having two annular partitions subtending the bell to the bowl bottom and radially spaced from each other and adpacent partitions, a flow-passage perforating the smaller of said partitions near its lower end with its inlet end adjacent the outer face of its partition and its outlet end intermediate the inner face and the next small partition, a second flow-passage perforating the smaller of said partitions near its lower end with its inlet end adjacent the inner face of said partition and its outlet end spaced from the outer face of said partition and the inner face of the next larger partition, a flow-passage perforating the larger of said partitions near its upper end with its inlet end adjacent the inner face of its partition and spaced from the outer face of said partition and the inner face of the next larger partition, a flow-passage perforating the larger of said two partitions near its upper end with its inlet end adjacent the outer face of its partition and its outlet end spaced from the inner face of its partition and the outer face of the next smaller partition, and a pressure-balancing conduit extending through the several partitions from the interior of the first partition to a region outside the largest diameter partition and skirt and short of the bowl wall.

7. A counter-flow stratification unit for centrifugal bowls comprising three nested radially-spaced annular partitions, the outer partition being perforated near one end by two flow-passages, the inlet ends of which are respectively adjacent the outer and inner faces of their partition and the outlet ends of which are respectively spaced inwardly from the inner face and outwardly from the outer face of their partition, and the intermediate partition being perforated near the other end by two flow passages the inlet ends of which are respectively adjacent the inner and outer faces of their partitions and the outlet ends of which are respectively spaced outwardly from the outer face and inwardly from the inner face of their partition, and a conduit perforating the several partitions near one end and formed at its inner end to receive a fluid during rotation about the axis of the group.

8. A counter-flow stratification unit of the character specified in claim 7 having a pressure-balancing conduit perforating the several partitions and forming a passage from the interior of the smallest partition to a zone outwardy spaced beyond the outer face of the largest partition.

9. The method of securing counter-current contact between a heavier liquid and a lighter fluid which comprises forcing the heavier liquid to traverse outwardly through a laterally closed passageway of increasing radius while rotating the passageway to exert centrifugal force on said liquid, said passageway having non-aligned openings whereby such centrifugal force causes an outward flow of the heavier liquid in addition to its progressive movement through said passageway, and supplying a lighter fluid to the outer extremity of the passageway under pressure to force it inwardly through the passageway and counter-current to the flow of said liquid.

10. The method of securing counter-current contact between a liquid and lighter fluid which comprises forcing the liquid to traverse a succession of laterally closed concentric passages while rotating said passages to exert centrifugal force on said liquid said passages having non-aligned openings therebetween at opposite ends of alternate passages whereby such centrifugal force causes an outward flow of the liquid from passage to passage and in addition thereto, a longitudinal movement of the liquid within each of said passages, and supplying a lighter fluid to the outer concentric passage under pressure to force it inwardly through said passages in counter-current to the flow of said liquid.

11. In apparatus for effecting counter-current contact between fluids, a rotor comprising a plurality of partitions forming therebetween laterally closed passages of enlarging radii, non-aligned openings in said partitions, means for supplying a heavier fluid within said passages, means for rotating the rotor to develop centrifugal force and cause said fluid to pass outwardly through the rotor from passage to passage, and to traverse said passages in a continuous film in its movement, and means for forcing a lighter fluid inwardly through the passages in said rotor.

12. In apparatus for effecting counter-current contact between fluids, a rotor, concentric partitions within said rotor forming concentric laterally closed passages therebetween, openings in said partitions forming passages therebetween, the openings in alternate partitions being at opposite ends thereof, means for supplying a fluid within said rotor, means for rotating said rotor to develop centrifugal force and thereby cause said fluid to traverse said passages longitudinally in a continuous film and pass outwardly from passage to passage through said openings, and means for supplying a lighter fluid and causing it to pass inwardly through the passages in said rotor counter-current to the flow of said first mentioned fluid.

13. The method of treating two incompletely miscible liquids of different specific gravities, which consists in establishing surface contact only of two definite streams of such liquids, the

components of which have not been preliminarily commingled; causing flow of said definite streams in opposite directions in surface contact only; and simultaneously pressing the stream of lighter liquid against the stream of heavier liquid by a pressure exceeding the normal weight of the lighter liquid per unit of contact area, such pressure being incrementally progressively varied during such surface contact; and finally separating one stream from the other.

14. The method of associating two liquids not readily miscible and of different specific gravities which comprises; establishment and maintenance of a definite flowing stream of the heavier liquid with an exposed lineally extending surface; establishment and maintenance of an oppositely flowing definite stream of lighter liquid in contact only with the said exposed surface of the heavy liquid stream; avoiding intermingling turbulence of the two liquids; and finally separating the two streams.

15. The method of associating two liquids not readily miscible and of different specific gravities which comprises; establishment and maintenance of a definite flowing stream of the heavier liquid with an exposed lineally extending surface; establishment and maintenance of an oppositely flowing definite stream of lighter liquid in contact only with the said exposed surface of the heavy liquid stream; avoiding intermingling turbulence of the two liquids; causing the lighter liquid to press upon the heavier stream with an incrementally varying pressure as surface contact between the two streams progresses; and finally separating the two streams.

16. The method of treating one liquid with another liquid of different specific gravity, which comprises, the establishment of a defined stream of heavy liquid without substantial commingling with a lighter liquid; the imposition on an exposed surface of said stream of a lighter liquid which has not been preliminarily commingled with the heavy liquid and forming said lighter liquid into a defined stream in only surface contact with the heavy stream; causing exertion of successively varied pressures upon the contacted surface of one stream laterally through the medium of the other stream, causing flow of the two contacting streams in opposite directions while in said pressure contact, and subsequently withdrawing of one stream from the other.

17. The method of treating one liquid with another liquid of different specific gravity, which comprises, effecting surface contact only between two incompletely miscible liquids of different specific densities by supplying the heavier liquid in a constant stream to the inner end of a curved passageway of increasing radius; rotating said passageway about an axis to develop by centrifugal action a defined stream of heavy liquid and a propellant force in said heavier liquid to propel it outwardly in stream form through said passageway; introducing into said passageway, without preliminary commingling with the heavier liquid, the lighter liquid to form a defined stream of lighter liquid in surface contact only with said heavier liquid; and causing the two streams of liquid to flow in opposite directions in surface contact only.

18. The method of treating two incompletely miscible liquids of different specific gravities, which consists in establishing surface contact only of two definite streams of such liquids the components of which have not been preliminarily commingled; causing flow of said definite streams in opposite directions in surface contact only; and simultaneously pressing the stream of lighter liquid on the heavy liquid by pressure exceeding the normal weight of the lighter liquid per unit of contact area; and finally separating one stream from the other.

FAY M. TOMLINSON.

Dec. 21, 1943. R. F. THOMPSON ET AL 2,337,137

APPARATUS FOR THE TREATMENT OF SOLID MATERIAL WITH LIQUID

Filed April 24, 1941

Fig. 1.

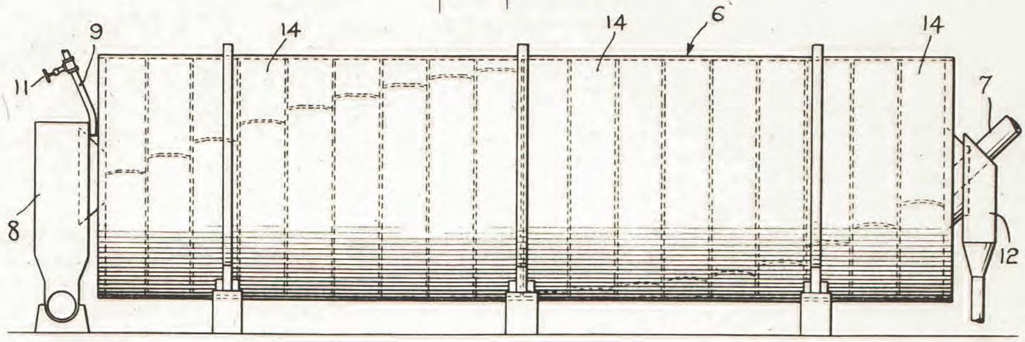


Fig. 2.

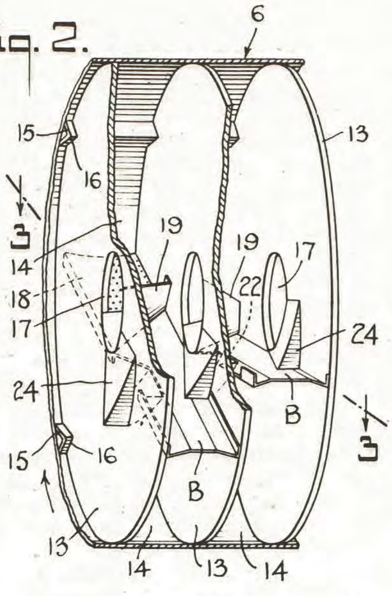


Fig. 3.

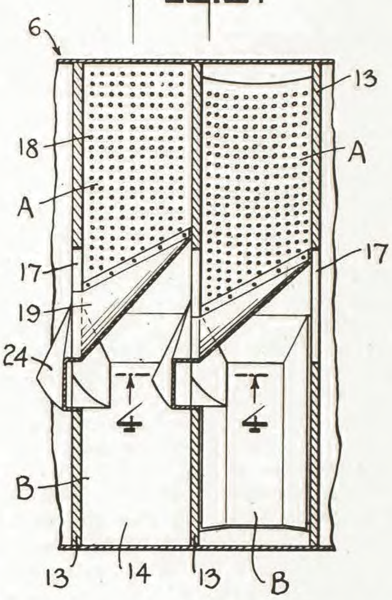


Fig. 4.

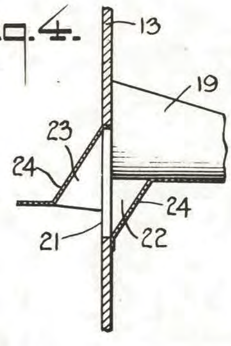
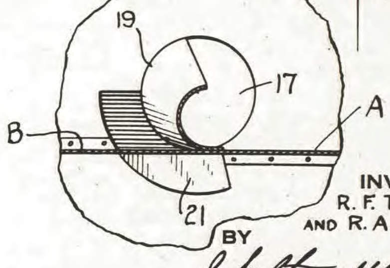


Fig. 5.



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APPARATUS FOR THE TREATMENT OF SOLID MATERIALS WITH LIQUIDS

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Application April 24, 1941, Serial No. 390,118

13 Claims. (Cl. 23—269)

This invention relates to apparatus for bringing substances in the solid phase into contact with substances in the liquid phase, and relates more particularly to apparatus for washing, leaching or extracting a fibrous or granular solid by countercurrent action with a suitable liquid medium.

An object of this invention is the provision of an improved apparatus for continuously bringing substances in the solid phase into contact with substances in the liquid phase.

A further object of this invention is to provide an apparatus for continuously washing cellulose acetate, which has been precipitated in particle form from a solution thereof in acetic acid, in such a manner that the cellulose acetate is washed substantially free of acetic acid and the wash liquor is of relatively high acid concentration.

Other objects of this invention, together with certain details of construction and combinations of parts, will appear from the following detailed description and the appended claims.

In many manufactures the problem arises of treating solid particles with liquid media in which the bulk of the solid is insoluble with a view, for example, to removing constituents from solid material whether by physical action, as in washing or extraction, or by chemical action of the liquid, or with the view to removing constituents from the liquid by the action of the solid for the purpose of purifying the liquid, recovering therefrom the substances removed, or impregnating the solid. In the treatment of solids with liquids or liquids with solids, it is obviously advantageous to insure as intimate a contact as possible therebetween. The present invention provides a means whereby this desideratum may be obtained in a continuous manner by causing the treating liquid to pass through the solid particles while the solid particles and the treating liquid are passing each other in opposite directions.

In accordance with this invention the solid particles are continuously fed into, propelled along, and discharged from, a rotating cylindrical vessel while the liquid is continuously introduced into said vessel and caused to flow through the body of the solid particles as the latter move in a direction opposite to that of the liquid, the construction and arrangement of the apparatus being such that the liquid remains in contact with the solid particles for an appreciable length of time. By this means the liquid is brought into intimate contact with the solid particles and the treatment is much more effective than if only the liquid flowed, for example, over the surface of the material instead of through it. The apparatus may be used with particular advantage for the treatment of materials with liquids of substantially the same or not very different specific gravities. Moreover, the apparatus may be employed for the treatment of fibrous solids, granular solids, or in fact any solid in a state of division which may be separated on a filter and which will flow from a chute.

The apparatus according to the present invention comprises a rotating cylindrical vessel containing a number of plates or partitions dividing said vessel into a plurality of compartments. The partitions are provided with openings and the compartments are provided with suitable means for passing the solid material from one compartment to another and so on through the cylindrical vessel. The apparatus is also provided with means for feeding the material thereto at one end of the same and means for discharging the material at the other end of the same, together with means for introducing a countercurrent of liquid at the discharge end of said cylindrical vessel. The rotation of the cylindrical vessel causes the means in the compartments to function to pass the solid material from one compartment to another and also to pass the liquid from one compartment to another but in the opposite direction.

We have found that convenient means for passing the material from one compartment to another are sheets which are fastened between the partitions so that they are tangent to the openings in the partition and which are of such size as to divide the compartment into two parts. A semi-cone or scoop shaped deflector co-operates with one end of the sheet to deflect the material into the opening in order to pass it on to the next succeeding compartment and additional openings are arranged near the center openings to permit the liquid to pass from one compartment to another.

One form of apparatus according to this invention is illustrated in the accompanying drawing, in which

Figure 1 is a side elevational view of the apparatus showing a cylindrical vessel partitioned off into sections,

Figure 2 is a detail view of the interior of the cylindrical vessel showing the openings in the partition walls and the means by which the solid particles are passed from section to section through the vessel and the treating liquid is passed through the sections in counter direction to the solid particles,

Figure 3 is a cross-sectional view taken along line 3—3 in Figure 2,

Figure 4 is a cross-sectional view, taken along line 4—4 in Figure 3, showing a detail of the construction about the openings in the partitions, and

Figure 5 is a front view of the structure shown in Figure 4.

Like reference numerals indicate like parts throughout the several views of the drawing.

Referring to the drawing, the device of this invention is shown as comprising a cylindrical vessel generally indicated by the reference numeral 6 arranged to rotate horizontally upon its axis by any suitable means (not shown). The vessel 6 is provided at one end with a conduit 7 by which the solid material is fed into said vessel, the solid material being discharged at the opposite end of the vessel into a suitable chute 8 from which it is passed into a suitable container, as is well understod in the art. At the material discharge end of the vessel there is provided a pipe 9 having a valve 11 for feeding the liquid into the vessel, either continuously or intermittently as required, the liquid being discharged into a suitable receptacle 12 at the material feed entrance of the vessel. To the inner surface of vessel 6 are fastened with a solid connection circular plates or partitions 13 which are spaced along the interior of the vessel and are arranged to divide the vessel into a number of compartments or cells 14. The partitions may be retained in position by means of right-angled bars 15 suitably fixed to the inner surface of the vessel and co-operating with grooves 16 arranged along the periphery of the partitions 13. While the drawing shows a vessel containing eighteen cells, it is to be understood that our invention is not limited to the use of a vessel containing any specific number of cells. It will be appreciated that the number of cells and the size of the vessel will depend upon the use to which it is intended to be put and/or the nature of the material being treated.

All of the partitions are provided with round center openings 17. Fastened rigidly to the partitions 13 defining each cell 14 and tangent to the center openings 17 are displacement sheets 18 which divide each cell into two parts of unequal size. These displacement sheets having a perforated portion and a solid portion. Furthermore, the displacement sheets may be straight or curved and the perforated portion may be set at an angle to the solid portion. Since these displacement sheets are tangent to the center openings of the partition, they are off the center line of the cylinder by the radius of the center opening. These displacement sheets are so arranged that, when viewed from the material discharge end of the vessel and assuming clockwise rotation, they are arranged in an even spiral and off-set an equal angle, of about 20 degrees, from each other clockwise from the feed end to the discharge end of the vessel. It is to be understood, however, that the displacement sheets may be arranged in a double spiral and in this case the displacement sheets will be off-set from each other on an angle of about 40 degrees. However, this angle may be increased to a greater number of degrees under special conditions of size and design to meet special requirements. A semi-cone or scoop shaped deflector 19 is rigidly mounted in each cell in such a manner that its base meets half of the circular center opening, the apex of the deflector being modified to a flat section and being fastened to the far partition of that cell at a line more than the diameter of the center opening through and away from the cylindrical vessel axis and normal to the displacement sheet 18. The junction of this deflector and the displacement sheet may be a solid connection or the deflector may be removably fastened in the compartment by means of bolts or cap screws. The construction and arrangement of the deflector 19 is such that it divides the displacement sheet into two unequal parts, the part in front of the concave face of the deflector being the shorter part. This part, indicated by the reference character A, is perforated and, as stated, may be either flat or curved. The other or longer part, indicated by reference character B, may be, as stated, off-set from the short part of the displacement sheet.

In order to provide for the passage of the liquid through the vessel in a direction counter to the direction of the flow of the solid material therethrough the inner partitions 13 are provided with an opening 21 radial from the axis of the cylindrical vessel and adjacent to the center opening 17, and also angular openings 22 and 23 in adjacent displacement sheets 18. The openings 21, 22 and 23 are provided with shields 24 which cause the liquid to flow in the desired direction upon the rotation of the vessel. If desired, manholes may be constructed in at least every other compartment to permit of easy inspection.

While we prefer to construct our apparatus of stainless steel, it will, of course, be appreciated that any other suitable material may be employed. Moreover, the vessel need not be cylindrical, but may be in the shape of a prism having any number of sides from three to infinity.

The operation of the apparatus of our invention will be described in connection with the washing of solid particles of material with water. In this case the solid particles to be treated are fed into the vessel 6 rotating at ⅙ to 2 R. P. M. at a rate of from 300 to 4,000 pounds per hour through conduit 7. Water is fed into the opposite end of vessel 6 through pipe 9 at the rate of from 1,000 to 40,000 pounds per hour. Upon rotation of the vessel 6 in a clockwise direction as viewed from its discharge end, the perforated portion A of displacement sheet 18, when it reaches its lowermost position lifts the wet solid particles. During about a 60 degree arc of travel, the wet solid particles drain slowly on perforated portion A and then slide down this portion into deflector 19 and are discharged therefrom into the adjacent compartment. During this draining period, the liquid in the compartment from which the solid particles had been lifted by perforated portion A of the displacement sheet 18 is being displaced by the solid portion B of said sheet. This liquid drains to the next compartment counter-current to the flow of the solid particles through the passage formed by openings 21, 22 and 23. In this manner, the solid particles are propelled through the vessel from compartment to compartment, falling in the liquor of one compartment, which liquor is subsequently drained therefrom, and the liquor is caused to pass through the compartments of the vessel counter-current to the flow of the solid particles.

The apparatus of the invention is of particular utility in the manufacture of cellulose acetate and like materials, for example cellulose nitrate, formate, propionate or butyrate. In the manufacture of cellulose acetate, the raw acetate obtained by acetylation, whether or not this has been followed by ripening, contains acetic acid which is desirable to remove both with a view to recovery of the acid and to purification of the cellulose acetate. This removal may very conveniently be effected by means of the apparatus of the invention, the raw cellulose acetate being continuously fed into, propelled through and discharged from a counter-current of a liquid capable of dissolving acetic acid but not cellulose acetate. During their passage in opposite directions through the apparatus the liquid becomes progressively richer and the cellulose acetate progressively poorer in acetic acid. As treating liquid we prefer to use water or other aqueous liquids relatively poor in acetic acid.

The application of the apparatus of the invention to a chemical treatment of flaky or granular materials by liquid media may also be illustrated by reference to the manufacture of cellulose acetate or the like substances. Certain processes result in the production of cellulose acetates containing small quantities of substances, e. g., sulphuric esters of cellulose, which it is desirable to remove with a view to stabilizing the product. This removal is effected in the so-called stabilizing step which frequently comprises treating the cellulose acetate with aqueous solutions containing acid, for example, with very dilute aqueous sulphuric acid solutions at temperatures in the neighborhood of the boiling point. This step may very conveniently be carried out by the process of the invention.

Moreover, where two or more consecutive processes both involving treatment of the solid material with liquids are involved, e. g., in cellulose acetate manufacture, where washing is followed by stabilization which is followed by a further washing, by applying the principles set out above, the various consecutive steps can be combined to give a continuous process. Cellulose acetate may for example be passed in succession through three units of the type described above arranged in series so that the material fed into the first passes through a counter-current of water or other suitable washing liquid, is fed into the second unit where it passes through a counter-current of hot, very dilute sulphuric acid and then into the third unit, where it is washed by a counter-current of water and discharged.

It is to be understood that the foregoing detailed description is given merely by way of illustration and that many variations may be made therein without departing from the spirit of our invention.

Having described our invention, what we desire to secure by Letters Patent is:

1. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel arranged for the passage of solid materials and another opening separated from said first opening and arranged for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, and means in each compartment, operable upon rotation of said vessel, constructed to lift said solid materials in its compartment at intervals to the level of the first-mentioned opening and to tip said solid materials through said opening.

2. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel arranged for the passage of solid materials and another opening separated from said first opening and arranged for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, and means, including a deflector, in each compartment, operable upon rotation of said vessel, constructed to lift said solid materials in its compartment at intervals to the level of the first-mentioned opening and to tip said solid materials through said opening.

3. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel arranged for the passage of solid materials and another opening separated from said first opening and arranged for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, and a displacement sheet in each compartment mounted on the partitions forming said compartments, said displacement sheet being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in its compartment at intervals to the level of the first-mentioned opening and to tip said solid materials through said opening.

4. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel arranged for the passage of solid materials and another opening separated from said first opening and arranged for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, a displacement sheet in each compartment mounted on the partitions forming said compartment and a deflector mounted on said displacement sheet, said displacement sheet and deflector being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in its compartment at intervals to the level of the first-mentioned opening and to tip said solid materials through said opening.

5. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an open-

ing spaced from the periphery of said vessel for the passage of solid materials and another opening for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, a displacement sheet in each compartment mounted on the partitions forming said compartment and tangent to the first-mentioned opening, and a deflector mounted on said displacement sheet and extending into said opening, said displacement sheet and deflector being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in its compartment at intervals to the level of the first-mentioned opening and to tip said solid materials through said opening.

6. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartemnts and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel arranged for the passage of solid materials and another opening separated from said first opening and arranged for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, and a displacement sheet in each compartment mounted on the partitions forming said compartment, said displacement sheets being off-set from each other to form a spiral arrangement thereof, each displacement sheet being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in its compartment at intervals to the level of the first-mentioned opening and to tip said solid materials through said opening.

7. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel for the passage of solid materials and another opening for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, a displacement sheet in each compartment, said displacement sheet having a perforate portion and an imperforate portion and a deflector attached to each displacement sheet between said perforate and imperforate portions, the perforate portion being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in the compartment at intervals to the level of the first-mentioned opening and in cooperation with said deflector to tip said materials through said opening.

8. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel for the passage of solid materials and another opening for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, a displacement sheet in each compartment, said displacement sheet having a perforate portion and an imperforate portion, and a curved deflector attached to each displacement sheet between said perforate and imperforate portions and to said first-mentioned opening, the perforate portion being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in the compartment at intervals to the level of the first-mentioned opening and in cooperation with said curved deflector to tip said materials through said opening into an adjacent compartment.

9. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel for the passage of solid materials and another opening for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, a displacement sheet in each compartment, said displacement sheet having a perforate portion and an imperforate portion, and a curved deflector attached at one of its longitudinal edges to a displacement sheet between said perforate and imperforate portions and at its ends to a partition and to the periphery of said first-mentioned opening, the perforate portion being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in the compartment at intervals to the level of the first-mentioned opening and in cooperation with said curved deflector to tip said materials through said opening into an adjacent compartment.

10. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions in said vessel dividing said vessel into a series of compartments, means for feeding the solid materials at one end of said series of compartments and means for feeding the liquid at the other end of said series of compartments, each partition having an opening spaced from the periphery of said vessel for the passage of solid materials and another opening for the passage of liquid in a direction opposite to the passage of said solid materials through said vessel, a displacement sheet in each compartment, said displacement sheet having a perforate portion and an imperforate portion and a deflector attached to each displacement sheet between said perforate and imperforate portions, the perforate portion being constructed and arranged so as, upon rotation of said vessel to lift said solid materials in the compartment at intervals to the level of the first-mentioned opening and in cooperation with said deflector to tip said materials through said opening into an adjacent compartment, and the imperforated portion being adapted to lift the liquid and to pass it through said second-mentioned opening into an adjacent compartment in a direction opposite to that in which the solid material was passed.

11. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, partitions dividing said vessel into a series of compartments, means for feeding the solid materials into the first of said compartments and means for feeding liquid into the last of said compartments, each partition

having a central opening for the passage of solid material and a second opening for the passage of liquid, a displacement sheet in each compartment tangential to said central opening and dividing the compartment into two parts, a portion of said displacement sheet being perforated and a portion thereof being unperforated, and a curved deflector in said compartment partly surrounding said central opening and attached to and extending obliquely across said displacement sheet so as to form a barrier between the perforated part of said displacement sheet and the unperforated sheet, each of said sheets being inclined at about 20° in lead of that in the preceding compartment, the perforated portion of said displacement sheet being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in the compartment at intervals to the level of the first-mentioned opening and in cooperation with said deflector to tip said materials through said opening in the adjacent compartment, and the unperforated portion being adapted to lift the liquid and pass it through said second-mentioned opening into an adjacent compartment in a direction opposite to that in which the solid material was passed.

12. In apparatus for treating solid materials in particle form with liquids, a vessel rotatable about a horizontal axis, transverse partitions dividing said vessel into a series of compartments, means for feeding the solid materials into the first of said compartments and means for feeding liquid into the last of said compartments, each partition having a central opening for the passage of solid material and a second opening for the passage of liquid, a displacement sheet in each compartment tangential to said central opening and dividing the compartment into two parts, a portion of said displacement sheet being perforated and a portion thereof being unperforated, and a curved deflector in said compartment partly surrounding said central opening and attached to and extending obliquely across said displacement sheet so as to form a barrier between the perforated part of said displacement sheet and the unperforated sheet, each of said sheets being inclined at about 20° in lead of that in the preceding compartment, the perforated portion of said displacement sheet being constructed and arranged so as, upon rotation of said vessel, to lift said solid materials in the compartment at intervals to the level of the first-mentioned opening and in cooperation with said deflector to tip said materials through said opening in the adjacent compartment, and the unperforated portion being constructed and arranged so as to lift the liquid and pass it through said second-mentioned opening into an adjacent compartment in a direction opposite to that in which the solid material was passed.

13. An apparatus for treating solid materials in particle form with liquids, comprising a vessel rotatable about a horizontal axis, means for feeding solid materials into one end of said vessel and means for feeding liquid into the opposite end of said vessel, transverse partitions dividing said vessel into a series of compartments, each partition having a central hole therein for the passage of solid material, a displacement sheet in each compartment tangential to said central hole and dividing the compartment into two parts, a portion of said displacement sheet being perforated and a portion thereof being unperforated, and each of said displacement sheets being inclined at about 20° in lead of that in the preceding compartment, a curved deflector in each compartment partly surrounding said central hole and attached to and extending obliquely across said displacement sheet so as to form a barrier between the perforated part and the unperforated part thereof, and a passage through each of said partitions for passing liquid from one compartment to an adjacent compartment, the construction and arrangement being such that at each rotation of the vessel solid material is lifted and drained by the perforated part of each displacement sheet and deflected by the curved deflector into the next compartment, while liquid is lifted by the unperforated part of each sheet and drained through said passage through said partition into the preceding compartment.

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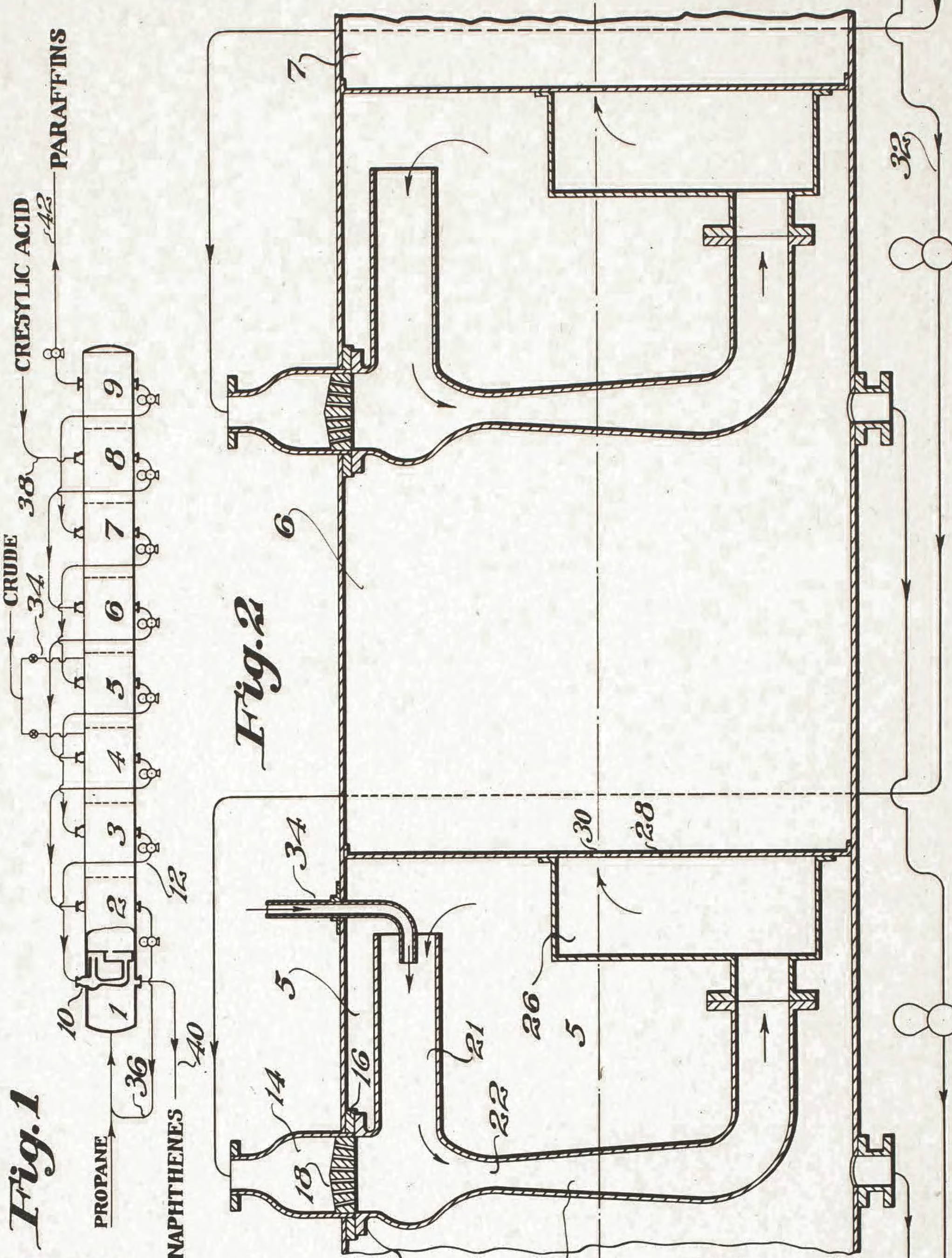
Aug. 31, 1937. **A. C. HAMPTON** **2,091,709**

COUNTERCURRENT CONTACT APPARATUS

Filed April 10, 1935 2 Sheets-Sheet 1



Witness

Paul F. Bryant

Inventor

Arthur C. Hampton

by his attorneys

Fish Hildreth Cary & Jenney

Aug. 31, 1937.

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2,091,709

COUNTERCURRENT CONTACT APPARATUS

Filed April 10, 1935

2 Sheets-Sheet 2

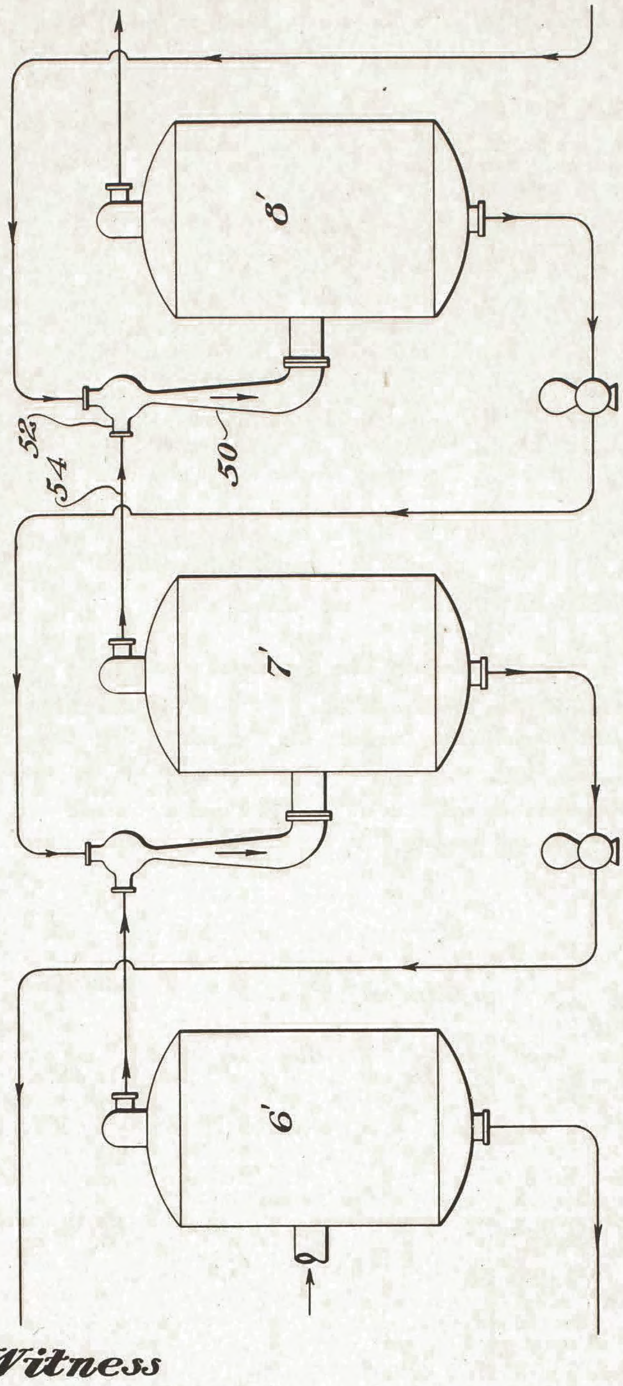

Fig. 3

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Patented Aug. 31, 1937 2,091,709

UNITED STATES PATENT OFFICE

2,091,709

COUNTERCURRENT CONTACT APPARATUS

Arthur C. Hampton, Belleville, N. J., assignor to The Lummus Company, New York, N. Y., a corporation of Delaware

Application April 10, 1935, Serial No. 15,729

9 Claims. (Cl. 23—270)

The present invention relates to countercurrent liquid contact apparatus and more particularly to mixing devices for promoting liquid contact.

The liquid contact apparatus of the type described herein is of value, for example, in the solvent extraction of lubricating oils for separa-

intermediate chambers. The liquids in each chamber settle into two layers, namely, a heavy layer comprising primarily cresylic acid with dissolved oils and a light layer comprising largely propane with dissolved oils. The proportions of materials vary from chamber to chamber and in general, the heavy layer has increasing propor-

CERTIFICATE OF CORRECTION.

Patent No. 2,091,709. August 31, 1937.

ARTHUR C. HAMPTON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 26, claim 9, for the word "mixtures" read mixers; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 12th day of October, A. D. 1937.

(Seal)

Henry Van Arsdale.
Acting Commissioner of Patents.

gram of the preferred form of apparatus for solvent extraction of lubricating oils; Fig. 2 is a section, on an enlarged scale, showing the details of the mixing apparatus; and Fig. 3 is a diagram of a modified form of apparatus.

The apparatus is herein illustrated as applied to the two-solvent method of separating a reduced crude into its paraffinic and naphthenic constituents. To this end, two immiscible solvents are employed, one a light solvent, such as propane, for extracting the paraffins and the other a relatively heavy solvent as cresylic acid for extracting the naphthenes. The reduced crude to be treated is introduced at an intermediate point of a countercurrent path along which the propane courses in one direction and the cresylic acid in the other.

The illustrated apparatus comprises a horizontal extraction cylinder having a series of extraction chambers numbered consecutively from 1 to 9. Propane is continuously introduced into the left-hand chamber **1** and cresylic acid into the right-hand chamber **8**, while the crude oil to be treated is introduced into one or more of the

tube **20** and the pipe **21**, the former is flared and immediately below the connection, the tube **20** is contracted, as indicated at **22**, whereby the liquid is drawn from the upper layer through the pipe **21** by injector action. The purpose of the spray head **18** is to introduce the liquid entering at **14** in a plurality of high velocity jets which converge in the restriction **22**, thereby promoting the injector action and preventing back flow through the pipe **21**.

The tube **20** is suitably supported at its upper end by a flange **24**. At the lower end, the pipe **22** leads into a plenum chamber **26** which extends completely across the extraction chamber and lies against the end wall **28** thereof. At the top of the plenum chamber and approximately at the interface of the light and heavy layers, there is a slot **30** extending across the chamber and opening into the next succeeding chamber.

As shown in Figs. 1 and 2, material from the bottom of chamber **7** is conducted by a pipe **32** to enter the mixer in chamber **5**. The flow of heavy material through the mixer acts to

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COUNTERCURRENT CONTACT APPARATUS

Arthur C. Hampton, Belleville, N. J., assignor to The Lummus Company, New York, N. Y., a corporation of Delaware

Application April 10, 1935, Serial No. 15,729

9 Claims. (Cl. 23—270)

The present invention relates to countercurrent liquid contact apparatus and more particularly to mixing devices for promoting liquid contact.

The liquid contact apparatus of the type described herein is of value, for example, in the solvent extraction of lubricating oils for separation of the naphthenic and paraffinic constituents. The apparatus comprises a series of extraction chambers, each of which contains two practically immiscible liquid layers of different densities and provision is made for progressing the materials of the two layers in opposite directions through the series of chambers. Existing apparatus has frequently been unsatisfactory either because of its failure to permit proper segregation of the liquid layers or because of variations in operation which tend to prevent differentiation of the liquids from chamber to chamber.

The principal object of the present invention is to provide countercurrent extraction apparatus which is dependable in continuous operation and which acts to promote proper contact and segregation of the liquids in the different chambers.

With this and other objects in view, as will hereinafter appear, the present invention comprises the apparatus hereinafter described and particularly defined in the claims.

In the accompanying drawings, Fig. 1 is a diagram of the preferred form of apparatus for solvent extraction of lubricating oils; Fig. 2 is a section, on an enlarged scale, showing the details of the mixing apparatus; and Fig. 3 is a diagram of a modified form of apparatus.

The apparatus is herein illustrated as applied to the two-solvent method of separating a reduced crude into its paraffinic and naphthenic constituents. To this end, two immiscible solvents are employed, one a light solvent, such as propane, for extracting the paraffins and the other a relatively heavy solvent as cresylic acid for extracting the naphthenes. The reduced crude to be treated is introduced at an intermediate point of a countercurrent path along which the propane courses in one direction and the cresylic acid in the other.

The illustrated apparatus comprises a horizontal extraction cylinder having a series of extraction chambers numbered consecutively from 1 to 9. Propane is continuously introduced into the left-hand chamber 1 and cresylic acid into the right-hand chamber 8, while the crude oil to be treated is introduced into one or more of the intermediate chambers. The liquids in each chamber settle into two layers, namely, a heavy layer comprising primarily cresylic acid with dissolved oils and a light layer comprising largely propane with dissolved oils. The proportions of materials vary from chamber to chamber and in general, the heavy layer has increasing proportions of naphthenes progressing from right to left, while the light layer has increasing proportions of paraffins progressing from left to right. In the chamber 1, the heavy layer comprises mainly cresylic acid with naphthenes in solution while in chamber No. 9, the light layer comprises mainly propane with paraffins in solution.

Included in each chamber, except the last, is a mixing device indicated generally at 10. To produce the general countercurrent flow of liquids, material is continuously pumped from the heavy layer of each of the chambers from 3 to 9 inclusive into the mixer of a preceding chamber. Thus, for example, a pipe 12 is connected from the bottom of chamber 3 leading to the mixer in chamber 1.

As shown in Fig. 2, each mixer comprises a nozzle 14 external to the cylinder and having a flange 16 secured to the shell. At the bottom of the nozzle 14, there may be placed a spray head 18 for introducing the liquid in a plurality of jets into the tube 20. Branching from the tube 20 is an injector pipe 21 having an open end in the light layer. At the point of connection of the tube 20 and the pipe 21, the former is flared and immediately below the connection, the tube 20 is contracted, as indicated at 22, whereby the liquid is drawn from the upper layer through the pipe 21 by injector action. The purpose of the spray head 18 is to introduce the liquid entering at 14 in a plurality of high velocity jets which converge in the restriction 22, thereby promoting the injector action and preventing back flow through the pipe 21.

The tube 20 is suitably supported at its upper end by a flange 24. At the lower end, the pipe 22 leads into a plenum chamber 26 which extends completely across the extraction chamber and lies against the end wall 28 thereof. At the top of the plenum chamber and approximately at the interface of the light and heavy layers, there is a slot 30 extending across the chamber and opening into the next succeeding chamber.

As shown in Figs. 1 and 2, material from the bottom of chamber 7 is conducted by a pipe 32 to enter the mixer in chamber 5. The flow of heavy material through the mixer acts to withdraw material from the upper layer of chamber 5 and to introduce a mixture of both materials into chamber 6. The action is therefore to introduce material from the heavy layer of chamber 7 and from the light layer of chamber 5 into chamber 6. The apparatus gives high velocity with turbulence and consequent effective contact between the liquid particles in the region 20. In the settling tank itself, however, turbulence is undesirable because it would mix the previously settled layers. The plenum chamber forms a transition space of large volume wherein the velocity is lowered and the liquid is brought to a relatively quiescent condition prior to its introduction into the settling chamber. The introduction of the mixture into chamber 6 results in some agitation of the liquids at the interface, thereby promoting the effective surface contact of the particles of the liquids. This turbulence is, however, largely confined to a small region immediately above and below the interface, so that the previously settled layers of liquid are not unduly disturbed.

Although the mixer by which liquid is introduced into chamber 6, for example, is, for reasons of convenience, physically placed within chamber 5, the invention does not require such disposition of the mixer. The mixer may be disposed anywhere so long as it operates to promote the countercurrent passage of light and heavy liquids.

The same action occurs for all of the chambers. There is therefore a continuous progression of heavy material toward the left and of light material toward the right. The heavy layer becomes enriched in naphthenes as it progresses toward chamber 1 and the light layer becomes enriched in paraffins as it progresses in the opposite direction.

The introduction of the crude oil to be treated is by pipe 34, the open end of which points directly into the open end of the injector pipe 21. The crude may be introduced into one or more of the chambers, as shown in Fig. 1. For those mixers into which the crude oil is introduced, the injector handles a portion of the crude as well as a part of the material of the light layer.

In the arrangement shown in Fig. 1, propane is pumped continuously into chamber 1 in mixture with heavy material pumped from chamber 2 through a pipe 36. Cresylic acid is introduced by the pipe 38 into the mixer in chamber 8, and enters the final chamber 9 in mixture with material obtained from the upper layer of chamber 8. The naphthenes dissolved in cresylic acid and possibly mixed with a small quantity of propane, are continuously withdrawn from the lower layer of chamber 1 by a pipe 40, and the paraffins dissolved in propane and possibly mixed with a small quantity of cresylic acid are continuously withdrawn from the upper layer of chamber 9 by a pipe 42. The pipes 40 and 42 lead to suitable solvent recovery apparatus, by which the extracted oils are separated from the solvents.

The apparatus affords maximum reliability and efficiency of contact. Since the injector pipe 21 of each chamber is disposed at all times entirely in the upper layer, and since the heavy material is withdrawn from the bottom of each chamber, the operation is not materially affected by fluctuations in the height of the interface. Furthermore, the rate of withdrawal of light material from any chamber is dependent upon the rate of flow of heavy material through the mixer, so that proper proportions in the mixture are always maintained.

The modified apparatus shown in Fig. 3 comprises a series of individual extraction chambers or vessels, each with an external mixing device. Only three vessels are shown, designated as 6′, 7′ and 8′, corresponding to the chambers 6, 7 and 8 of the apparatus of Fig. 1. Each chamber is provided with a mixer 50, of the same general form as those shown in Fig. 2, having an injector pipe 52 connected by a pipe 54 with the upper layer of the preceding chamber. Material from the lower layer of the succeeding chamber is pumped into the top of the mixing device, and the mixture of materials is introduced into the corresponding extraction vessel approximately at the interface of the two layers. The operation is identical with that taking place in the apparatus of Figs. 1 and 2.

Although the invention has been described as embodied in a method and apparatus for extracting the paraffinic and naphthenic portions of petroleum oils, it will be understood that the invention is not limited to such use but may be employed for other purposes involving the countercurrent flow of liquids.

Having thus described the invention, what is claimed is:

1. In countercurrent extraction apparatus having a succession of chambers to maintain an upper layer and a lower layer of liquid, a mixer having an outlet leading into one of the chambers, and having two inlets, one of said inlets being connected with one layer of one adjacent chamber, means for forcing liquid from the other layer of the other adjacent chamber into the second inlet, the mixer being constructed to take liquid by injector action through the first inlet, and a plenum chamber into which the liquids flow between the inlets and the outlet.

2. In countercurrent extraction apparatus having a succession of chambers to maintain an upper layer and a lower layer of liquid, a mixer having an outlet leading into one of the chambers, and having two inlets, one of said inlets being an injector pipe disposed in the upper layer of one adjacent chamber, a connection from the lower layer of the other adjacent chamber to the other inlet, and a plenum chamber into which the liquids flow between the inlets and the outlet.

3. In countercurrent extraction apparatus having a succession of chambers to maintain an upper layer and a lower layer of liquid, a mixer having an outlet leading into one of the chambers, and having two inlets, one of said inlets being disposed in one layer of one adjacent chamber, means for forcing liquid from the other layer of the other adjacent chamber into the second inlet, the mixer being constructed to take liquid by injector action through the first inlet, and a plenum chamber into which the liquids flow between the inlets and the outlet, said outlet being disposed approximately at the interface of the liquid layers in the chamber.

4. In countercurrent extraction apparatus having a succession of chambers to maintain an upper layer and a lower layer of liquid, a mixer having an outlet leading into one of the chambers, and having two inlets, one of said inlets being an injector pipe disposed in the upper layer of one adjacent chamber, a connection from the lower layer of the other adjacent chamber to the other inlet, and a plenum chamber into which

the liquids flow between the inlets and the outlet, said outlet being disposed approximately at the interface of the liquid layers in the chamber.

5. In countercurrent extraction apparatus having a succession of extraction chambers, each maintaining an upper layer and a lower layer of liquid, a mixer having an outlet to discharge into one of the chambers, inlets for the mixer connected with the upper layer of a chamber at one side and the lower layer of a chamber at the other side of the chamber into which the mixer discharges, the mixer having provision for turbulently mixing the liquids entering the inlets, and a plenum chamber between the inlets and the outlet.

6. In countercurrent extraction apparatus having a succession of extraction chambers, each maintaining an upper layer and a lower layer of liquid, a mixer having an outlet to discharge into one of the chambers, inlets for the mixer connected with the upper layer of a chamber at one side and the lower layer of a chamber at the other side of the chamber into which the mixer discharges, the mixer having provision for turbulently mixing the liquids entering the inlets, and means providing a substantial enlargement of the passage through which the mixed liquid flows to lower the velocity of the mixed liquid prior to its discharge through the outlet of the mixer into the corresponding chamber.

7. In countercurrent extraction apparatus having a succession of extraction chambers, each maintaining an upper layer and a lower layer of liquid, a mixer having an outlet to discharge into one of the chambers, inlets for the mixer connected with the upper layer of one adjacent chamber and the lower layer of the other adjacent chamber, the mixer having provision for turbulently mixing the liquids entering the inlets, and means providing a substantial enlargement of the passage through which the mixed liquid flows to lower the velocity of the mixed liquid prior to its discharge through the outlet of the mixer into the corresponding chamber.

8. In countercurrent extraction apparatus having a succession of extraction chambers, each maintaining an upper layer and a lower layer of liquid, a mixer having an outlet to discharge into one of the chambers, inlets for the mixer connected with the upper layer of a chamber at one side and the lower layer of a chamber at the other side of the chamber into which the mixer discharges, means for pumping liquid into one of the inlets, means for injecting liquid into the other inlet by the flow of the first liquid to produce a turbulent mixing of the liquids, and means providing a substantial enlargement of the passage through which the mixed liquid flows to lower the velocity of the mixed liquid prior to its discharge through the outlet of the mixer into the corresponding chamber.

9. In countercurrent extraction apparatus having a succession of extraction chambers, each maintaining an upper layer and a lower layer of liquid, a plurality of mixtures, one for each of several of the chambers and having an outlet to discharge into its corresponding chamber, two inlets for each mixer connected respectively with the upper and lower layers of adjacent chambers, means for turbulently mixing the liquids introduced into the inlets, and means providing a substantial enlargement of the passage through which the mixed liquid flows to lower the velocity of the mixed liquid prior to its discharge through the outlet of the mixer into the corresponding chamber.

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April 13, 1937. J. W. POOLE 2,077,057

APPARATUS FOR SOLVENT REFINEMENT OF HYDROCARBONS

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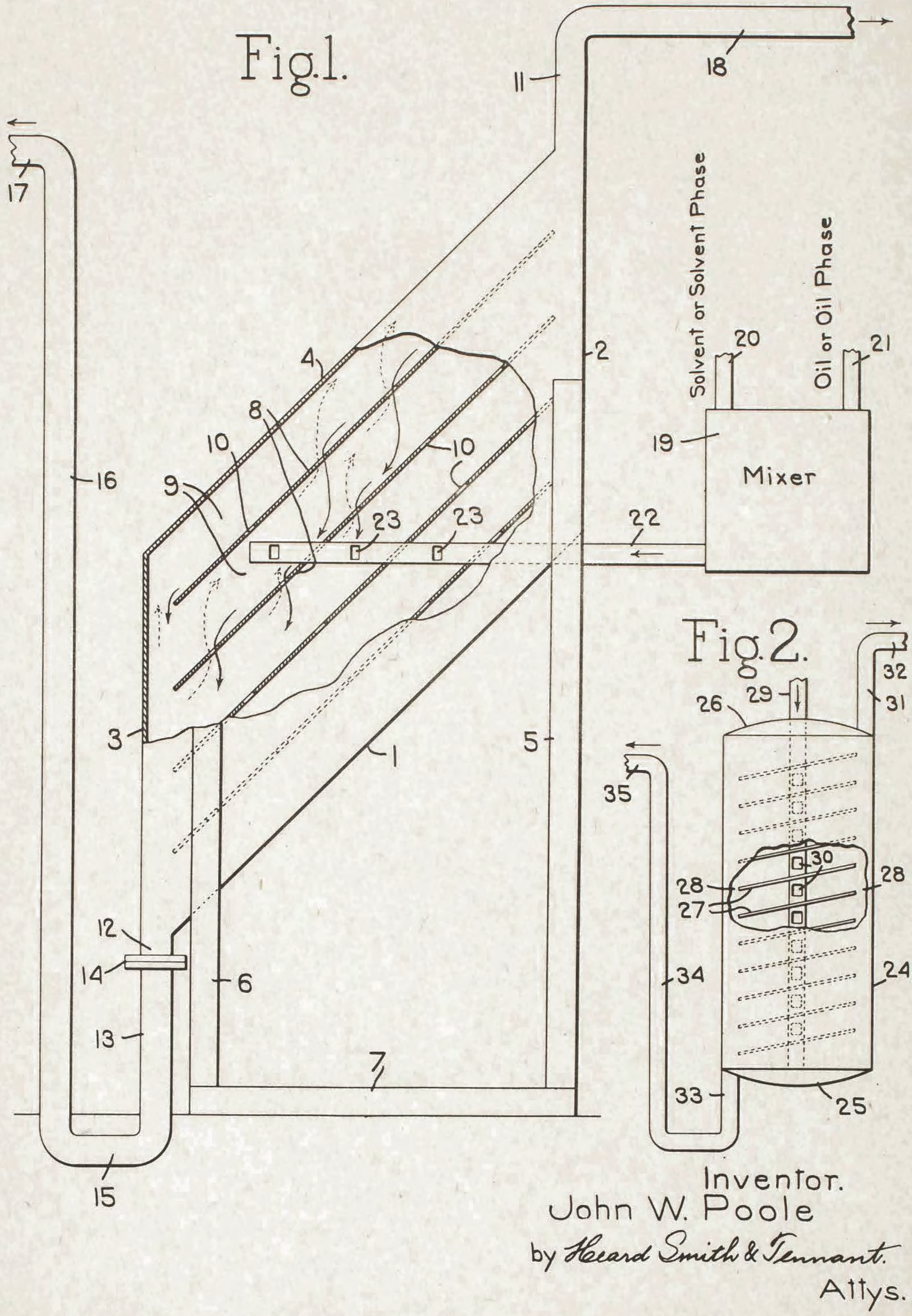

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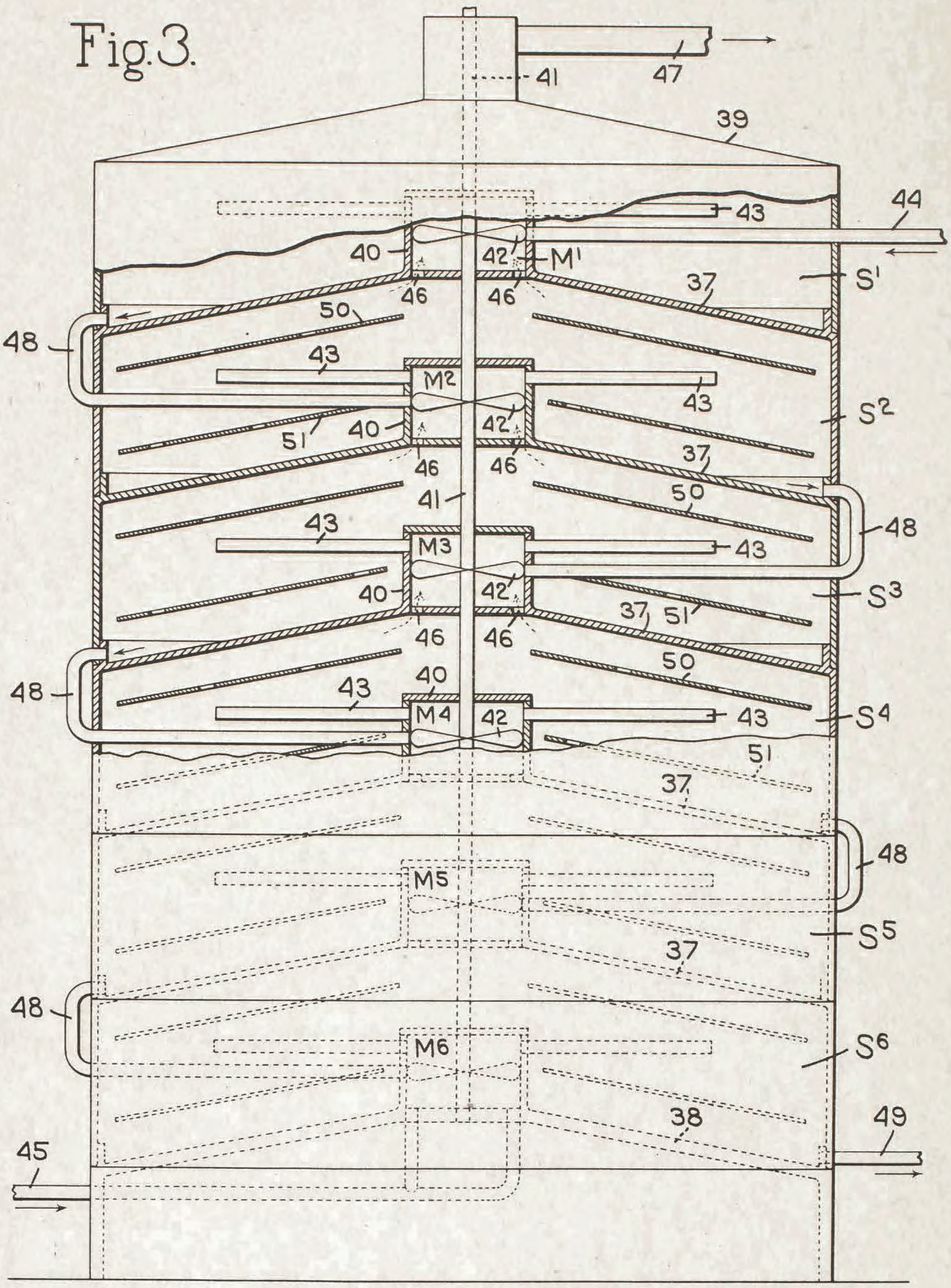
APPARATUS FOR SOLVENT REFINEMENT OF HYDROCARBONS

Filed Sept. 21, 1934 3 Sheets-Sheet 2

Fig. 3.



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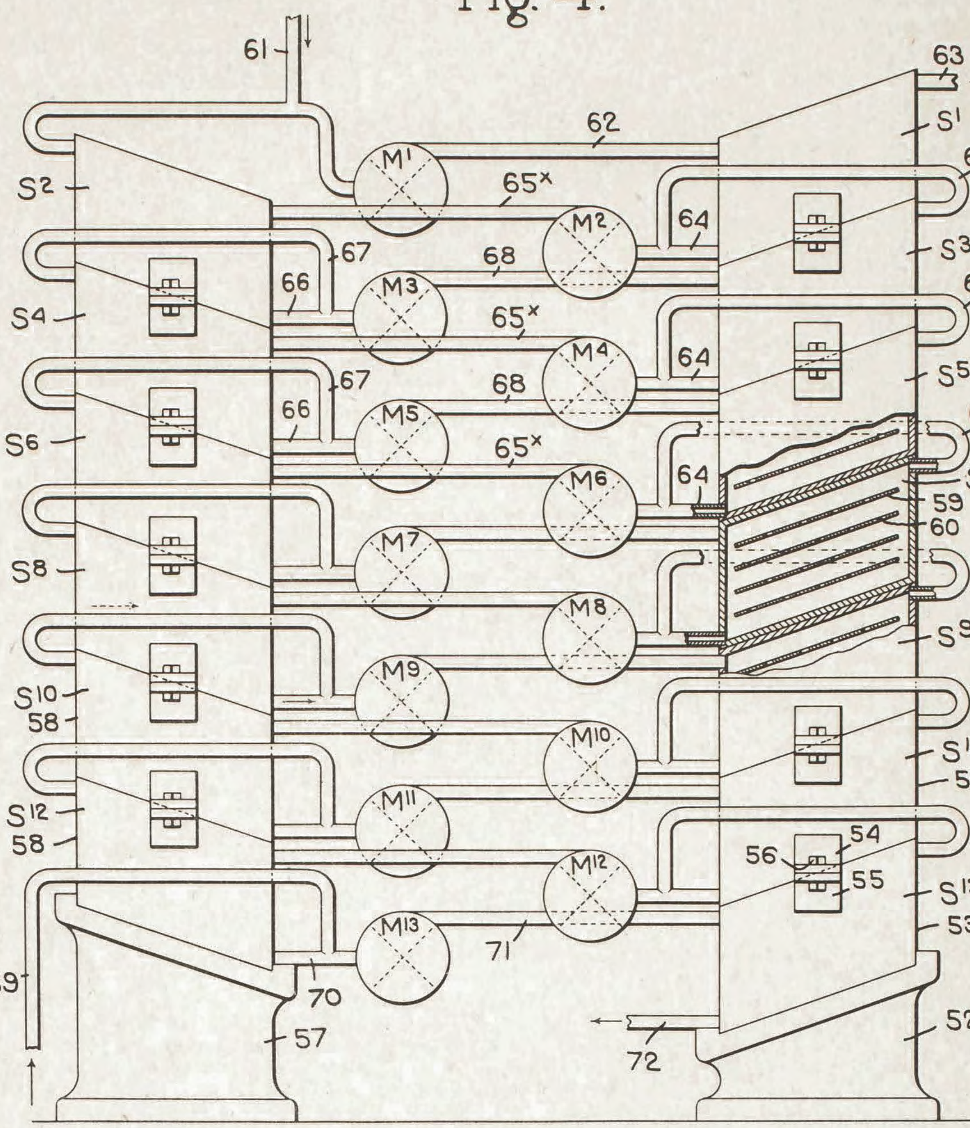
APPARATUS FOR SOLVENT REFINEMENT OF HYDROCARBONS

Filed Sept. 21, 1934 3 Sheets-Sheet 3

Fig. 4.



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Patented Apr. 13, 1937

2,077,057

UNITED STATES PATENT OFFICE

2,077,057

APPARATUS FOR SOLVENT REFINEMENT OF HYDROCARBONS

John W. Poole, Jaffrey, N. H.

Application September 21, 1934, Serial No. 744,874

18 Claims. (Cl. 196—13)

This invention relates to improvements in apparatus for use in processes of solvent extraction of mixtures of hydrocarbons and/or hydrocarbon derivatives, and the general object of the invention is to provide mechanism for more rapidly and effectively separating the oil phase and the solvent phase, thereby speeding up production.

A further object of the invention is to provide an apparatus of the character above described smaller in size but equal in capacity to previous types of apparatus and which can be easily and economically constructed.

In the present disclosure the term "hydrocarbons" is employed in a broad sense as defining not only hydrocarbons but compounds derived from hydrocarbons, such as asphalts, asphaltenes, and hydrocarbon derivatives containing sulphur, nitrogen, etc.

As is well known, any process of solvent extraction as at present practised comprises two important steps which are directly opposite in nature each from the other. Primarily solvent extraction is practised by thoroughly mixing the solvent used with the material to be extracted in order to attain as near as possible to the conditions of equilibrium, i. e. in order to attain as nearly as possible to the maximum extractive efficiency of the solvent used. Subsequent to this step the mixture is separated either by settling and decantation or by other means such as centrifuging. In general, centrifuging and gravity settling comprise the two most important methods of effecting such separation. This separation should be complete and definite in order that the process may operate at its maximum efficiency. In general, any solvent process will be operated by a succession of stages such as described above, wherein flow of solvent and the material to be processed is maintained countercurrent. However, regardless of the sequence of steps, the efficiency of the process depends on the efficiency of the steps of successively mixing and separating.

With many solvents the step of separating the two phases which co-exist in the material passing from the mixing stage to the separation stage is so slow that settling chambers of extreme size or separation by centrifuge is necessary. From my experiments and observations, I have discovered that settling is roughly proportional to the distance through which globules of the separating phases must settle. For example, settling through a twelve inch column of material will be accomplished in roughly one-half the time as would settling through a twenty-four inch column, although, due to a slight degree of coagulation of particles during their passage through the mixture, a slight tendency does exist to decrease the time required over that indicated by the inverse ratio of the settling distance.

One of the principal objects of the present invention is to provide a novel settling chamber for use in solvent extraction in which, if necessary, the effect of considerable height of column necessary to produce sharp delineation between the solvent phase and the oil phase is preserved and at the same time to provide means for producing the effect of short settling distances for the particles to be separated and coagulated from the mixture entering the separating chamber.

I have discovered that the rate of coagulation, which is slow during the actual settling period, takes place readily when two particles of the same phase become superimposed upon each other, so that by virtue of their weight, coagulation thereof is enforced. In other words, providing the heavier material in the dispersed phase coagulation is found to take place mainly at the bottom of a settling chamber after the individual globules have settled through the dispersing medium. Furthermore, it is well known that as globules increase in size because of coagulation, settling is increased in speed.

A further object of the invention is to provide an apparatus comprising a series of mixers for the hydrocarbon and solvent and a complementary series of settling chambers of the character above described embodying the invention through which solvent extraction of the hydrocarbon mixture may be progressively effected and countercurrent flow of the respective phases maintained by gravitational force, thereby to simplify the plant, to reduce the expense of installation, and to render the process of solvent extraction more profitable.

Illustrative apparatus embodying the invention is shown in the accompanying drawings, in which:

Fig. 1 is a view, partly in vertical section, of a preferred form of settling chamber embodying the invention;

Fig. 2 is a view of a modified form of settling chamber, a portion of the outer wall of which is broken away;

Fig. 3 is a view, partly in vertical section, illustrating an apparatus providing a complete extraction plant in a single upright vessel, in which a vertical series of settling tanks of the character above described are provided with mixers complementary to each settling chamber drawing heavy material from the settling chamber next above and light material from the settling chamber next below; and

Fig. 4 is a view, partly in section, of an apparatus comprising two vertical series of settling chambers with mixers associated with each of the chambers of one series, drawing heavy material from the lower portion of one chamber and light material from the top chamber therebeneath and discharging it into a complementary settling chamber of the other series, thus providing a separation plant of relatively low height, but of large capacity.

In the commercial practice of solvent separation it is common practice to utilize vertical settling tanks of sufficient dimensions to secure approximately complete settling of the two phases and ordinarily such tanks are constructed to vertical height of several feet, so that the settling particles must pass several feet through the mixture contained in the tank.

One of the principal objects of the present invention, as heretofore pointed out, is to provide a novel settling tank for use in solvent extraction in which the effect of considerable height of column necessary to produce sharp delineations between the solvent phase and oil phase is preserved, but will produce satisfactory separation of the phases by short settling distances for the heavier particles, with means for aiding coagulation of the heavier particles.

Preferred forms of settling tanks adapted to perform this function are illustrated in the accompanying drawings.

The construction illustrated in Fig. 1 comprises a settling chamber, preferably longitudinally in the form of a parallelogram, and of rectangular cross section, having a base 1 which is inclined to the horizontal, vertical ends 2 and 3, and a top 4, inclined to the horizontal in substantial parallelism with the bottom 1. The settling tank may be made of any suitable material and supported upon suitable columns 5 and 6 from a base 7. A series of baffle walls 8 extend in parallelism to the lower and upper walls 1 and 4 and terminate short of the ends of the chamber, thereby dividing the chamber longitudinally into a series of compartments 9 which are intercommunicating at their upper and lower ends with the chamber and with each other. These baffle walls or partitions desirably are provided with essentially horizontal slots 10 staggered in respect to those in adjacent partitions in such manner as to prevent short circuiting of the material flowing from one compartment to another.

The upper end of the settling chamber is provided with an outlet conduit 11 which may consist of a standard pipe of suitable diameter to permit the unrestricted flow of the light phase after separation from the mixture. At the bottom of the chamber is located a similar outlet 12 through which the heavy material is discharged from the separating chamber. Desirably a standard pipe 13 of suitable diameter is connected to the outlet 12 by a suitable coupling 14 and extends downwardly to or below the base of the machine where it is connected with a horizontal pipe 15 which in turn is connected to a vertical pipe 16 of sufficient length to form in conjunction with said separating chamber a so-called U-bend separator. The outlet 17 of the pipe 16 is arranged at such height in respect to the outlet 18 of the pipe 11 as to afford essentially automatic and independent discharge of the two phases.

The hydrocarbon and solvent phases introduced to a mixer 19 through pipes 20 and 21 are so dispersed by rapid agitation that there will be produced droplets of sufficient fineness to permit of rapid and easy extraction. The mixture is fed from the mixer through a pipe 22 which extends across the mixing chamber and is delivered to the various compartments therein through suitable orifices 23 communicating with the several compartments intermediate of their lengths.

Upon leaving the orifices 23 the mixture is shortly reduced in velocity to a sufficient degree to eliminate turbulence at which point settling begins. Assuming that the oil phase constitutes the heavier of the two phases to be separated, the path of the oil, which is indicated by solid line arrows, will then be as follows:—

Issuing horizontally through the orifice 23 the particle having become reduced below the point of turbulence will settle downwardly until it comes in contact with another particle or particles on the baffle wall 8. This coagulated material will then flow downwardly until it reaches the upper edge of a slot 10. It then passes downwardly as indicated by arrows to another baffle wall, thence downwardly on the baffle wall to another slot and so on until it reaches the outlet conduit 13. At each successive lower baffle wall there is a tendency to encounter other material of a similar nature and with the resulting effect that further coagulation will occur upon the baffle walls and settling by reason of the increased size of the drops, will become progressively easier and more rapid. The effect of these partitions is to reduce the vertical distance through which any individual oil particle must travel before it comes into contact with another particle in such a manner as to induce coagulation and by reason of increased particle size resulting from this coagulation, will continue to settle with increased rapidity.

The slots 10 in the baffle walls perform valuable service in the processing of certain types of stock. I have found that an oil phase which results from the mixing of a selected solvent with a petroleum fraction suitable for lubricating oil manufacture, which comprises high percentages of wax, will possess considerable structural strength at the temperatures of operation. It is not unusual to encounter waxy charging stocks possessing pour points as high as 110-degrees F. In consequence, at temperatures appreciably below the pour point, the waxy material in the oil phase will tend to impart such a high degree of tensile strength to the oil phase, that globules of solvent will be mechanically held within the oil phase, and provided no agitation of this phase takes place or no expressive forces are applied greater than the difference in gravity of the two phases, this mechanically restrained solvent phase will remain permanently held within the oil phase. Where the oil phase flows through the slots 10 this mechanically held material is largely worked out of the oil phase and allowed to rejoin other portions of the solvent phases which are flowing upwardly through the separator. The action by which this material is released is that of disruption of the waxy structure by passing over the edge of the slot. The change in direction of flow at this point may be described as similar to the bending of a bar of material and results in rupture of the upper surface of the waxy material which encloses the globules of solvent, thereby releasing it from confinement and permitting it to pass freely upwardly.

The passage of the solvent phase, which by assumption is the lighter phase, and which is indicated by broken line arrows, is in reality considerably more simple than that of the oil phase. In the first place, there is very little in the way of a coagulation problem. Except for the mechanically restrained globules of solvent previously mentioned, the solvent phase is in general continuous throughout and will flow freely from one portion of the settling chamber to any other, and as more material is charged to the settling chamber, it will continuously flow between particles of oil phase upwardly and out through the conduit **11** to the outlet **18** thereof. However, the baffle walls or partitions **8**, the utility of which has been previously discussed, in respect to the oil phase, also serve a desirable purpose with respect to the solvent phase. A typical portion of solvent phase will pass, upon issuance from an orifice **23**, in an upward direction until it reaches a zone existing along the under part of each baffle wall **8** through which such material will then flow freely. The baffle walls or partitions therefore serve to prevent the solvent phase from tending to re-mix and interfere with the flow of such oil droplets as have been carried to points higher in the settling chamber, but which have by this time started to coagulate and to descend, as heretofore described.

It has been found that the shape of the passages or channels through which separated or partially separated oil or solvent phase is to flow is an important factor in the efficiency and capacity of the apparatus. Desirably these passages should be straight, at least until flow of the phase in question has carried the material comprising that phase to a point in the apparatus where none of the other phase is present. It has been found that if these passages can be made straight or nearly so turbulence is reduced over that which would occur in a tortuous or curved channel. With phases that differ comparatively little in density the greater efficiency of an apparatus with straight passageways over one with curved walls can be considerable. An explanation of this fact can be found by considering the mechanics involved:—For example, in Fig. 1 the space between the vertical wall or end **3** and the terminals of the baffle walls **8** constitutes the passageway for the downward flow of the heavier phase. However, except near the bottom portion both phases will to some extent inevitably coexist within this channel, the quantity of the lighter phase steadily increasing the higher is the actual point within this channel. At a point above mid-height, the compartments **9** (even that portion of the compartment adjacent to the channel) tend to contain more of the lighter phase than of the heavier phase; furthermore, this channel is in effect two channels which may be termed "major" and "minor" channels, although these two channels are not physically separated by a partition. The major channel is that through which the heavier material flows downwardly and occupies the space between end **3** and baffle **8** which adjoins the latter. The other or minor channel acts as a scavenger for small amounts of lighter phase. Near the bottom it fades away to negligible importance; higher up, flow may even be greater through it than through the adjoining portion of the major channel. Conditions are analogous at the opposite side of the apparatus except conditions are inverted. It will be apparent, therefore, that any turbulence in these passageways, the exterior walls of which are supplied by ends **2** and **3**, will be most undesirable and tend to defeat separation by destruction of the minor channels, the substance of which then becomes merely an "adulterant" of the material flowing in the major channel. Furthermore, a turbulent condition set up in these areas has been found to transmit itself into adjacent portions of the compartments **9**, so that they in turn deliver material to the passageways which is less efficiently separated. In consequence, I have found it very desirable to avoid channels the walls of which are curved with respect to the line of flow. In practice therefore the convenient method of accomplishing this result is to use vessels having straight vertical walls.

By the use of this invention I have been able to produce in a settling chamber of greatly reduced size for a given capacity, solvent phase of purity equal to that which is generally produced by the use of settling chambers having a volumetric hold-up in excess of twice the hold-up possessed by the apparatus utilizing my invention. Furthermore, when processing a waxy stock, the oil phase issuing from the settling chamber embodying the present invention tends to be more free of mechanically held solvent phase than does similar material issuing from a conventional type of gravity separator.

In such instance, as the hydrocarbon charge to an extraction plant does not contain appreciable quantities of waxy and high melting substances, the use of slots in the partitions may be dispensed with. For example, in Fig. 2 is shown a settling chamber utilizing my invention which comprises a tubular, preferably cylindrical, shell **24** having a bottom **25**, and top **26**, and provided with narrowly spaced imperforate baffles **27** which in the plane shown do not extend the full width of the tubular shell **24**, thereby providing a series of compartments communicating with vertical channels **28** between the ends of the baffles or partitions and the shell **24**. The mixture to be separated may be introduced through a pipe **29** having orifices **30** communicating with the several compartments defined by the partitions **27**.

A pipe **31** leading from the upper end of the settling chamber is provided with an outlet **32** to discharge the lighter phase and a pipe **33** communicating with the lower end of the chamber serves to discharge the heavier phase. The pipe **33** has a vertical section **34** provided with an outlet **35** so arranged with respect to the height of the outlet **32** as to afford essentially automatic and independent discharge of the two phases, as above described.

By reason of the greatly decreased time necessary for settling in the improved settling chamber above described, the volume of the settling chamber may be radically reduced. Because of this fact it is possible to construct and operate an extraction plant of new and compact design, for example an apparatus of the so-called "tower" type, but which is free of the fundamental deficiencies to which such apparatus has heretofore been subject.

As has previously been stated, the two steps of mixing and settling are completely antithetical with respect to their accomplishments. In the case of one, turbulence is necessary. In the case of the other, turbulence is detrimental. It is then evident that to attempt to bring about the two steps,—mixing and settling—within a common chamber, is inconsistent, and that if conditions ideal for the accomplishment of one step are maintained, that of the other step will be impossible of accomplishment. Furthermore, any compromise from one ideal condition, to an intermediate state of turbulence, will result in a corresponding detriment to the other condition, and in consequence neither operation may take place at its maximum efficiency. Such a state of compromise is that which exists in the so-called extraction columns or towers as now operated. In such columns the heavier of the two materials, solvent and oil, is admitted near the top of an upright vessel, the lighter material being admitted near the bottom. In consequence, the two materials will tend to pass through the vessel in opposite directions, being so impelled by virtue of the difference in their respective densities. Such movement, may be reasonably rapid provided no great degree of turbulence exists in the system. However, in order that the first of the two steps, mixing to effect transfer of extracted material to the solvent, may be accelerated, it is customary to introduce a degree of turbulence by means of mixing devices. In short, a condition is established which is inconsistent both with efficient mixing and efficient settling in that turbulence must be comparatively low to allow some settling, and in consequence must be too low to cause the most efficient and speedy diffusion, therefore the efficiency of the process as a whole suffers in each of its essential steps.

In usual practice, this failure to attain a high efficiency is compensated for by increasing the length of the paths through which each phase must flow. Although by such lengthening it is theoretically possible to eventually attain a length of path which will give the same efficiency as would be produced in a smaller unit, in which complete efficiency of solvent was developed, such increase results in increased volume of solvent continuously held in the system and due to the comparatively high price of solvents, results in increased capital and operating costs. Furthermore, it may also result in the use of unnecessarily large volumes of solvent which must later be recovered by distillation and consequent consumption of energy.

I have discovered that by dividing such an extraction tower into definite mixing and settling zones, in which neither of the two steps,—mixing and settling—may interfere with the operation of the other, that it is possible to greatly increase the efficiency of such towers and thereby correspondingly to reduce their size to effect the same degree of extraction. To accomplish this result and to secure complete countercurrent flow, one phase is bypassed from the settling stage around the corresponding mixing stage. This constitutes an important feature of the present invention. An illustrative embodiment of the invention in which the length of the tower is reduced by the employment of settling chambers of the character above described is shown in Fig. 3 and comprises a preferably cylindrical shell **36** having therein a superimposed series of settling chambers S1, S2, S3, S4, S5, S6, which may be formed by conoidal partitions **37** which form the base of one settling chamber and the top of the chamber below. The lowermost chamber has a corresponding conoidal base **38** of much heavier material as it necessarily supports all of the liquid of the several chambers. The top **39** of the uppermost chamber S1, likewise desirably is of conoidal form and spaced the same distance from the bottom of said chamber as the spacing of the tops and bottoms of the other chambers.

The central portions of the base **38** of the separating chambers and the partitions **37** desirably support the casings **40** of suitable mixing chambers M1, M2, M3, M4, M5, M6, and a vertical shaft **41** extending axially through the mixing chambers is provided with suitable vanes **42**, preferably disposed at such angles to the horizontal as will propel the liquid in the mixing chamber gently upwardly. Distributing conduits **43** extend outwardly from the upper portions of the mixing chamber to such distance as to discharge the material from the mixing chamber approximately midway of the radius of the settling chambers.

The heavy material is supplied through a pipe **44** to the mixer M1, from which it is forced through the pipe **43** into the settling chamber S1. The light material is introduced through the pipe **45** into the lower mixing chamber M6 in which it is mixed with heavy material taken from the next higher settling chamber S5. The mixture of light and heavy material is discharged from the mixer M6 through the outlet pipe **43** into the settling chamber S6 where the lighter material rises to the top and enters the mixing chamber M5 while the heavy material is discharged through the outlet **49**.

The bottom of each of the mixing chambers M5, M4, M3, M2, M1, is provided with ports **46** which communicate with the upper portion of the settling chamber therebeneath, so that the lighter material is progressively fed from each of the settling chambers to the mixer of the chamber next above, as indicated by broken line arrows, and finally to the uppermost chamber S1, from which it passes through an outlet pipe **47** from the extractive plant for proper subsequent treatment.

In each of the mixing chambers a mixture of light and heavy material is discharged through the pipe **43** into the settling chamber corresponding thereto. The heavy material, which is introduced through the pipe **44** into the mixing chamber M1, and thence through the pipe **43** into the settling chamber S1, descends by gravity to the bottom of the chamber, and passes therefrom through an outlet bypass **48** to the mixer M2 of the settling chamber S2 therebeneath, as illustrated by full line arrows. Similarly, the heavy material passes along the bottom of each of the lower settling chambers S2, S3, S4, S5, through similar bypasses to the mixer of the chamber next beneath, and is finally discharged from the lower portion of the settling chamber S6 through a delivery conduit **49**.

Each of the settling chambers desirably is provided with a plurality of partitions or baffles **50** and **51**, which are spaced apart in such manner as to divide the settling chamber into a plurality of compartments communicating with each other, and serve to divert the descent of particles of the dispersed material and cause coagulation thereof as above described, thereby increasing the rapidity of separation of the heavier material from the light and thereby enabling the size of the settling chamber to be reduced.

While in the above description the base **38** and the partitions **37** are illustrated and described as inclining downwardly toward the circumference of the shell, it is obvious that the same effect would be obtained if the construction shown were inverted so that the partitions would extend upwardly instead of downwardly with the mixing chambers located beneath said partitions instead of superimposed thereupon. In such case the broken and heavy line arrows indicating the direction of flow of the light and heavy materials would be reversed. This may be easily noted by inverting the drawing, Fig. 3.

A further modification of the invention illustrating a convenient manner of forming a duplex-tower of greater capacity is shown in Fig. 4. The construction shown in Fig. 4 is one more economical for plants of large capacity than would be the construction illustrated in Fig. 3, although the actual operation of the two types would differ in no essential detail.

In the construction illustrated in Fig. 4, two series of superimposed settling units of the character above described are employed with mixers having inlets communicating respectively with the bottom and upper portions of two adjacent settling chambers of one series and discharging into a corresponding settling chamber of the other series. In this construction countercurrent flow of the light and heavy materials is maintained, but for structural reasons the separating chambers are arranged in two columns composed of separators which with respect to the flow of heavy material through the system may be designated by alternate numbers. Furthermore, the respective settling chambers are manufactured as identical interchangeable units. In addition, the various mixers are also manufactured as identical interchangeable units. By virtue of this type of construction there arises certain advantages particularly with respect to extraction plants of large capacity. By arrangement of alternate separators in a single column countercurrent flow with respect to a single stage which requires that light material be delivered from one adjacent separator and that heavy material be delivered from the other adjacent separator, is more easily attained. Therefore, the material to be delivered to any one mixer will be drawn from settling chambers which are structurally adjacent in one series each to the other although from the viewpoint of flow through the system they are not consecutive. In this manner the necessary piping and connections are less complicated and more simple of installation. Furthermore, by reducing the separate units of a solvent plant to a few identical and interchangeable units, the actual manufacture of such a plant is simplified and construction costs reduced. The separate units completely assembled may be shop manufactured and after transportation to the desired site may be readily erected with a minimum of field construction. Again, due to the interchangeability of various units, the number of stages of a plant may be easily increased and in case of damage to one or more units, replacement can be readily effected. In addition, by simplification and standardization of the various parts, advantage may be taken of the resulting reduction in engineering and fabrication costs.

As illustrated in Fig. 4, one of the series comprises a suitable base **52** upon which is superimposed a series of preferably identical settling chamber units **53** which may be secured together in any suitable manner as by flanged plates **54** and **55** welded to the sides of adjacent units and having their horizontal flanges secured together by bolts **56** to form a rigid construction. The other series comprises a base **57** having superimposed thereupon a series of separator chamber units **58** in all respects like the units **53** and secured together in a like manner. Each of the separator units desirably is of the form illustrated in Fig. 1 and may be provided with inclined partitions **59** dividing the same into a series of compartments, the partitions being provided with apertures **60** which are so disposed that the apertures in the several partitions are in staggered arrangement.

In this construction the heavy material is introduced through a pipe **61** into the mixer **M1**, from which it is discharged through the pipe **62** into the uppermost mixing chamber **S1**. The lighter material is also drawn from the upper end of the mixing chamber **S2** of the other series and mixed with the heavier material is discharged through the pipe **62** into the separator **S1** and is discharged from the upper portion of the mixer **S1** through the outlet pipe **63**.

The heavy material in the settling chamber **S1** settles to the bottom of said chamber and passes therefrom through a pipe **64** to the mixer **M2**. At the same time light material is taken from the upper portion of the separator chamber **S3** through a pipe **65** to the mixer **M2** and after having been mixed with the heavy material from the chamber **S1** is discharged from the mixer **M2** through the pipe **65**x into the settling chamber **S2**. Similarly, the heavy material is drawn from the lower portion of the settling chamber **S2** through a pipe **66** into the mixer **M3** and light material is drawn from the upper portion of the chamber **S4** through a pipe **67** to the mixer **M3** from which the mixture of light and heavy material is discharged through a pipe **68** to the settling chamber **S3**. Similarly, denoting a typical mixer between **M4** and **M12** inclusive as Mn, light material will be drawn to mixer Mn from separator S$n+1$ and heavy material from separator S$n-1$ for any number of separators of the series. In order to provide for the counterflow through the system the light material is introduced through the pipe **69** into the lowermost mixer **M13** and finally discharged through the pipe **63** from the uppermost chamber **S1**, while the heavy material is introduced through the pipe **61** into the mixer **M1** and finally discharged from the lowermost chamber **S13** of the series through the outlet pipe **72**.

It will be obvious that the embodiments of the invention specifically described herein are of an illustrative character and that various changes in construction and arrangement may be made within the spirit and scope of the following claims. For example, it may be mentioned that four series of superimposed settling chambers may be employed and the settlers so staggered with respect to relative arrangement that the heavy material drawn from S$n+1$ and the light material drawn from S$n-1$ to mixer Mn may be delivered at the same level thereby resulting in further simplification of the necessary connections.

Having thus described the invention, what is claimed as new, and desired to be secured by Letters Patent, is:

1. Apparatus for refining hydrocarbons by selective solvent action comprising a settling chamber having straight vertical walls, means for introducing into said chamber a mixture of said hydrocarbons and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities one of which is a dispersed phase, a plurality of narrowly spaced baffle walls within said chamber having a minimum inclination to the horizontal consistent

with the free movement of the separated phases acting so to divert the direction of flow of the droplets of the dispersed phase as to facilitate rapid accumulation and coagulation thereof, and means for separately delivering the respective phases from upper and lower portions of said chamber.

2. Apparatus for refining a petroleum substance by selective solvent action comprising a settling chamber having straight vertical walls, means for introducing into said chamber a mixture of said substance and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities one of which is a dispersed phase, a vertical series of narrowly spaced baffle walls having a minimum inclination to the horizontal consistent with the free movement of the separated phases and dividing the chamber into a plurality of communicating compartments of small height, said baffle walls having apertures arranged to change the direction of gravitational flow of the respective phases and acting to release such particles of one phase as may be entrained in the other, and means for delivering the respective phases from the upper and lower portions of said chamber.

3. Apparatus for refining a petroleum substance by selective solvent action comprising a settling chamber having straight vertical walls, means for introducing into said chamber a mixture of said substance and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities one of which is a dispersed phase, said chamber having narrowly spaced baffle walls acting so to divert the direction of flow of the droplets of the dispersed phase as to produce rapid accumulation and coagulation thereof, and discharge pipes having legs communicating respectively with the top and bottom portions of said chamber separately delivering the respective phases from said chamber and so arranged as to form a trap, the effective legs of which are of such relative height that delivery of the quantity of each phase produced will be automatically and continuously effected.

4. Apparatus for refining a petroleum substance by selective solvent action comprising a settling chamber having vertical walls, means for introducing into said chamber a mixture of said substance and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities one of which is a dispersed phase, a plurality of narrowly spaced parallel baffle walls inclined to the horizontal within said chamber providing a series of communicating settling compartments of vertical heights small in comparison with the other dimensions of the chamber by means of which the vertical distance through which a settling particle must pass before encountering other particles under conditions which will accelerate coagulation will be decreased, said compartments communicating with straight vertical passageways separately delivering the respective phases from the upper and lower portions of the chamber.

5. Apparatus for refining a petroleum substance by selective solvent action comprising a settling chamber having vertical walls, means for introducing into said chamber a mixture of said substance and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities one of which is a dispersed phase, a plurality of inclined narrowly spaced parallel baffle walls inclined to the horizontal and terminating short of the end walls thereof to provide straight vertical passageways and a series of settling compartments communicating therewith of vertical height small in comparison with other dimensions of the chamber by means of which the vertical distance through which a settling particle must pass before encountering other like particles will be decreased, means for separately delivering the respective phases from the upper and lower portions of the chamber comprising conduits for the respective phases communicating respectively with said passageways at the upper and lower portions of the settling chamber and of proper cross sectional area to permit unrestricted flow of said phases but not to excessively increase the hold-up of the solvent.

6. Apparatus for refining hydrocarbons by selective solvent action comprising a series of mixers and a vertical series of complementary superimposed settling chamber units having straight vertical walls, means for supplying hydrocarbon to the mixer at one end of said series, means for supplying solvent to the mixer at the other end of said series, means for delivering the oil phase and solvent phase to each mixer and the mixture thereof to the complementary settling chamber in such manner as to maintain a true countercurrent flow by gravitational forces, baffle walls in each settling chamber having a minimum inclination to the horizontal consistent with the free movement of the separated phases acting so to divert the direction of flow of the droplets of the dispersed phase as to produce rapid accumulation and coagulation thereof, and means for delivering one phase from the upper end of said series and the other phase from the lower end thereof.

7. Apparatus for refining hydrocarbons by selective solvent action comprising a series of settling chambers arranged in a plurality of columns with the settling chambers of said series alternating in the respective columns, a power actuated mixer complementary to each of said settling chambers having inlets communicating respectively with the bottom and upper portions of two adjacent settling chambers in the same column, and a discharge outlet communicating with its complementary settling chamber of another column, means for introducing the hydrocarbon at one end of said series, means for introducing the solvent at the other end of said series of settling chambers, and means for delivering the lighter phase from the uppermost of said series and the heavier phase from the lowermost of said series.

8. Apparatus for refining hydrocarbons by selective solvent action comprising a series of settling chambers arranged in two columns with the settling chambers of said series alternating in the respective columns, a power actuated mixer complementary to each of said settling chambers having inlets communicating respectively with the bottom and upper portions of two adjacent settling chambers in the same column, and a discharge outlet communicating with its complementary settling chamber of another column, means for introducing the heavier material into the mixer having an inlet communicating with the upper portion of the upper settling chamber of one column, means for introducing the lighter material into the mixer having an inlet communicating with the bottom of the lowermost settling chamber of the same column, and means for discharging the lighter and heavier phases respectively from the top of the uppermost and

the bottom of the lowermost separators of the other column.

9. Apparatus for refining hydrocarbons by selective solvent action comprising a series of settling chambers arranged in a plurality of columns with the settling chambers of said series alternating in the respective columns, a mixer complementary to each of said settling chambers having inlets communicating respectively with the bottom and upper portions of two adjacent settling chambers in the same column, and a discharge outlet communicating with its complementary settling chamber of another column, means for introducing the hydrocarbon at one end of said series, means for introducing the solvent at the other end of said series of settling chambers, means for delivering the lighter phase from the uppermost of said series and the heavier phase from the lowermost of said series, and baffle walls in each of said settling chambers inclined to the horizontal and terminating short of the ends of said chambers dividing the respective chambers into communicating compartments of relatively short height and acting to facilitate coagulation of the descending droplets of the dispersed material.

10. Apparatus for refining hydrocarbons by selective solvent action comprising a series of settling chambers arranged in a plurality of columns with the settling chambers of said series alternating in the respective columns, a mixer complementary to each of said settling chambers having inlets communicating respectively with the bottom and upper portions of two adjacent settling chambers in the same column, and a discharge outlet communicating with its complementary settling chamber of another column, means for introducing the hydrocarbon at one end of said series, means for introducing the solvent at the other end of said series of settling chambers, means for delivering the lighter phase from the uppermost of said series and the heavier phase from the lowermost of said series, a plurality of baffle walls in each settling chamber inclined to the horizontal and terminating short of the ends of said chamber dividing the respective settling chambers into a plurality of compartments of relatively short height acting to facilitate coagulation of descending droplets of dispersed material, said baffle walls being provided with apertures in vertically staggered arrangement and acting to facilitate the release from the heavier material passing therethrough of such lighter material as is entrained therein.

11. Apparatus for refining hydrocarbons by selective solvent action comprising a settling chamber, within said chamber a plurality of narrowly spaced baffle walls having a minimum inclination from the horizontal consistent with the free movement of fluids present, means for delivering at a plurality of points between different pairs of baffle walls a mixture of said hydrocarbons and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities, and means for separately delivering the respective phases from the upper and lower sections of said chamber.

12. Apparatus for refining a petroleum substance by selective solvent action comprising a settling chamber having straight essentially vertical walls, a plurality of narrowly spaced baffle walls inclined to the horizontal within said chamber providing a series of communicating settling compartments, means for delivering at a plurality of points between different pairs of said baffle walls intermediate of their lengths a mixture of said substance and a solvent selectively dissolving certain constituents thereof to form oil and solvents phases of different densities, said compartments communicating with essentially vertical passageways separately delivering the respective phases from the upper and lower portions of the settling chamber.

13. Apparatus for refining a petroleum substance by selective solvent action comprising a settling chamber having straight essentially vertical walls, a plurality of narrowly spaced baffle walls having essentially horizontal slots and inclined to the horizontal within said chamber providing a series of communicating settling compartments, means for delivering at a plurality of points between different pairs of said baffle walls intermediate of their lengths a mixture of said substance and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities, said compartments communicating with essentially vertical passageways separately delivering the respective phases from the upper and lower portions of the settling chamber.

14. Apparatus for refining hydrocarbons by selective solvent action comprising a settling chamber having straight vertical walls, means for introducing into the chamber a mixture of said hydrocarbons and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities one of which is a dispersed phase, a plurality of narrowly spaced baffle walls provided with essentially horizontal slots within said chamber having a minimum inclination to the horizontal consistent with a free movement of the separated phases acting so to divert the direction of flow of the droplets of the dispersed phase as to facilitate rapid accumulation and coagulation thereof, and means for separately delivering the respective phases from upper and lower portions of said chamber.

15. Apparatus for refining hydrocarbons by selective solvent action comprising a settling chamber, a plurality of narrowly spaced baffle walls within said chamber having a minimum inclination from the horizontal consistent with the free movement of fluids present and providing a series of settling compartments, means for delivering between different pairs of baffle walls a mixture of said hydrocarbons and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities, essentially vertical passageways connecting with opposite portions of said settling compartments into and through which the respective phases flow, and means communicating with said passageways for separately delivering the respective phases from the upper and lower sections of said chamber.

16. Apparatus for refining hydrocarbons by selective solvent action comprising a settling chamber, a plurality of narrowly spaced baffle walls within said chamber having a minimum inclination from the horizontal consistent with the free movement of fluids present and providing a series of settling compartments, said baffle walls having spaced slots, the slots in adjacent walls being arranged in staggered relationship, means for delivering between different pairs of baffle walls a mixture of said hydrocarbons and a solvent selectively dissolving certain constituents thereof to form oil and solvent phases of different densities, essentially vertical

passageways connecting with opposite portions of said settling compartments into and through which the respective phases flow, and means communicating with said passageways for separately delivering the respective phases from the upper and lower sections of said chamber.

17. Apparatus for refining hydrocarbons by selective solvent action comprising a series of mixers and a vertical series of complementary superimposed settling chamber units, means for supplying hydrocarbon to the mixer at one end of said series, means for supplying solvent to the mixer at the other end of said series, means for delivering the oil and solvent phases to each mixer and the mixture of said said phases to the complementary settling chamber in such manner as to maintain a true counter-current flow by gravitational forces, baffle walls in each settling chamber providing a series of settling compartments and having a minimum inclination to the horizontal consistent with the free movement of the separated phases and acting so to divert the direction of flow of the droplets of the dispersed phase as to produce rapid accumulation and coagulation thereof, essentially vertical passageways connecting with opposite portions of said settling compartments into and through which the respective phases flow, and means for delivering one phase from the upper end of said series and the other phase from the lower end thereof.

18. Apparatus for refining hydrocarbons by selective solvent action comprising a series of vertically disposed settling chambers, each having a mixer associated therewith, means for supplying hydrocarbon to the mixer at one end of said series, means for supplying solvent to the mixer at the other end of said series, means for delivering the oil phase to the mixer associated with one of the settling chambers from a chamber disposed thereabove, means for delivering the solvent phase to said last mentioned mixer from a chamber disposed therebelow, means for delivering the mixture of the two phases from said last mentioned mixer to the settling chamber with which it is associated, the arrangement being such as to maintain counter-current flow of the phases by gravitational forces, baffle walls in each settling chamber providing a series of settling compartments and having a minimum inclination to the horizontal consistent with the free movement of the separated phases and acting so to divert the direction of flow of the droplets of the dispersed phase as to produce rapid accumulation and coagulation thereof, essentially vertical passageways connecting with opposite portions of said settling compartments into and through which the respective phases flow, and means for delivering one phase from the upper end of said series and the other phase from the lower end thereof.

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LIXIVIATOR AND METHOD OF LEACHING

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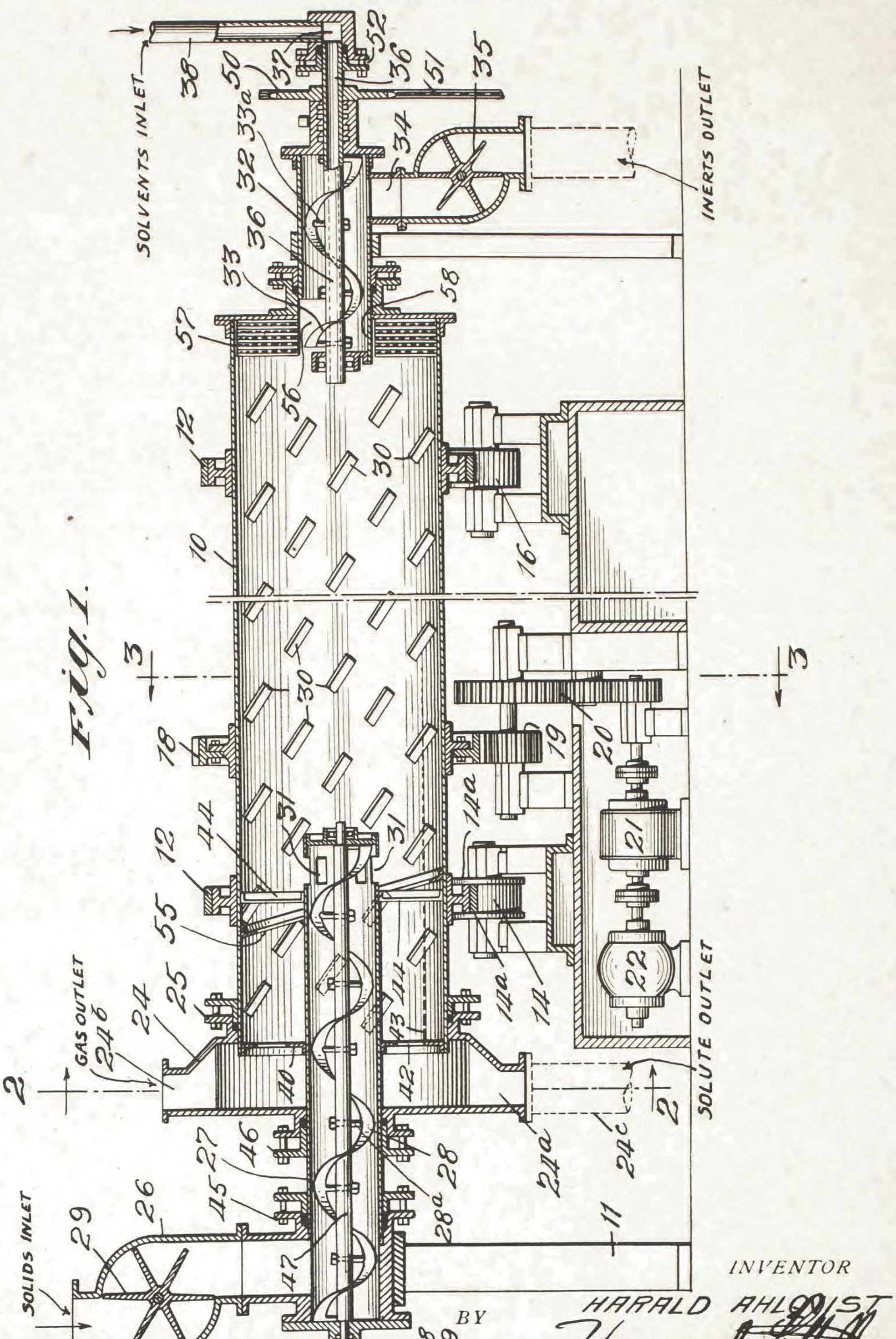

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LIXIVIATOR AND METHOD OF LEACHING

Filed March 2, 1931 2 Sheets-Sheet 2

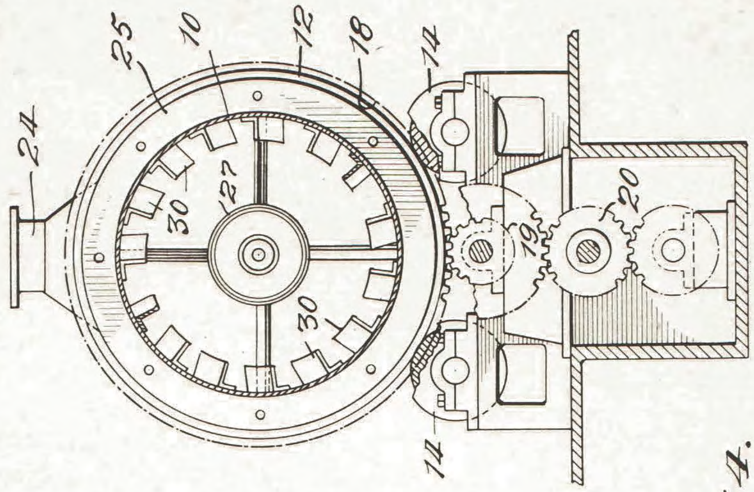

Fig. 3.

Fig. 4.

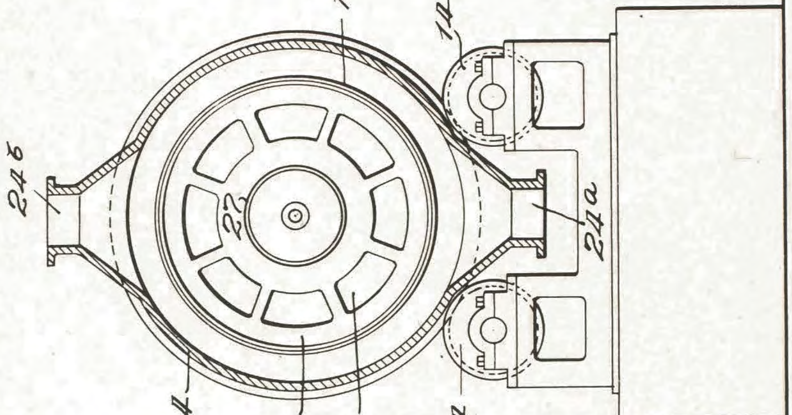

Fig. 2.

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LIXIVIATOR AND METHOD OF LEACHING

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Application March 2, 1931, Serial No. 519,702

12 Claims. (Cl. 23—269)

This invention relates to a lixiviating apparatus and process for dissolving soluble materials out of a mixture or compound of such soluble material and insoluble material by leaching or the like.

In many metallurgical and chemical industries the separation of valuable matter from inert matter is accomplished by dissolving the valuable soluble matter in a solvent in which the inert matter is insoluble. The same process is often used to effect a separation of two or more materials which may all be soluble in the solvent but to a different degree by a careful regulation of flow condition and choice of solvents. The apparatus used in such process has often heretofore been objectionable because of escape of obnoxious or expensive gases or vapors and because of the lack of continuity of operation.

It is the principal object of this invention to provide an apparatus for leaching which will continuously dissolve out soluble matter from a mass of soluble and insoluble material and in which the raw material is continuously introduced into one end of the lixiviator and the separated materials are continuously removed from other parts of the lixiviator.

A further object of the invention is to provide a lixiviation apparatus in which a gaseous instead of a liquid solvent medium may be used to dissolve out certain ingredients of the solids, or in which the leaching may be carried out under superatmospheric pressures or in which a gaseous medium may be passed counter current to a liquid medium to effect selective separation of parts thereof.

A further object of this invention is to provide a lixiviator with a continuous counter-current flow of solvents and solids in which the solvent is separately introduced under suitable control and is removed at the end opposite the discharge of the solids to provide complete treatment and whereby the strongest solvent acts on the more completely leached solids and the weaker solvent is most effectively used on the incoming raw products.

Another object of this invention is to provide an apparatus for the automatic separation of solution and inerts whereby the solution may be subsequently treated and the inerts will be discharged substantially free of the solution of solvents and solubles.

Another object of this invention is to provide a sealed lixiviator apparatus for the leaching of soluble from insoluble materials in which the vapors or gases may be controlled without escape of obnoxious gases and whereby low boiling point solvents may be recovered with economy if desired.

A further object of this invention is to provide a lixiviator tank with a multiplicity of spaced flights in such relation as to agitate the solids and solvents introduced into the tank and continually move the undissolved material forward to the discharge end and in which the flights are loosely secured in the tank and free to move a slight amount to cause a jarring action to remove any solids which might stick to the flight.

A further object of this invention is to provide a process of lixiviation in which the solvents and solids are introduced and passed through the sealed tank in counter-current and whereby the tank vapors may be recovered and removed through one discharge, the inert solids removed through a separate discharge, and the solvent recovered from a third discharge for greatest economy and completeness of separation.

Further objects and advantages of this invention will appear from the following description thereof taken in connection with the attached drawings which disclose a preferred form of embodiment thereof and in which;

Figure 1 is a vertical section substantially centrally of the apparatus,

Figure 2 is a vertical cross-section substantially on the line 2—2 of Figure 1,

Figure 3 is a vertical cross-section substantially on the line 3—3 of Figure 1,

And Figure 4 is a detail section of the tank showing a modified form of flight.

The lixiviator of my invention includes a cylindrical tank or drum **10** which is provided with the peripheral tires or rims **12** which support the drum on pairs of rollers **14** and **16**, as more clearly shown in Figures 2 and 3.

In order to prevent longitudinal shifting of the drum **10**, rollers **14** are provided with flanges **14a** cooperating with the side of the track **12**. The rollers **16** are flat however, so that any expansion of the drum due to the temperature change may take place on the rollers **16**.

The drum **10** is also provided with a central gear **18** by which the drum **10** is driven through the gear **19**, gear train **20**, speed reducer **21**, and motor **22**, or other source of power in any preferred manner. The drum **10** is provided with a fluid discharge head **24** suitably held against rotation by the piping connections **24c** which may be sealed against the escape of pressure within the drum **10**, and provided with packing flanges

25 in which the drum 10 rotates in a pressure-tight manner.

The fluid discharge end of the drum 10 is also provided with a feed box for the solid material, which may be mounted on supports 11. The feed box communicates with a screw conveyor housing 27 rotating with and adapted to extend partially into the drum 10. The screw conveyor housing 27 is provided with a screw conveyor 28 preferably of the ribbon type which is adapted to receive solids which pass through the star feeder wheel 29 in the feed box 26, and which are discharged into the drum 10 by the screw conveyor 28. The star feeder wheel 29 is preferably used to seal the feed box 26 against escape of gases and pressure although other well known or preferred methods for sealing the feed chamber may be used equally as well.

The screw conveyor 27 is supported within the drum 10 by spider members 44 and by the head 40 of the drum. The conveyor housing is thus rotatable with the drum and stuffing boxes 45 and 46 are used to seal the housing from the fluid discharge head 24 and the feed box 26, thus preventing leaks. The screw conveyor 28 is preferably of the ribbon type and supported by posts 28*a* from the shaft 47, which shaft is driven by the sprocket 48 and chain 49.

The drum 10 is provided with a plurality of flights or upstanding angular projections 30 and are mounted on the inner surface in an overlapping progressive spiral so that the solid material will be continually raised and agitated and forced forward through the drum. The solids fed into the drum by the screw conveyor 28 thus drop through the apertures 31 in the conveyor housing 27 and drop onto the inwardly projecting flights 30. As the drum 10 continues to rotate, the solids will be continuously urged toward the discharge end of the drum where they are picked up and dropped into the solids discharge conveyor housing 32 having the solids discharge conveyor 33 therein. The solids are carried by the conveyor 33 to the solids discharge head 34 and by means of a star feeder 35 or other sealing means are discharged from the lixiviator. The flights or upstanding projections 30 are shown in end view in Figure 3, the projections extending partially toward the center of the drum and adapted to carry the material forward and agitate it.

Cooperating with the flights 30 is a spiral baffle 55 which is secured within the drum 10. This baffle in its continuous movement, aids to prevent insoluble materials from passing out of the open apertures 42 and being inadvertently discharged from the wrong end of the drum 10. The baffle 55 continuously aids to force the material forward together with the flights 30 so that it will be eventually carried up and deposited in the opening 56 in the conveyor housing 32.

The conveyor 33 is mounted on a hollow shaft 36 which is connected into the stuffing box 37 to which the solvent is piped. The screw conveyor 33, similar to the conveyor 28, is of the ribbon type and mounted free and above the hollow shaft 36 by the posts 33*a* which project outwardly from the shaft 36; the shaft 36 being rotatable by means of the sprocket gear 50 and driving chain 51. A suitable flange 52 is provided to seal the shaft 36 into the stuffing box 37.

The solvent passes through pipe 38 and through the hollow shaft 36 and is discharged near the discharge end of the drum 10. The liquid solution of soluble materials rest on the bottom of the drum 10 until a predetermined liquid level is reached. This liquid level is governed by the head 40 on the drum 10 which, as particularly shown in Figure 2, is provided with a series of apertures 42 which are spaced from the rim of the drum 10. As shown in Figure 1, the apertures determine a liquid level at approximately the line 43, and when the solution exceeds the level 43 it passes out of the drum through the apertures 42 and into the solution discharge end 24*a* of the fluid discharge head 24. At the same time any gas or vapor within the drum 10 will be discharged out of the gas discharge end 24*b* of the fluid discharge head 24 either by use of a vacuum pump (not shown) or because they are lighter than air.

In order to completely remove the inert solids from the drum 10 the pick up plates 57 are provided and spaced a sufficient amount so that the solid material may be worked into the space between the plates and then carried up and dropped into the chamber 56 above the discharge screw 33. The pick up plates 57 are perforated to permit draining of the solids. The lower end 58 of the conveyor housing 32 is sealed to insure the discharge movement of solids which are deposited within the conveyor housing.

In operation of the lixiviator a certain part of the raw material is to be separated from the total feed by a solvent which in special cases may also act as a flotation medium. The solids enter through the star feeder 26 which seals the entrance against escape of gases and vapors and by means of the screw conveyor are forced into the lixiviator cylinder. At the same time the solvent enters through the hollow shaft 36 at the opposite end of the continually rotating drum 10 and comes in contact with the solid materials fed into the cylinder. The pick up flights 30 carry the undissolved solids in counter-current to the flow of solvent toward the discharge end and the pick up plates 57 then discharge the solids to the discharge screw which discharges also in gas tight relation through the star feeder 35. The solvent, which is strongest as it enters the lixiviator tank, contacts with the most reduced materials reducing the final solids as much as possible. The solution then passes along the drum contacting with the material and then passes out of the head of the drum after finally contacting with the most concentrated solids, the solution being the weakest at this point. The solution may then pass through sealed pipes to storage tanks (not shown) or any other desired place for retreatment and recovery. At the same time the gases or vapors such as steam, acids, low boiling hydrocarbons, or gases or volatile liquids used as solvents pass out of the upper part of the fluid discharge head through a single conduit to a condenser or other appropriate apparatus (not shown) to be recovered and condensed if valuable or obnoxious.

For a successful operation, the relative quantities of feed and solvent must be proportioned and the proper time of contact between feed and solvent determined. If heat is to be preserved, the drum may be lagged and by means of the star feeders and the flight conveyors the rate of feed may be corefully controlled. The star feeders may not be essential however, as the material itself may act as a seal for the feeding discharge conveyors.

Such an apparatus is continuous and automatic and brings about a leaching which may be exactly controlled and by which there is a complete separation or flotation of the soluble materials from inert materials and/or non-dissolved materials. The time element may be readily changed by varying the speed of rotation of the cylinder, by varying the feeding or corresponding quantity of solvent, by changing the angle of the pick up flights and by adjusting the discharge holes in the head of the drum either closer or further from the center. The horizontal axis of the drum may be raised at one end to also vary the rate at which the solids will travel through.

In this apparatus it is possible to use other feed control means than a star feeder, which, however, is preferred for its simplicity and completeness of sealing. The ribbon screw conveyors may be of different shape and construction and may be continuous conveyors if desired. Similarly the projecting flights for agitating the materials within the drum may be changed although the separate flights are preferred for complete agitation and forward movement of the solid products. The flights may be movable as shown in Figure 4 in which the flight projection **30** may be secured to the drum **10** by a bolt **59** which has a lock nut **60** but which bolt is longer than the thickness of the flight and drum. In such construction, the flight will lie against the surface of the drum when the flight is at the bottom of the drum and will then pick up the solids on the bottom of the drum. As the drum rotates however, the solids will be carried up the side of the drum to an elevated point at which most of the solids will drop off. As the drum continues to rotate, the flight will reach a point near the top of the drum at which time the flight itself will move downward due to the extra length of the securing bolt. As the flight drops, it suddenly reaches the head of the securing bolt and the shock will jar the sticky solids from the flight to completely clean it. A similar action of shock cleaning continuously takes place with the flights continuously reaching the top of the drum and the solids are thus completely agitated.

It will thus be seen that I have produced a lixiviator which is most efficient in contacting the solvent in its greatest strength with the solubles in their most reduced stage and in contacting the weakened solution with the entering materials by a continuous counter-current flow of solids and solvent. The lixiviator is completely self-cleaning and is continuous in operation as the solvent and solids enter the tank at axial points and no stop is necessary for cleaning except when a new process is carried out. The inerts are discharged separately and without contamination of other products through a gas tight seal on one end while the solution of soluble materials is separately removed at another point. The tank being gas tight is particularly suitable for reduction of solids with volatile solvents such as acids, steam or volatile mineral oils which can be recovered, condensed, and reused. Obnoxious and poisonous odors can also be controlled by the separate gas discharge conduit. Gases may also be introduced either as solvents or oxidizing agents and maintained under slight superatmospheric pressure if desired.

The lixiviator is also suitable for leaching liquids either by other liquid solutions or by gases. The liquids would pass into the feeding conveyor at the end opposite the gas or solvent feed and the gas would remove the soluble material and be drawn out at an opposite end to the feed for complete contact and reduction. Liquids can also be removed from the solids fed in, or part of the solids dissolved, and in either case, the inerts will be discharged free of the soluble material.

While I have shown a preferred form of embodiment of my invention and described the apparatus primarily with reference to leaching a solid with a liquid solvent, it will be readily apparent that being sealed against escape of gases, a gaseous solvent, under pressure if desired, may be used to remove or act upon certain ingredients in the solid, or that the same apparatus may be used for passing a gas countercurrent to a liquid with agitation of the liquid to effect removal of a portion of the liquid and scrubbing or purifying of the gas and that various modifications may be made in the apparatus without departing from the spirit of my invention or the scope of the following claims.

I claim:

1. The method of leaching soluble from inert material under superatmospheric pressure in a lixiviation apparatus which comprises, maintaining a pressure seal at each end of said apparatus, independently feeding the soluble and inert material into one end of the apparatus at a regulatable rate, feeding the solvent into the opposite end of said apparatus, rotating the apparatus, automatically conveying the solvent and soluble and inert material counter-current to each other through said apparatus and withdrawing the solvent and dissolved material from one end of the apparatus, and separating the undissolved inert material from the solvent and withdrawing the separated inert material from the other end of the apparatus while still maintaining the pressure seal.

2. The method of leaching soluble from inert material under superatmospheric pressure in a lixiviation apparatus which comprises, maintaining a pressure seal at each end of said apparatus, feeding the soluble and inert material into one end of the apparatus, feeding the solvent into the opposite end of said apparatus, conveying the solvent and soluble and inert material counter-current to each other through said apparatus, agitating the solvent and soluble and inert material together in said apparatus, and withdrawing the solvent and dissolved material from one end of the apparatus, and raising the undissolved inert material from the solution at the bottom, draining said inert material and discharging said inert material from the other end of the apparatus while still maintaining the pressure seal.

3. A lixiviator apparatus of the class described comprising a rotatable cylindrical drum, a plurality of upstanding flights secured to said drum in a substantially spiral manner to progressively advance solids through said drum, a ribbon conveyor to introduce solids containing soluble matter at one end of said drum, means to independently actuate said conveyor, a second conveyor to discharge inert matter at the opposite end of said drum, said conveyors being in substantially gas tight relation to seal said drum, solvent intake means at said insert discharge end of the drum, and a solute discharge means at the other end of the drum.

4. A lixiviator apparatus of the class described comprising a cylindrical drum, means for rotating said drum, means for feeding the solid material, and means to agitate and progressively advance the solid materials through said drum, comprising a plurality of spaced flights loosely secured to the interior of said drum for limited radial movement, said flights being self-cleaning, and adapted to move with respect to their support an amount sufficient to jar loose materials carried thereon.

5. A lixiviator apparatus of the class described, comprising a driven rotating drum, feeding means including a star feeder and a conveyor to feed solids in gas tight relation into said drum, a discharge means including a conveyor and a star feeder to discharge inerts in a gas tight relation, a solvent intake co-axial with said drum adapted to introduce solvent counter-current to said solids, means to progressively contact said solvents and said solids with the strongest solution contacting with the most inert solids, and the weakest solution with the entering solids, and means to separately and in gas tight relation remove the gases and vapors and the solvent including the soluble materials.

6. A lixiviator apparatus of the class described, comprising a driven rotating drum, feeding means including a star feeder and a conveyor to feed solids in gas tight relation into said drum, a discharge means including a conveyor and a star feeder to discharge inerts in a gas tight relation, a solvent intake co-axial with said drum adapted to introduce solvent counter-current to said solids, means to progressively contact said solvents and said solids with the strongest solution contacting with the most inert solids, and the weakest solution with the entering solids, and means to separately, and in gas tight relation remove the gases and vapors and the solvent including the soluble materials, said lixiviator having a plurality of pick up shovels to assist in removing the inerts, said pick up shovels having perforated bottoms to additionally drain said inerts.

7. A lixiviator apparatus of the class described, comprising a gear driven rotating drum, feeding means to feed solids in gas tight relation, a discharge means to discharge inerts in a gas tight relation, a solvent intake coaxial with said drum adapted to introduce solvent counter-current to said solids, means to progressively contact said solvents and said solids with the strongest solution contacting with the most inert solids, and the weakest solution with the entering solids, and means to separately, and in gas tight relation remove the gases and vapors and the solvent including the soluble materials, said lixiviator having a ported head to govern the liquid level therein, and a spiral baffle adjacent said ported head to prevent the discharge of solids in the solvent discharge conduit.

8. In a lixiviating apparatus of the type described for solids, liquids and gases, a rotating drum, stationary sealed heads at each end of the drum, means on the inside of the drum to propel a substance from one end to the other thereof, separate conveyors to introduce and remove substances through said heads, means to control the escape of gases from said drum, and means within the drum to separate the soluble material from the inerts, said means lifting the inert material out of the soluble material and depositing it on its discharge conveyer.

9. An apparatus for agitating a mixture containing solid material, and a liquid, comprising a gas tight sealed cylindrical vessel, means for rotating said vessel, a non-rotatable head on one end of the vessel, means for feeding the material to be agitated through said head into one end of the vessel, separate upstanding flights independently secured to the interior of said vessel, said flights being spirally arranged to progressively move solid materials through the vessel, a non-rotatable head on the opposite end of the vessel, means to discharge inerts through said head, and means to raise the inert material onto said discharge means, said non-rotatable heads sealing said vessel against escape of gas.

10. A lixiviator apparatus of the class described comprising a gas tight sealed rotating drum having a sealed head means to rotate the drum, means to continuously introduce solvents and solids into said drum including independently rotatable feeding means, means to continuously convey said solids and solvents in countercurrent through said drum means to raise the unreacted solids from the solution, and means to continuously and independently discharge the unreacted solids through the sealed head, whereby said lixiviator is self-cleaning.

11. A lixiviator apparatus of the class described comprising a gas tight sealed rotating drum, a fluid discharge head secured to said drum in non-rotatable manner, said head having a gas discharge conduit and a separate liquid discharge conduit, said gas discharge conduit being above the normal liquid level whereby solvents may be separately recovered and gas or vapors may be separately discharged, a second head secured to said drum in non-rotatable manner and means to separately discharge inerts from said drum through said second head, said means including a ribbon conveyor and means to load the conveyor.

12. A lixiviator apparatus of the class described, comprising a gas tight sealed rotating drum, a fluid discharge head secured to said drum in non-rotatable manner, said head having a gas discharge conduit and a separate liquid discharge conduit, said gas discharge conduit being above the normal liquid level whereby solvents may be separately recovered and gas or vapors may be separately discharged, said drum having a separate inert discharge head at the opposite end of the drum from said solvent discharge conduit and a conveyor operating through said inert discharge head whereby said inerts may be discharged substantially free of solvents.

HARALD AHLQVIST.

F. H. MALONEY.

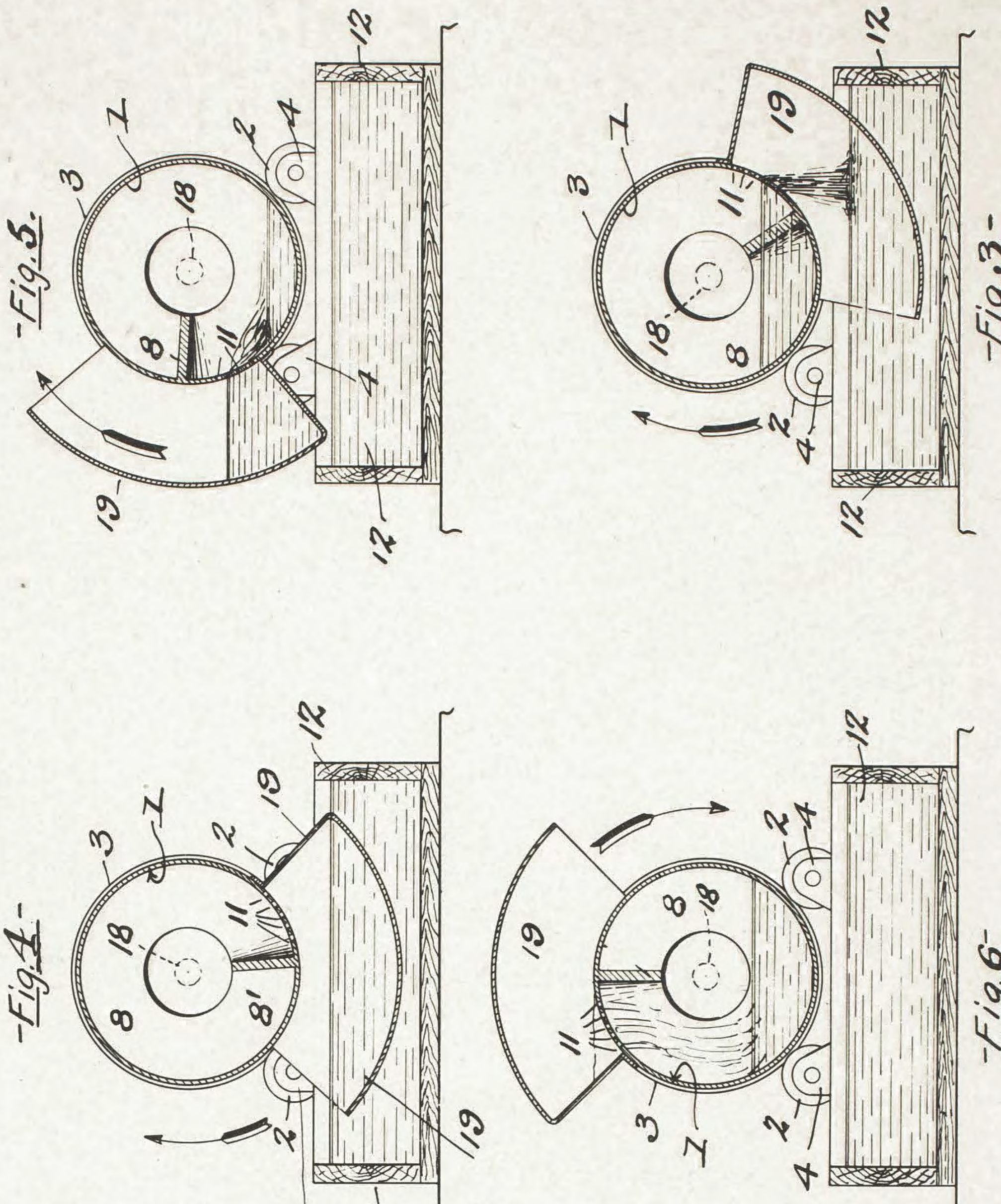
PICKLING AND WASHING MACHINE.

APPLICATION FILED JULY 31, 1917.

1,251,073.

Patented Dec. 25, 1917.

2 SHEETS—SHEET 2.



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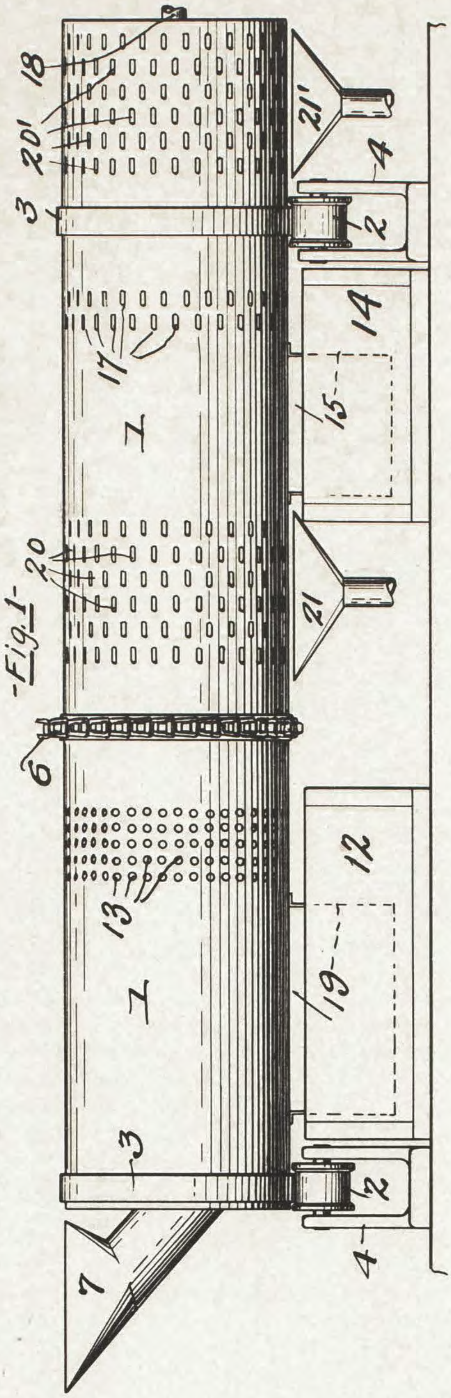

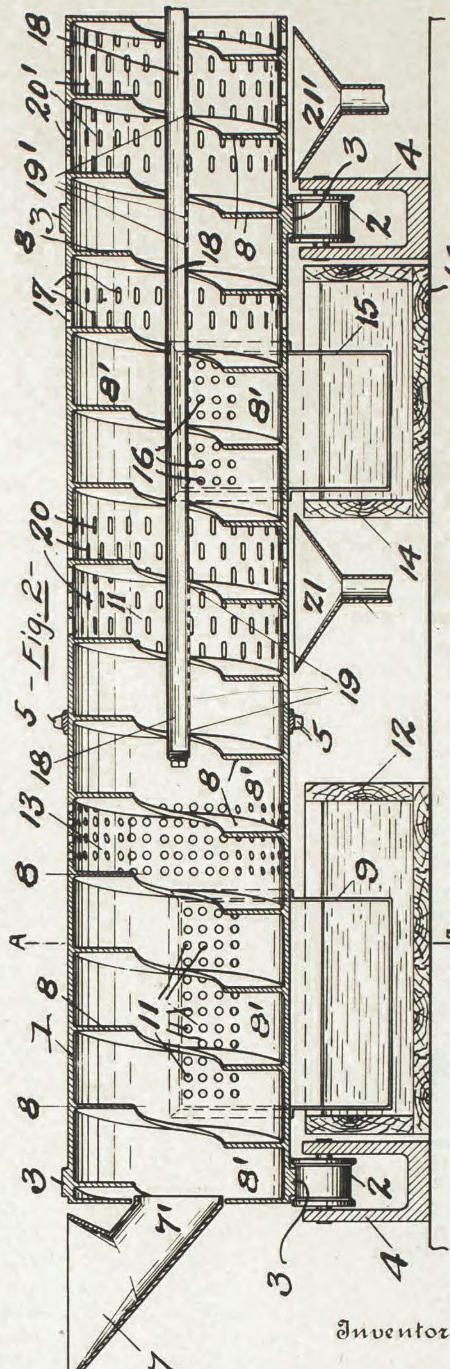

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UNITED STATES PATENT OFFICE.

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PICKLING AND WASHING MACHINE.

1,251,073. Specification of Letters Patent. Patented Dec. 25, 1917.

Application filed July 31, 1917. Serial No. 183,801.

To all whom it may concern:

Be it known that I, FRANK H. MALONEY, a citizen of the United States, residing at Bridgeport, in the county of Fairfield and State of Connecticut, have invented certain new and useful Improvements in Pickling and Washing Machines, of which the following is a specification.

The invention relates to improvements in machines for pickling, cleaning, and washing relatively small articles such as brass stampings, screw machine products, valve casings, and like articles which require treatment in order to relieve them of oxid and other foreign substances collected during the course of manufacture.

The object of the invention is to provide a continuously operating machine adapted to feed materials therethrough whereby to permit the materials to be subjected to a bath of a suitable solution, and to a washing bath so as to cleanse them of all foreign substances engendered during the course of manufacture, the construction and arrangement of the machine being such that the articles passing through the machine are first subjected to a bath of a cleaning solution, and then subjected to another bath and washed of the cleansing influence before being delivered through the discharge end of the machine. A further object of the invention is to provide an arrangement whereby to subject the articles passing through the machine to a tumbling or agitating movement, so as to insure an immersion and washing of the materials before being discharged at the delivery end of the machine.

The invention comprises a cylinder adapted to be continuously rotated and having an internal helical or spirally arranged web or blade extending throughout the length thereof providing a helical channel for feeding materials through the cylinder; in the arrangement of scoops carried by the cylinder and associated with tanks designed for containing acid or other cleansing solutions, said cylinder being provided with perforations whereby to permit the liquids collected by the scoops to flow into the cylinder upon the articles as they are fed therethrough. The invention further comprises means for washing the articles after passing through the cleansing influence, and in certain peculiar and novel features of construction and arrangement whereby waste of the solution is avoided, and still further in the novel and peculiar construction of the machine whereby the articles passing through the machine are immersed and rinsed before being delivered.

In the drawings, illustrating the invention, in the several figures of which like parts are similarly designated, Figure 1 is a side elevation of the machine. Fig. 2 is a longitudinal section of the machine. Fig. 3 is a transverse section drawn on the line A—A of Fig. 2, showing the scoop or dipper immersed in the cleaning influence holding tank, and Figs. 4, 5, and 6 illustrate the several positions of the scoop or dipper during the revolution of the cylinder.

1 designates a cylinder of substantially uniform diameter throughout its length supported by rollers 2 operating upon circumferentially arranged bands or tracks 3 carried by the cylinder. The said rollers 2 are journaled in brackets or frames 4, and are so disposed to hold the cylinder 1 in a substantially horizontal position. The cylinder 1 is designed to be rotated upon the rollers 2, and, for the purpose of illustration, I show the cylinder 1 provided with a band or rim of sprocket teeth 5 over which operates a drive sprocket chain 6 extending from a suitable source of power (not shown). It will be appreciated that while I have shown and specified a sprocket and chain mechanism for revolving the cylinder, that other mechanism may be employed for revolving the cylinder, and that the mechanism may be located in other positions than that shown in the drawings of the present application. While I have shown the cylinder 1 mounted upon rollers 2 supported in frames located at the inner and outer ends of the cylinder, it will be apparent that other supporting rollers may be employed according to the length of the cylinder.

Carried by suitable brackets (not shown), positioned adjacent to the inner end of the cylinder 1, is a hopper 7 having its discharge 7′ opening into the inner end of the cylinder 1. The cylinder is formed with an internal spirally arranged web or blade 8 extending throughout the length thereof providing a spiral or helical groove or channel 8′ adapted for feeding the materials through the cylinder.

Located adjacent to and below the inner or forward end of the cylinder 1, is a tank 12, adapted for holding a solution of sulfuric acid or other cleansing solution. The cylinder 1 is provided with a scoop or dipper 9 open at one end and closed at its opposite end, and adapted to operate through said tank 12 during the revolution of the cylinder. The cylinder is provided between the end walls of the scoop or dipper with a plurality of perforations 11 designed to permit the feeding of the liquid into the cylinder and the escape of the liquid from the cylinder back into the tank 12 during the revolution of the cylinder, thereby flooding the channels 8′ and completely immersing the articles as they are fed through the machine. In order to avoid any waste of the cleansing influence, the cylinder 1 is provided with a plurality of circumferentially arranged perforations 13 located immediately forward of the scoop or dipper 9, which serve to drain the liquids fed into the channels 8′ forward of the scoop or dipper 9. Adjacent to the outer end of the cylinder 1 there is located a tank 14 adapted for containing a solution of soap and water or other suitable cleansing or washing solution, and operating in conjunction with this tank 14 is a scoop or dipper 15 carried by the cylinder 1, and which, like the scoop or dipper 9, is open at one end and closed at its opposite end, and is adapted to collect the solution contained in the tank 14 and spray and immerse the material as it is fed through the cylinder. The cylinder between the end walls of the scoop or dipper 15 is provided with perforations 16, whereby to permit the inflow and discharge of the liquid upon the material as it passes through the cylinder. Immediately forward of the scoop or dipper 15 the cylinder is provided with a plurality of circumferentially arranged perforations or slots 17 whereby to collect and drain back into the tank 14 the liquid that has been previously scooped up by the scoop or dipper 15. Arranged centrally within the outer end of the cylinder 1 is a pipe 18 having a plurality of perforations 19, said pipe being designed for supplying cleansing water to the materials to wash them of the first cleansing influence and subject them to an immersion of pure water, which is drained off through perforations 20 into a drain hopper 21 located below the cylinder and having a suitable drain pipe connected thereto for carrying off the water as it escapes through the perforations 20. Immediately adjacent to the outer end of the cylinder, the latter is provided with perforations 20′, and the pipe 18 is provided with a plurality of perforations 19′, through which cleansing water is sprayed upon the materials before being delivered from the cylinder. A drain hopper 21′ is arranged below the perforations 20′ for carrying off the cleansing water as it escapes through the perforations 20′.

The operation of the machine is as follows:—

Taking, as an example, small brass pieces coming from an annealing furnace, and which are consequently coated with oxid, they are dumped or poured into the hopper 7, from which they flow into the groove or channel 8′ at the forward end of the machine, and through the rotation of the cylinder, it will be appreciated that the materials are fed therethrough in a manner similar to that of all screw conveyers. Now as the materials pass through the channels 8′ embodied within the length of the scoop or dipper 9, they will be sprayed and immersed in a suitable cleansing solution collected from the tank 12, and as the solution is fed into the channels 8′, immediately forward of the scoop or dipper 9, the solution will run back into the tank, through the perforations 13, and hence used over and over again. As the articles continue through the machine they are subjected to an immersion of fresh water supplied by the pipe 18, rinsed, and this rinsing water is drained through the perforations 20 formed in the cylinder 1. Then as the articles are passed through the cylinder they are subjected to a bath of the solution contained within the tank 14 in a similar manner as that described with respect to the scoop or dipper 9, after which the articles are subjected to a further washing, rinsing, and draining before being delivered out through the free end of the cylinder.

It will thus be seen that I provide a very simple and highly efficient apparatus for the purpose described, and it will be understood that while I have shown only two solution containing tanks and two scoops or dippers associated therewith, that a greater number may be employed should occasion require. I therefore do not limit myself to any specific number of scoops or dippers and tanks, or solutions or washes, as it will be obvious to anyone skilled in the art to which the invention relates that a greater or less number may be employed without departing from the spirit of the invention.

It will be particularly noted that the inlet and escape ports or perforations of the cylinder are arranged at intervals throughout the length thereof so that as the materials are fed through the helical channel they are subjected to an immersion, and that the solutions or water in which the materials are immersed are drained and fed back into the several tanks, or into the drainage funnels as hereinbefore described.

It is to be noted that the scoop or dipper 9 forms a means for positively delivering fluid to the drum during a portion of each revolution thereof.

What I claim is:—

1. A machine of the character described, comprising a rotatable drum having an internally arranged helically disposed member for conveying work therethrough, means exteriorly arranged upon said drum for automatically supplying fluid to the work passing through said drum as the drum is rotated, said drum having a plurality of discharge openings to permit of the escape of the fluid at intervals during the passing of the work through the drum.

2. A machine of the character described, comprising a rotatable drum having an internally arranged helically disposed member, and means carried upon the periphery of the drum for positively delivering fluid to the drum during a portion of each revolution thereof.

3. In an apparatus of the character described, a drum having means at one end for receiving the work to be treated, means arranged within the drum for passing the work therethrough, and means carried by and connected to the periphery of the drum for positively delivering fluid to the work passing through the drum, said drum having a plurality of perforations to permit the escape of the fluid at intervals during the passage of the work through said drum.

4. A machine of the character described, comprising a rotatable drum provided with a helically arranged channel therein forming a plurality of separate work-carrying chambers, and means arranged externally upon the cylinder for positively delivering a cleansing solution to and discharging the same from said chambers to act upon the work in each a plurality of times while passing through the drum.

5. A machine of the kind described, comprising a rotatable cylinder having a spirally arranged web extending throughout the length thereof providing a spirally arranged channel, said cylinder having a plurality of perforations arranged throughout its length, in combination with a fluid holding tank, and a scoop or dipper arranged upon said cylinder and adapted to coöperate with said tank to positively deliver fluid to the cylinder during a portion of each revolution thereof, as and for the purpose specified.

6. A machine of the kind described, comprising a rotatable cylinder having a spirally arranged web or blade extending throughout the length thereof providing a spirally arranged channel adapted for feeding materials through the cylinder, said cylinder having a plurality of perforations arranged in its periphery, a scoop or dipper carried by said cylinder and embracing said perforations, a fluid holding tank through which said scoop or dipper is adapted to operate, and means for rotating said cylinder.

7. A machine of the kind described, comprising a rotatable cylinder having a spirally arranged channelway therein adapted for feeding materials through the cylinder, said cylinder having perforations, a scoop or dipper carried by the cylinder embracing the perforations thereof, a solution holding tank arranged below the cylinder through which the said scoop or dipper passes during the revolution of the cylinder, and means for revolving said cylinder.

8. A machine of the kind described, comprising a rotatable cylinder having a spirally arranged channel extending therethrough, means for rotating said cylinder, a hopper associated with the forward end of the cylinder and discharging into said channel, a tank arranged below said cylinder adapted for containing a suitable bath, and means carried by and arranged externally of said cylinder for collecting and delivering the solution of said bath upon the materials passing through said cylinder.

9. A machine of the kind described, comprising a rotatable cylinder having a spirally arranged channel extending therethrough, the said cylinder having a plurality of perforations opening into said channel, scoops or dippers carried by the said cylinder and embracing said perforations, tanks located below the said cylinder in the path of said scoops or dippers, as and for the purpose specified, and means for supplying rinsing water to the materials as they are fed through the cylinder.

10. A machine of the kind described, comprising a perforated cylinder having helical or spirally arranged feeding channels therein, a scoop or dipper carried by and arranged upon the periphery of said cylinder adapted for positively delivering a cleansing influence to materials passing through the cylinder, and a tank arranged below said cylinder through which the scoop or dipper operates, said cylinder having a plurality of perforations arranged forward of said scoop or dipper whereby to drain the said cleansing influence back into said tank.

11. An apparatus of the kind described, comprising a rotatable cylinder, a scoop or dipper arranged upon the periphery thereof to positively deliver fluid to the cylinder during a portion of each revolution thereof, said cylinder having a series of perforations adjacent to the inner or closed end of the scoop or dipper and a series of escape openings adjacent to the forward end of said scoop or dipper, a solution holding

tank arranged below said cylinder within the path of said scoop or dipper, said perforations forward of the scoop or dipper being so located as to drain the fluid sprayed upon the work passing through the cylinder back into said fluid holding tank, substantially as and for the purpose specified.

In testimony whereof I have hereunto set my hand this 26 day of July, A. D. 1917.

FRANK H. MALONEY.

Witnesses:
MARY E. LYDDY,
MILDRED SEXTON.

A. E. HOLLEY & O. E. MOTT.

APPARATUS FOR THE TREATMENT OF ONE LIQUID WITH ANOTHER.

APPLICATION FILED DEC. 5, 1917.

1,297,171. Patented Mar. 11, 1919.

Fig. 1.

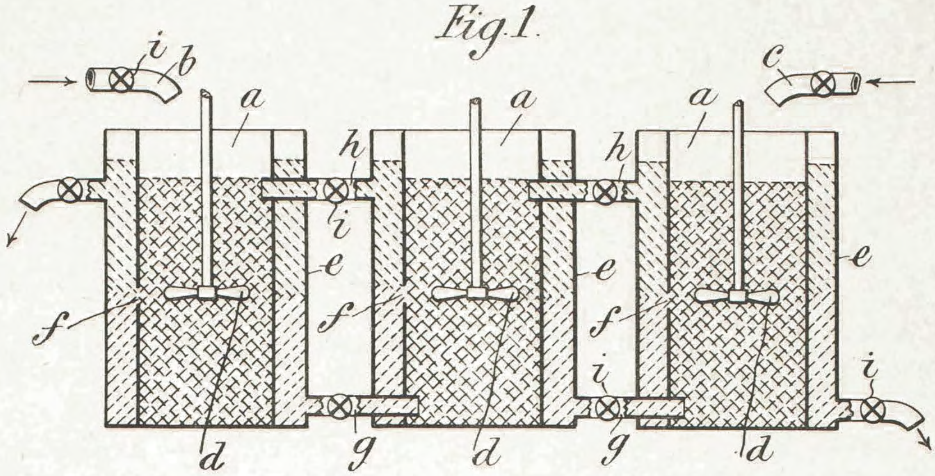
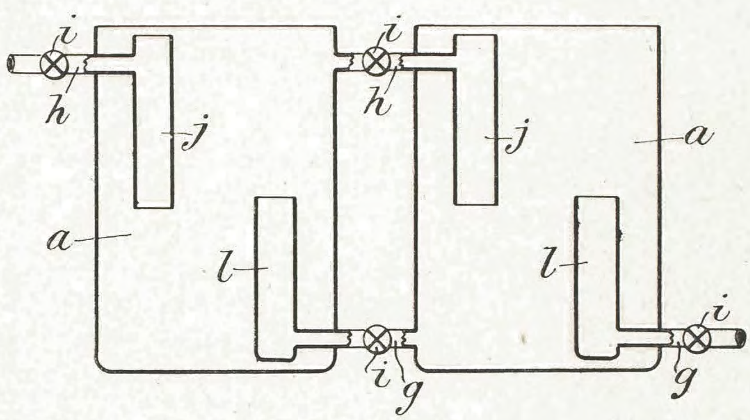


Fig. 2.



Inventors:
A. E. Holley
and O. E. Mott
by their attorneys
Baldwin & Wight.

UNITED STATES PATENT OFFICE.

ALFRED EWART HOLLEY, OF OLDBURY, AND OWEN EDWIN MOTT, OF WOOLWICH, ENGLAND, ASSIGNORS TO THEMSELVES, AND CHANCE AND HUNT, LIMITED, OF OLDBURY, ENGLAND.

APPARATUS FOR THE TREATMENT OF ONE LIQUID WITH ANOTHER.

1,297,171. Specification of Letters Patent. **Patented Mar. 11, 1919.**

Application filed December 5, 1917. Serial No. 205,574.

To all whom it may concern:

Be it known that we, ALFRED EWART HOLLEY, residing at Chemical Works, Oldbury, England, and OWEN EDWIN MOTT, residing at the Research Department, Royal Arsenal, Woolwich, England, subjects of the King of Great Britain, have invented an Improved Apparatus for the Treatment of One Liquid with Another, of which the following is a specification.

The invention relates to an improved apparatus for the treatment of one liquid with another.

By the term "liquid" it is intended to include suspensions, emulsions and solutions, but the process is limited to cases in which there are two liquids of different specific gravities and not completely miscible.

According to this invention one liquid is treated with another liquid by mixing them in a series of vessels fitted with stirrers and all at the same level, which vessels are hereinafter referred to as agitators, and allowing the mixture to flow into vessels at the same level as the agitators and hereinafter referred to as separators, in which gravity may cause a separation, and from which heavier liquid passes by an opening near the bottom and lighter liquid by an opening near the top, the passage from the agitator to the separator lying between these openings. The stirrer may take the form of an injector for air or steam.

Physical or chemical interactions may be carried out by these means and provisions may be made for cooling or heating the liquids.

The apparatus is particularly applicable for nitrating organic matter and for washing nitro compounds but the plant is useful for many other physical and chemical interactions.

The lighter liquid from any separator passes to the agitator next in the series in one direction and the heavier liquid from that separator to the next agitator in the other direction. Thus, provided light liquid is supplied to the first agitator and heavy liquid to the last, there will be, due to the head produced in the separator, a constant flow of light liquid from the last separator and of heavy liquid from the first, the flow of the liquid being controlled by valves.

The invention is illustrated in the accompanying drawings in which Figure 1 is a section and Fig. 2 is a similar view showing a modification.

In the drawings *a* are the agitators to the first of which heavy liquid is supplied by the pipe *b*, and to the last of which light liquid is supplied by the pipe *c*.

The liquid in the agitators is stirred by the stirrers *d*.

e are the separators communicating with the agitators by a passage *f*. *g* are pipes leading from the bottom of the agitators to the bottom of the separators and *h* are pipes leading from the top of the agitators to the top of the separators.

i are valves for controlling the flow of the liquid.

The separators need not be in one with the agitators but may be separate vessels communicating with the agitators at about half way up.

Each separator also may consist of two parts one for the light and one for the heavy liquid.

This is illustrated in Fig. 2 which shows only these features the apparatus being otherwise identical with Fig. 1. Similar parts are indicated by the same letters.

The separator consists of two parts *j* and *l*, the part *j* being open top and bottom and collecting the lighter liquid and the part *l* being closed at the bottom and open at the top and collecting the heavier liquid.

What we claim is:—

1. Apparatus for the treatment of one liquid with another, comprising a series of agitators all at the same level, a series of separators at the same level as the agitators, the bottom of a separator being connected to the bottom of an agitator in one direction and the top of a separator to the top of an agitator in the other direction, and each

separator being in direct communication with the agitator at a point situated between the other connections.

2. In apparatus for the treatment of one liquid with another comprising a series of agitators all at the same level, a series of separators communicating with and at the same level as the agitators and means whereby the flow of the two liquids in opposite directions is caused solely by the head produced in the separators.

ALFRED EWART HOLLEY.
OWEN EDWIN MOTT.

July 4, 1933. G. J. STREZYNSKI 1,916,870

CENTRIFUGAL BOWL

Filed June 25, 1931 2 Sheets-Sheet 1

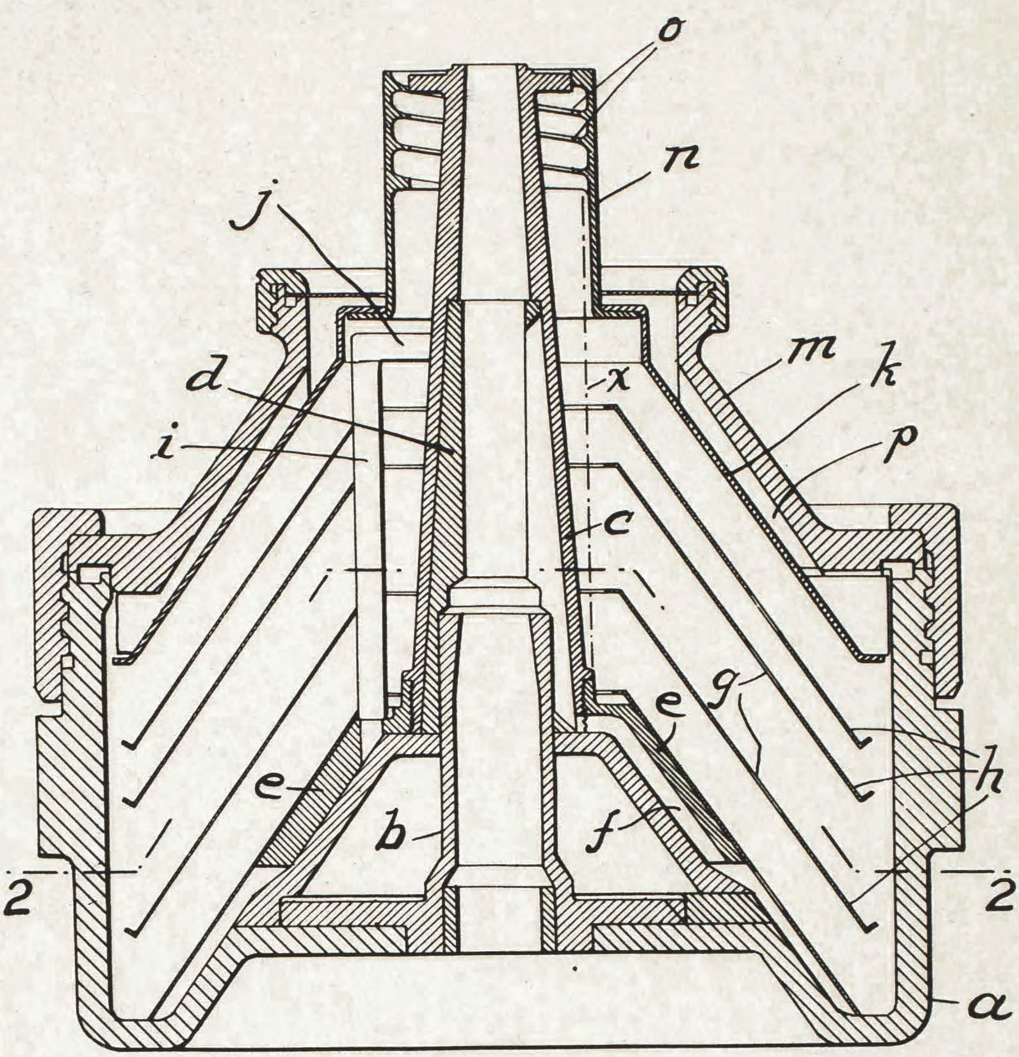


FIG. 1.

WITNESS:

Robt R. Kitchel

INVENTOR

George J. Strezynski

BY

Busser and Harding

ATTORNEYS.

CENTRIFUGAL BOWL

Filed June 25, 1931 2 Sheets-Sheet 2

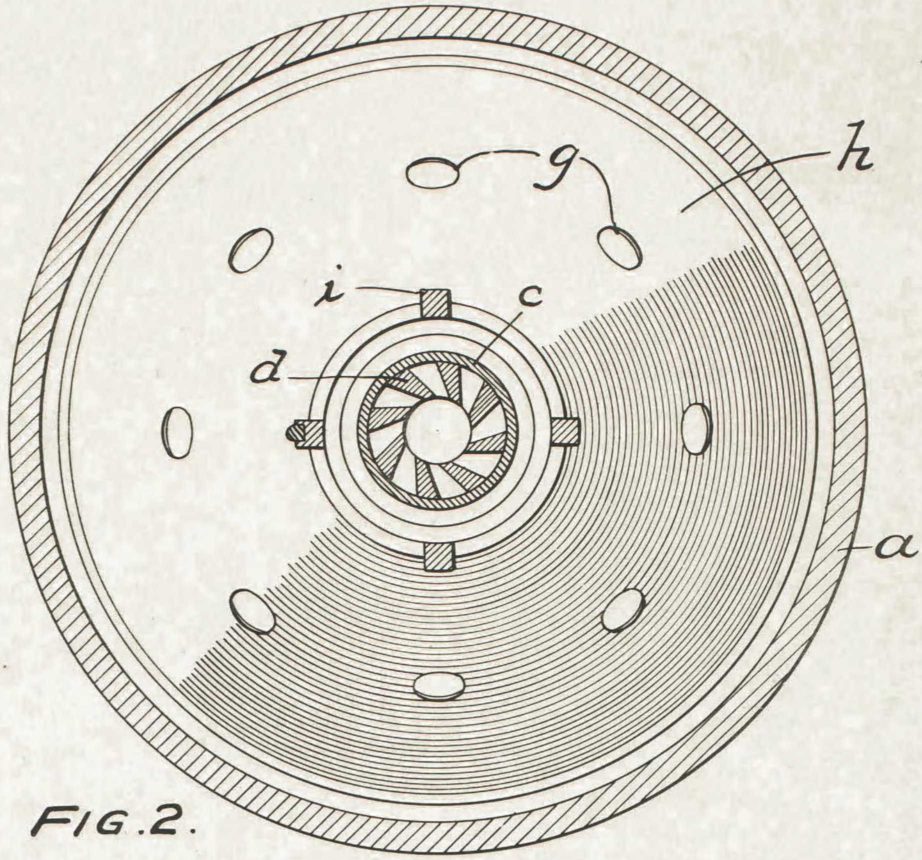


FIG. 2.

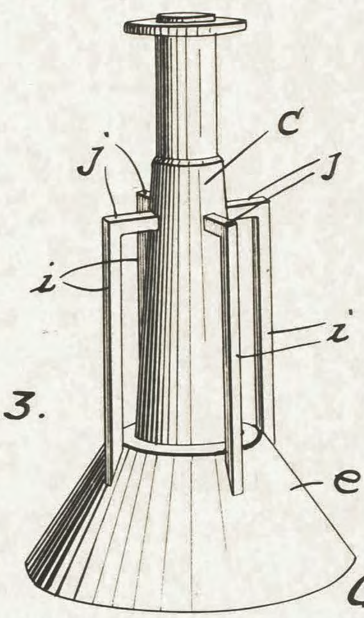


FIG. 3.

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INVENTOR
George J. Strezynski
BY
Busser and Harding
ATTORNEYS

Patented July 4, 1933 1,916,870

UNITED STATES PATENT OFFICE

GEORGE J. STREZYNSKI, OF POUGHKEEPSIE, NEW YORK, ASSIGNOR TO THE DE LAVAL SEPARATOR COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY

CENTRIFUGAL BOWL

Application filed June 25, 1931. Serial No. 546,756.

My invention relates to bowls for centrifugally separating liquids of different specific gravities and has for its object the provision of a bowl that will have less tendency to be clogged by viscous sticky liquids.

In the operation of centrifugal separators, the lighter of the two constituents when it emerges from the inner edge of the inter-disc spaces comes in contact with the outside of the tubular shaft or with the wings that ordinarily project therefrom to support the discs. If such lighter liquid be of high viscosity, and especially if it be of a sticky nature, it will frequently adhere to such shaft or wings and cause plugging of the bowl. This, in some cases, makes continuous operation impossible.

In my invention the outside diameter of the tubular shaft is made so much smaller than the outlet for the lighter constituent that it will be substantially less than the inside diameter of the annulus of such constituent in the bowl and the wings are omitted from the space betwen the discs and the tubular shaft, thereby substantially eliminating all surfaces to which it is possible for the above described viscous and sticky material to adhere, whereby there is no obstruction to the continuous discharge of such material from the bowl.

In the accompanying drawings, which illustrate a bowl made in accordance with my invention: Fig. 1 is a vertical section of the bowl, Fig. 2 a cross-section on the line 2—2 of Fig. 1, and Fig. 3 a perspective view of the tubular shaft.

The bowl shell *a* has an upstanding central nave *b* around which is a tubular shaft *c* through which the mixture to be separated is fed to the bowl. Between the nave and the tubular shaft is a liquid feed distributor *d* and at the lower part of the tubular shaft is a petticoat *e* having passages *f* communicating, at their iner ends, with the inter-bar spaces of the liquid feed distributor and at their outer ends with the distributing holes *g* through a series of frusto-conical members *h*, technically called discs, only a few of which are shown, which surround the tubular shaft above its petticoat and divide the liquid being treated into many thin layers. This liquid feed contrivance forms the subject-matter of another application filed of even date herewith, Serial No. 546,757.

The discs *h*, which are spaced from the tubular shaft, are guided by a plurality of vertical bars *i* having their lower ends attached to the petticoat *e* and their upper ends supported by bars *j* from the upper part of the tubular shaft.

Above the series of discs *h* is a top disc *k* which separates the outflowing lighter constituent from the outflowing heavier constituent in the passages *p* under the bowl top *m*. The top disc *k* is provided with a neck *n* having therein helices *o* described in my copending application Serial No. 472,277, filed August 1, 1930.

The diameter of the neck *n* is so much greater than that of the tubular shaft *c* that the inner surface *x* of the lighter component will be a substantial distance from the tubular shaft.

In operation, liquid to be separated is fed into the center of the bowl. When it strikes the top of the nave it is spread outward and caught between the bars of the distributor *d*, which cause it to rotate with the bowl. Centrifugal force then makes it flow through passages *f* to the distributing holes *g* whence it passes into the spaces between the discs *h*. Here centrifugal force causes the heavier constituent to move toward the bowl shell while the lighter constituent moves toward the center where, because it has ample space and nothing to which it can adhere, it flows upward and discharges from the top of the bowl.

Having now fully described my invention, what I claim and desire to protect by Letters Patent is:

1. A centrifuge comprising a bowl, a central tubular feed shaft, discs whose inner edges are spaced a substantial distance from the feed shaft and whose outer edges are spaced from the bowl wall, and disc-guiding devices extending substantially parallel to the axis of the feed shaft and spaced from the feed shaft so as to provide a substantial-

ly unobstructed discharge passage for the light constituent.

2. A centrifugal bowl and spaced-apart discs contained therein, said bowl having a substantially unobstructed solids-collection space between its outer wall and the outer edges of the disc and having an annular passage, substantially unobstructed in both axial and circumferential directions, for a light constituent discharged from the spaces between said discs.

3. A centrifuge comprising a bowl, discs contained therein, said bowl having a substantially unobstructed solids-collection space adjacent its peripheral wall, and means providing, for the discharging light separating constituent, an annular flow passage substantially devoid of obstructing surfaces to which sticky viscous materials can adhere, and disc-guiding means engaging the discs adjacent their inner edges but not extending into said flow passage.

4. In a centrifugal bowl, the combination with a central tubular shaft of relatively small external diameter and a nest of discs having center holes of much greater diameters than that of the tubular shaft, said bowl having a substantially unobstructed solids-collection space adjacent its peripheral wall, of disc-guiding contrivances engaging said discs adjacent said center holes and also spaced a substantial distance from said shaft, thereby providing a substantially unobstructed space surrounding the tubular shaft.

5. In a centrifugal bowl, the combination with a feed device comprising a tubular shaft of relatively small external diameter and a nest of discs having center holes of much larger diameters than that of the tubular shaft, said bowl having a substantially unobstructed solids-collection space adjacent its peripheral wall, of disc-guiding bars substantially parallel to the axis of said shaft and spaced from the shaft and supported only at top and bottom by said feed device.

6. In a centrifugal bowl, the combination with a central tubular shaft and discs in the bowl having center holes spaced a substantial distance from said tubular shaft, of vertically extending disc-supporting contrivances also spaced a substantial distance from said tubular shaft, said bowl having a substantially unobstructed solids-collection space adjacent its peripheral wall and having an outlet for the lighter separated constituent so positioned that the inner wall of discharging lighter constituent will be positioned between said contrivances and said shaft.

7. In a centrifugal bowl, the combination with a relatively small diameter tubular shaft and a nest of separating discs having center holes of much greater diameters than the diameter of the tubular shaft, said bowl having a substantially unobstructed solids-collection space adjacent its peripheral wall, of vertically extending disc-guiding bars spaced a substantial distance from said shaft, a top disc having a discharge neck smaller than the diameters of the holes in the other discs but so much greater than the diameter of the tubular shaft that the interior wall of discharging separated lighter liquid will be at a substantial distance from the annular shaft and from the vertically extending bars.

8. In a centrifugal bowl, the combination, with a bowl having a neck for discharge of the lighter separated constituent, of a central tubular shaft, discs in the bowl having center holes, the inside diameters of said neck and holes being substantially greater than the outside diameter of said shaft, said bowl having a substantially unobstructed solids-collection space adjacent its peripheral wall, and disc-supporting bars located outside the cylindrical plane of the discharge neck, thereby providing a substantially unobstructed space through which the separated lighter liquid is conveyed from the locus of separation to the discharge neck.

9. In a centrifugal bowl, the combination, with a bowl having a neck for discharge of the lighter separated constituent, of a central tubular shaft whose external diameter is substantially smaller than the internal diameter of said neck, discs in the bowl having center holes whose inside diameters are greater than the inside diameter of said neck, said bowl having a substantially unobstructed solids-collection space adjacent its peripheral wall, and disc-supporting bars located outside the cylindrical plane of the discharge neck, thereby providing a substantially unobstructed space through which the lighter separated liquid is conveyed from the locus of separation to the discharge neck.

In testimony of which invention, I have hereunto set my hand, at Poughkeepsie, N. Y., on this eighteenth day of June, 1931.

GEORGE J. STREZYNSKI.

W. S. ESTEP.
CENTRIFUGAL SEPARATOR.
APPLICATION FILED APR. 20, 1918.

1,307,000.

Patented June 17, 1919.
3 SHEETS—SHEET 1.

Fig. 1.

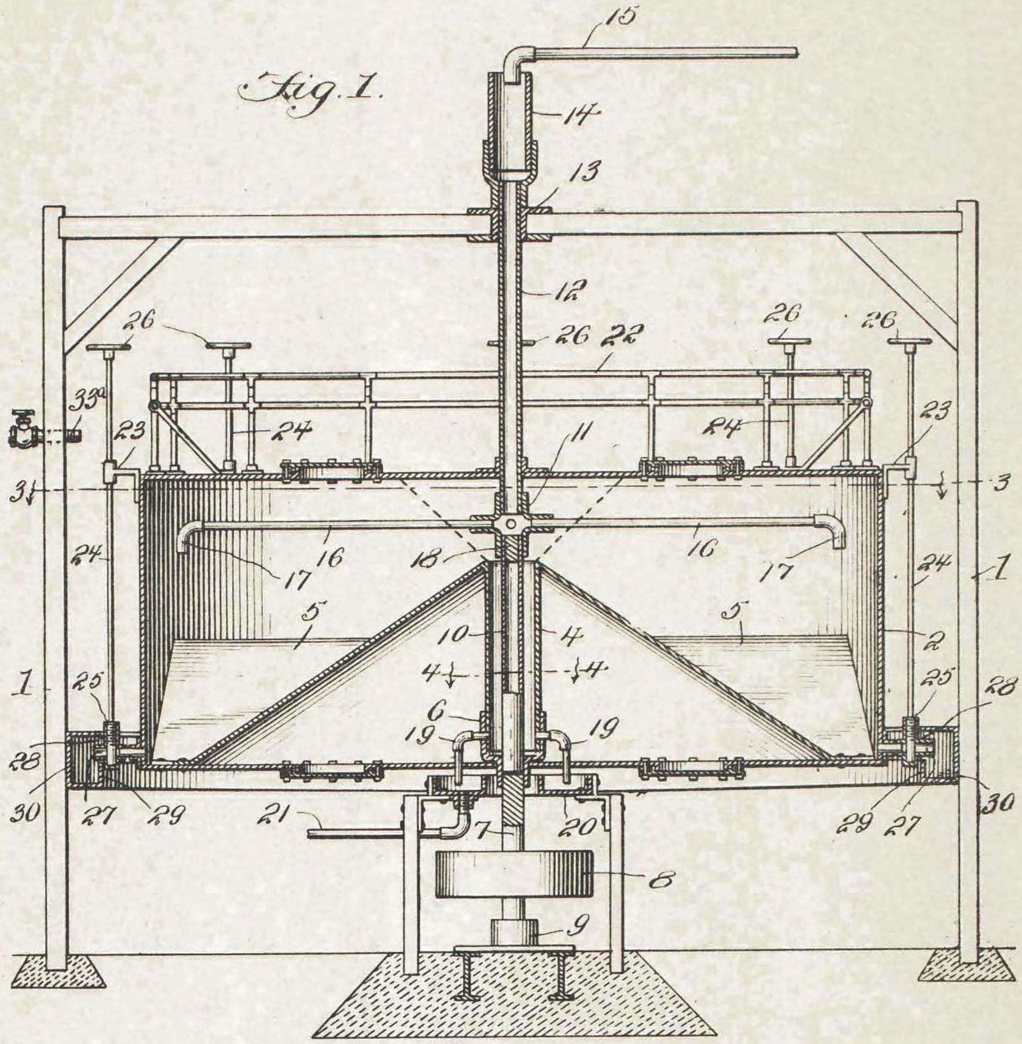
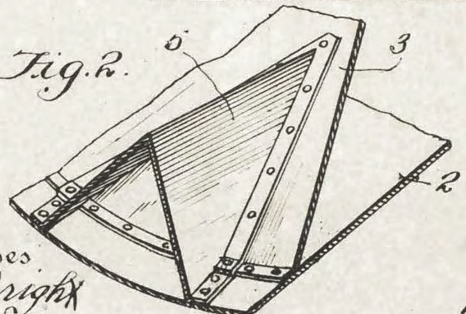


Fig. 2.



Witnesses
J. T. L. Wright

Inventor
W. S. Estep

By Victor J. Evans
Attorney

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APPLICATION FILED APR. 20, 1918.

1,307,000.

Patented June 17, 1919.
3 SHEETS—SHEET 2.

Fig. 3.

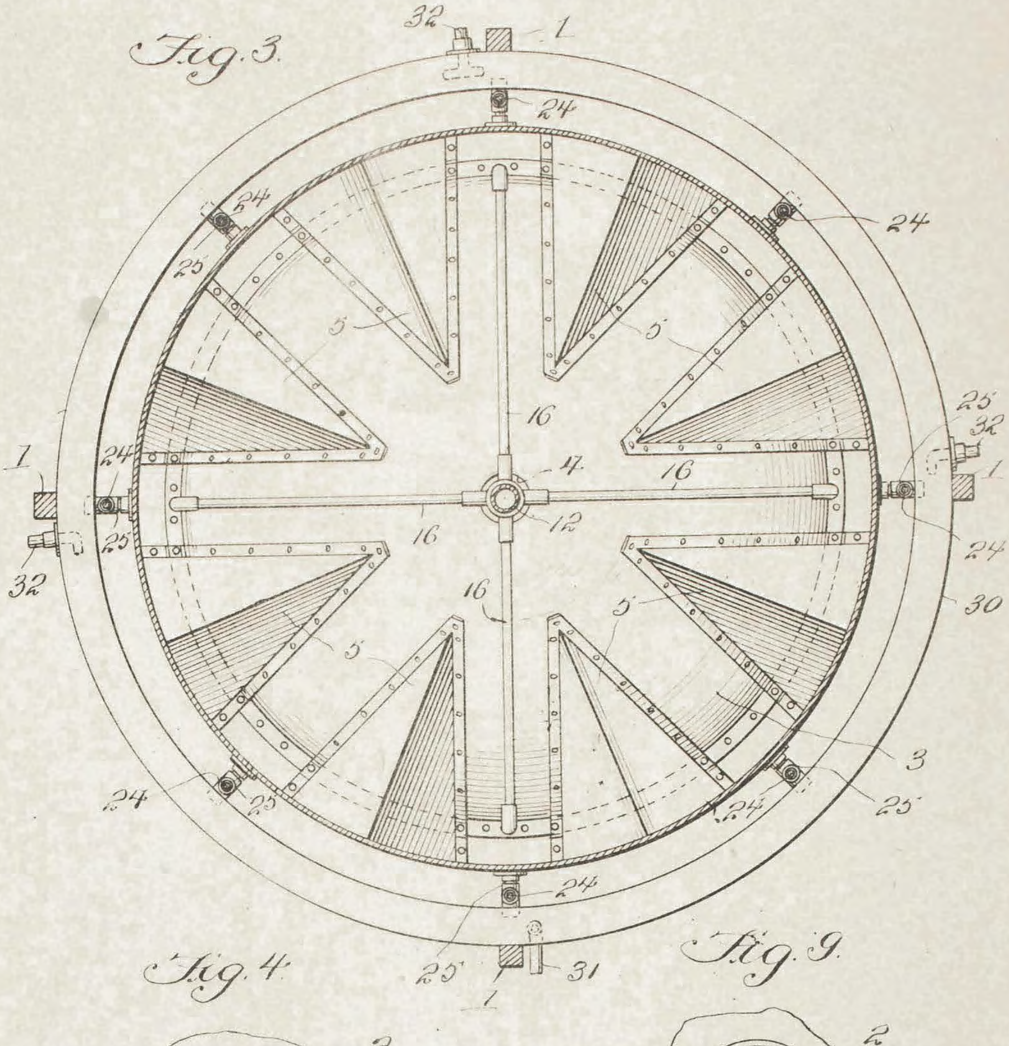

Fig. 4.

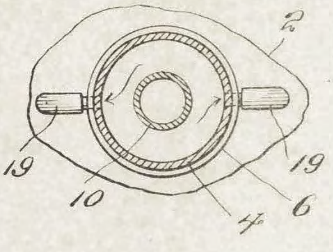

Fig. 9.

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CENTRIFUGAL SEPARATOR.

APPLICATION FILED APR. 20, 1918.

1,307,000. Patented June 17, 1919.

3 SHEETS—SHEET 3.

Fig. 5.

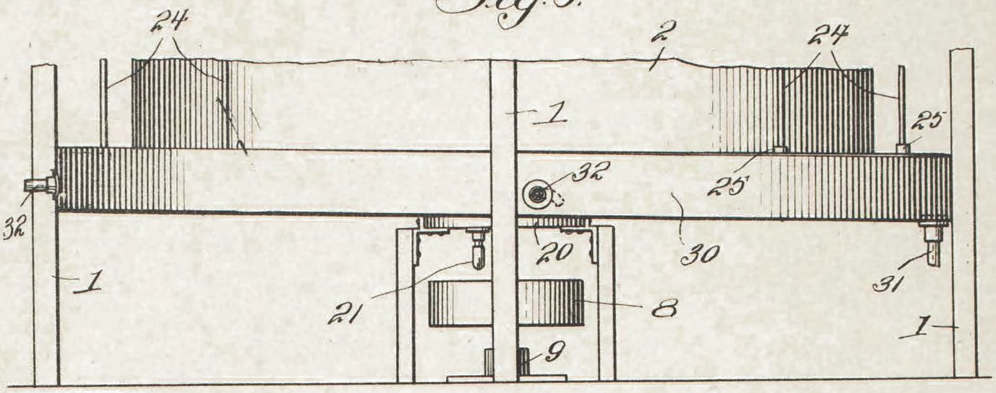


Fig. 6.

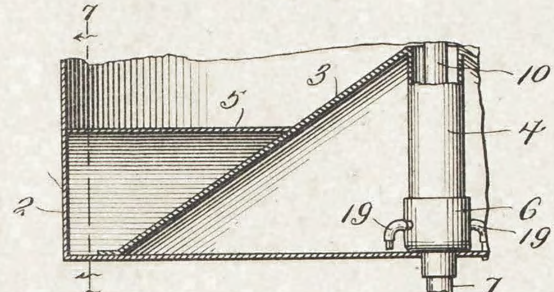


Fig. 7.

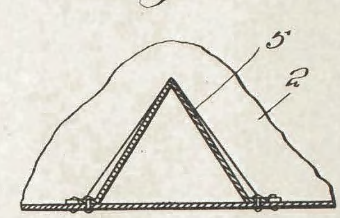
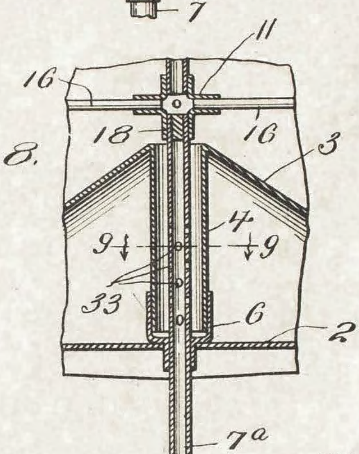


Fig. 8.



Inventor

W. S. Estep

Witnesses

J. T. L. Wright

By Victor J. Evans

Attorney

UNITED STATES PATENT OFFICE.

WALDRON S. ESTEP, OF CLEVELAND, OKLAHOMA, ASSIGNOR OF ONE-HALF TO RUFUS V. HENRY, OF AUGUSTA, KANSAS.

CENTRIFUGAL SEPARATOR.

1,307,000. Specification of Letters Patent. Patented June 17, 1919.

Application filed April 20, 1918. Serial No. 229,805.

To all whom it may concern:

Be it known that I, WALDRON S. ESTEP, a citizen of the United States, residing at Cleveland in the county of Pawnee and State of Oklahoma, have invented new and useful Improvements in Centrifugal Separators, of which the following is a specification.

My present invention has to do with the separation of foreign substance from mineral oil, more particularly crude oil.

The object of the invention is the provision of mechanical means for bringing about the thorough separation of a foreign substance known as "B. S." from crude oil, and this expeditiously and without the employment of chemicals or any other extraneous means. The substance referred to as B. S. is largely composed of water in the form of small particles coated with cut oil.

With the foregoing in mind, the invention will be fully understood from the following description and claims when the same are read in connection with the drawings accompanying and forming part of this specification, in which—

Figure 1, is a vertical and diametrical section of a separator constructed in accordance with my invention and designed especially for handling a heavy volume of oil.

Fig. 2, is a detail perspective illustrative of one of the cone-like separator memb rs comprised in the apparatus.

Fig. 3, is a horizontal section taken in the plane indicated by the line 3—3 of Fig. 1, looking downwardly.

Fig. 4, is a detail horizontal section taken in the plane by the line 4—4 of Fig. 1, looking downwardly.

Fig. 5, is a detail view showing the arrangement of the valved discharge nipples of the centrifugal vessel relative to the annular stationary trough, which receives from said nipples.

Fig. 6, is a detail longitudinal vertical section taken through one cone-like separator member of the centrifugal vessel.

Fig. 7, is a section taken at right angles to Fig. 6, and in the plane indicated by the line 7—7 of Fig. 6.

Fig. 8, is a detail vertical diametrical section of a modification hereinafter specifically referred to.

Fig. 9, is a horizontal section in the plane of line 9—9 of Fig. 8.

Referring by numeral to the said drawings, and more particularly to Figs. 1–7 thereof:

1, is the frame of my novel separator apparatus. Obviously this frame may be of any construction compatible with its purpose, though the construction illustrated has been found to be well adapted to the use to which it has been put.

Suitably mounted in the frame 1 is the centrifugal vessel 2, which constitutes a highly important part of the apparatus. The said vessel 2 is provided at 3 with a bottom wall in the form of a truncated cone, and from the inner and upper portion of the said cone bottom 3 depends a tube 4. It will also be noted by comparison of Figs. 1–3 that the bottom 3 is provided at intervals on its outer portion with separator members 5 of inverted V-shape in cross section for an important purpose hereinafter set forth. At its lower end the tube 4 is disposed and suitably fixed in the cup 6, and this cup 6 is fixed on the upper end of a solid shaft 7 that bears a band pulley 8, and is stepped at its lower end in the fixed bearing 9. Also fixed in the cup 6, and to solid shaft 7 is a tubular shaft section 10. This shaft section 10 extends upwardly through the tube 4 and is joined through a coupling 11 with a tubular shaft section 12. This latter shaft section is generally adjacent to its upper end in the bearing 13 and the upper portion of the frame 1, and above the said bearing 13 is equipped with the receiving element 14. The said receiving element 14 is made proportionately large diameter as illustrated in order to receive crude oil from an inner pipe 15 as illustrated, or from a plurality of pipes in the discretion of the party practising the invention.

The coupling member 11 serves to effect connection of the tubular shaft sections 12 and 10 to radially disposed pipes 16 equipped with depending discharge spouts 17. It will be noticed, however, that the section 12 alone is not in communication with the radial pipe 16, the upper end of the section 10 being closed by plug 18, and the said section 10 being made tubular purely for the sake of lightness.

Communicating with and extending outwardly and downwardly from the cup 6 and grouped about the said cup are discharge pipes 19. These pipes 19 have their eduction disposed in the annular tray 20, and from the said tray extends a pipe 21, which has for its function to conduct the clarified oil to a stock tank, or to any other suitable point of storage.

Superimposed and fixed to the top of the vessel 2 adjacent to the circumference thereof is a safety rail 22, and journaled in exterior bearing 23 on vessel 2 are the vertically disposed stems 24 of valves 25 which are preferably for practical purposes in the form of gate valves. At their upper ends the stems 24 are provided with hand wheels 26, arranged within convenient reach of an attendant who may under certain conditions stand upon the vessel 2.

It will be understood from the foregoing that the valves 25 and their complementary stems 24 and hand wheels 26 are grouped at intervals about the vessel 2, and by reference to Fig. 1 it will be noted that each valve 25 is arranged to control a radially disposed nipple 27 which communicates with and leads from the interior of the vessel 2 adjacent to the bottom thereof. The said nipples 27 are arranged and movable in the opening 28 provided in the inner wall 29 of an annular receiving trough 30, which is suitably fixed within the frame 1 and is provided with a pipe 31, as best shown in Fig. 5 and designed to lead "B. S." to a suitable point of discharge. It will also be observed by comparison of Figs. 1 and 5 that the trough 30 is inclined or canted downwardly toward the pipe 31, so as to promote the passage of "B. S." to the said pipe 31; also that the opening 28 in the inner wall of trough 30 is so disposed that the lower portion of the inner wall 29 of the trough is gradually increased in height as it approaches the discharge pipe 31. From this it follows that notwithstanding the inclination of the trough 30 and the arrangement of the nipples 27 which move in the horizontal plane in the trough, there is no liability of "B. S." overflowing from the trough through the opening 28.

On Fig. 3, 32 is a valved pipe designed to be connected with a suitable source of steam supplied and leading into the discharge pipe 31 of the trough 30, and at 33ª is another valved pipe designed to lead from the source of steam supply and also designed for the connection of a hose to which steam may be conveniently applied to the interior of the vessel 2 for thoroughly cleaning the said vessel subsequently to an operation of the apparatus.

As will be noted by comparing Figs. 1 and 3, the separator members 5 extend entirely between the cone bottom 3 and the said wall of the vessel 2; also, the nipples 27 are arranged to lead "B. S." from the vessel 2 at points between the members 5 and the radial pipes 16 are arranged to discharge streams of oil into the vessel at points between the separator members 5.

The construction hereinbefore specifically referred to, and best shown at the bottom of Fig. 1, is designed more especially for embodiment in a large machine adapted to handle a heavy volume of oil; the solid shaft 7, and the cup interposed between the stem and the tube 4 being well adapted to withstand a great amount of torsional strain imposed on the rotary portion of the apparatus.

In Figs. 8 and 9, I show a modification relating more particularly to the lower portion of the apparatus and designed for incorporation in a comparatively small apparatus, or one designed for handling a light volume of oil. In the said modified construction, a tubular shaft 7^a is employed to conduct the clarified oil to a stock tank or other suitable point of storage. The said shaft 7^a is fixably connected to a cup 6: and the said cup 6 is fixably connected in turn with the tube 4 through the medium of which it is connected with the inner portion of the truncated cone-shape bottom 3. The portion of the pipe 7^a within the tube 4 is foraminous, as indicated by 33 in order to enable oil to pass from the tube 4 into the pipe 7^a; and it will also be noted that the portion of the pipe 7^a within the coupling 11 is plugged to prevent the direct passage of the incoming oil to the pipe 7^a.

As set forth in my statement of invention, the object of this my invention is the provision of an apparatus for eliminating the foreign substance well known in the art as "B. S." from crude oil; it being an established fact that crude oil containing more than approximately 2% of the said foreign substance is not marketable.

In the operation of my apparatus to attain the end stated, the crude oil is conducted through one or more pipes 15 into the primary receiver 14 of the apparatus. From the said receiver 14 the crude oil passes downwardly through the tubular shaft section 12, and this radially outward through the pipes 16 from the spouts 17 from which it is discharged downwardly into the centrifugal vessel 2, which is rotated at a high rate of speed. In the said vessel 2, and by reason of the centrifugal action plus the action of gravity, the foreign substance known as "B. S." is caused to collect in the lower and outer portion of the vessel 2, while the comparatively light clarified oil has a tendency to rise and to assume a position adjacent to the upper receiving end of the tube 4. Into the said tube 4 the clear oil passes, and from said tube 4 the clear oil is discharged into the annular tray 20, in which the discharge ends of the pipes 19 are arranged to revolve as above described.

From the tray 20 the clear oil is carried to storage through the pipe 21.

Incidental to the described segregation of the foreign substance "B. S." in the outer and lower portion of the centrifugal vessel 2, and during the holding of the said foreign substance in said vessel portion, the separator members 5 serve the important purpose of effectually preventing collection of the "B. S." into a unitary mass, this being materially advantageous for the reason that the gathering of the heavy foreign substance "B. S." at any one point in the vessel 2 would have the effect of destroying the balance of the vessel 2, and would, therefore, seriously interfere with the efficient operation of the apparatus. It will also be noted in this connection that by reason of the relative arrangement of the cone-shaped separators and the pipes 16, the oil is initially discharged into the vessel 2 at points between the separators 5, and hence the said separators 5 have only to retain the foreign substance "B. S." at the points in which said substance is initially placed. I would, therefore, have it understood that the foreign substance "B. S." is not continually discharged from the vessel 2. On the other hand the separation of the substance "B. S." is effected in the following manner, namely:

After the vessel 2 has been rotated for a necessary period of time with a full complement of oil therein, the speed of the said vessel 2 is reduced to a very considerable extent, or so that it slowly rotates but yet has a tendency to move the mass therein radially outward. At this time while standing on the vessel 2 and holding to the rail 22, the operator manipulates the hand wheel 26 so as to open the gate valves 25. When this is done it is to be understood that the comparatively heavy foreign substance "B. S.", which has collected between the separators 5, and in the lower outer portion of the vessel 2 during the previous rotation of the vessel 2 at a high rate of speed, will pass through the nipples at 27 into the annular trough 30, and by reason of the inclination of the said trough will be carried to the pipe 31, and through the latter to a suitable point of discharge. At this time steam is let into the pipe 32, and being discharged by the said pipe 32 into the pipe 31 will have the effect of heating and reducing the thickness of the foreign substance "B. S.", with the result that the free flow of the latter through the pipe 31 will be promoted. During the described taking off or elimination of the foreign substance "B. S.", a free flow of the comparatively clear crude oil into the tube 4 takes place, from whence the comparatively clear oil is carried through the pipes 19 and the tray 20 and the pipe 21 to a storage point, as before described. By observing the oil passing to the point of storage, as stated, the attendant is enabled to ascertain when such oil is practically free from the substance "B. S.", and when the oil is in such state the attendant is apprised of the fact that it is time to close the valves 25, which purpose he accomplishes by manipulation of the hand wheels 26.

After the steps set forth in the operation are carried out, the driving of the vessel 2 at a comparatively high rate of speed is resumed to bring about the collection of the foreign substance "B. S." in the outer and lower portion of the vessel, and the gathering of the clear oil in the upper and inner portion of the vessel, and the free flow of such clear oil into the upper end of the tube 4. It will be noticed in this connection, and particularly to Fig. 1, that the truncated cone-shape of the vessel bottom 3 is materially advantageous in bringing about the result stated, and inasmuch as the said bottom 3 facilitates the gravitation of the substance "B. S." to the outer and lower portion of the vessel 2, and in this the said bottom 3 is assisted by the shape and sloping sides of the separators 5. It will also be noted that the truncated cone-shaped bottom 3 assists the tendency of the comparatively light and clarified oil, which tendency is to rise and gather initially in the upper portion of the vessel 2, but also in the inner portion of said vessel from whence it is free to pass in company with but an infinitesimal quantity of the foreign substance "B. S."

It will be appreciated from the foregoing that my novel separating apparatus when properly operated is adapted to reduce the proportion of the foreign substance "B. S." to less than 2% in a large volume of crude oil, and in a short period of time; also that the operation of the apparatus does not entail the employment of skilled labor, and that it may be carried out to the best advantage without the assistance of chemicals, or other extraneous means whatsoever. In other words my novel apparatus is adapted to accomplish the elimination of the foreign substance "B. S." by purely mechanical means, which takes advantage of the principles of centrifugal action and gravity.

I prefer to employ gate valves, as stated, for controlling the nipples 27, as said valves leave the passages through the nipples entirely unobstructed. I do not desire, however, to be understood as to be confining myself to valves of the gate type, since other valves might be employed, if necessary, without affecting the general operation of my apparatus.

I would also have it understood that my novel apparatus is not designed to reclaim any portion of the foreign substance "B. S." On the other hand the function of my apparatus is purely to free, or practically free, the crude oil of the substance "B. S.", so as to render the crude oil perfectly marketable, and that which is done with the foreign substance "B. S." after separation from the oil is not of my invention.

Subsequently to an operation of my novel apparatus, it is desirable to quickly and thoroughly clear the vessel 2 of collected sediment, and to attain this end the valves 25 are opened and the vessel 2 is slowly rotated while steam from a hose connected to the valved pipe 33 is played into the vessel 2 and upon the separators 5 and the other parts thereof.

In the modified construction shown in Figs. 8 and 9, the clarified oil passes from the tube 4 through the foraminations of the shaft section 7^a into said shaft section, and is conducted by the stem to a suitable point of storage.

Experience has demonstrated that the apparatus herein shown and described is possessed of large capacity in proportion to its size and the power required to drive it, and I, therefore, prefer to employ in carrying out of my invention an apparatus in which the parts are similarly constructed and relatively arranged. I do not desire, however, to be understood as confining myself to the said specific construction and relative arrangement of parts, as since in the future practice of the invention changes in the form and arrangement of the parts may be made without involving departure from the principle of my invention as defined in my appended claims.

Having described my invention, what I desire and claim by Letters Patent is:

1. In a centrifugal separating apparatus, the combination of a vessel mounted for rotation about its axis, means in the vessel for receiving oil from the upper inner portion of the vessel, means for delivering oil to the vessel at intervals and at points adjacent to the side wall of the vessel, means forming the bottom of the vessel and inclined outwardly and downwardly toward the said side wall, means on the said inclined bottom means for separating the oil in the vessel into portions; said separating means being arranged in staggered relation to the oil delivering means, and means carried by the vessel and arranged in substantial vertical coincidence with the oil delivering means for conducting foreign substance from the vessel.

2. In a centrifugal separating apparatus, the combination of a vessel mounted for rotation about its axis, means in the vessel for receiving oil from the upper inner portion of the vessel, means for delivering oil to the vessel at intervals and at points adjacent to the side wall of the vessel, means forming the bottom of the vessel and inclined outwardly and downwardly toward the said side wall, means on the said inclined bottom means for separating the oil in the vessel into portions; said separating means being arranged in staggered relation to the oil delivering means, means carried by the vessel and arranged in substantial vertical coincidence with the oil delivering means for conducting foreign substance from the vessel, and valves in the said conducting means.

3. In a centrifugal separating apparatus, the combination of a vessel mounted for rotation about its axis, means in the vessel for receiving oil from the upper inner portion of the vessel, means for delivering oil to the vessel at intervals and at points adjacent to the side wall of the vessel, means forming the bottom of the vessel and inclined outwardly and downwardly toward the said side wall, means on the said inclined bottom means for separating the oil in the vessel into portions; said separating means being arranged in staggered relation to the oil delivering means, means to be carried by the vessel and arranged in substantial vertical coincidence with the oil delivering means for conducting foreign substance from the vessel, valves in said conducting means, and a stationary annular trough having an opening in its inner wall for the reception and play of the said conducting means of the vessel.

4. In a centrifugal apparatus, the combination of the vessel in rotation about its axis, and having a bottom in the form of a truncated cone, a tube extending downwardly from the inner portion of said bottom, separators of inverted V-shape in cross-section arranged at intervals on the outer portion of said bottom, means for delivering oil to the receptacle at points above the spaces between said cone-shaped separators, and means for conducting foreign substance from the vessel at points between said separators.

5. A centrifugal separating apparatus comprising a vessel mounted for rotation about its axis, and having a bottom of the shape of a truncated cone, a central shaft carrying the said vessel, and having an upper tubular portion, means for supplying oil to said tubular portion, radial pipes extending from said tubular portion and arranged to discharge in the outer upper portion of the vessel, separators of inverted V-shape in cross section arranged on the outer portion of the truncated cone bottom and disposed in staggered relation to the said radial pipes, a tube connected with and adapted to receive oil from the upper inner portion of the truncated cone bottom, means for conducting oil from the said tube, and means for conducting collected foreign substance out of the vessel at points between the separators.

6. A centrifugal separator apparatus, comprising a vessel mounted in rotation about its axis and having eduction conduits extending outwardly from its lower outer portion at intervals, valves controlling said conduits, a safety rail on the vessel, and valve stems grouped about the vessel at intervals and connected therewith, and having handles arranged in the plane above that of the vessel.

7. In a centrifugal apparatus, the combination of the vessel mounted in rotation about its axis, and having eduction conduits extending outwardly from its outer lower portion at intervals, and also having valves in said conduits, and stems grouped about the vessel and extending above the stem and connected to the said valves, and carried by the vessel so as to rotate therewith.

8. In a centrifugal apparatus, the combination of a fixed stationary trough inclined downwardly to a point of discharge and having an inner side wall, and an opening in said wall, and also having the inner wall portion below the opening increased in height as it approaches said point of discharge, and a centrifugal vessel mounted for rotation within the annular trough and having eduction conduits disposed and movable in a horizontal plane in the said opening of the trough.

9. In a centrifugal separating apparatus, the combination of a stationary annular trough open at its inner side, and a vessel arranged within the trough and for rotation about its axis, and having eduction conduits at intervals of its outer and lower portion disposed and movable in the opening of the trough, and also having a truncated cone-shaped bottom, a tube adapted to receive an element of the oil from the upper inner portion of said bottom, separators of inverted V-shape in cross section arranged on the outer of the bottom at intervals, means for conducting an element of the oil from the said tube to a point of storage, and means for delivering oil to be separated into elements to the vessel above the spaces between the cone-shaped separators.

10. In a centrifugal separating apparatus, the combination of stationary, annular receiving means, a vessel mounted for rotation about its axis and arranged within said means, and having valved eduction means at intervals arranged to deliver substance to said receiving means, means in the vessel for accelerating the passage of heavy substance to the outer lower portion of the vessel, means at intervals on the last named means for separating the substance into portions, and means rotatable with the vessel and constructed and arranged to supply substance to be separated to the vessel at points above the spaces between the said separating means.

In testimony whereof I affix my signature.

WALDRON S. ESTEP.

Dec. 14, 1937. H. WALCH ET AL **2,102,297**

PROCESS AND APPARATUS FOR SEPARATION OF THE COMPONENTS
OF A MIXTURE OF MORE THAN TWO COMPONENTS

Filed May 11, 1931

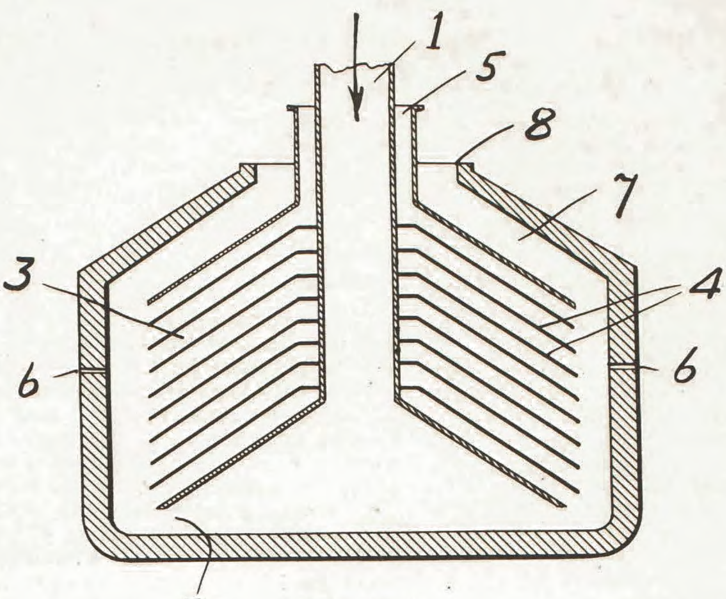


FIG. 1.

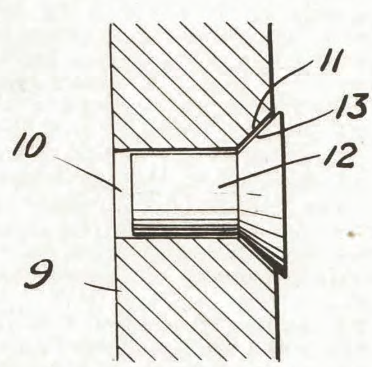


FIG. 2.

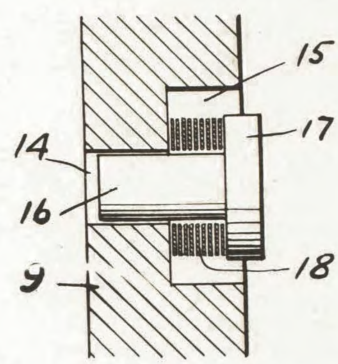


FIG. 3.

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BY

Busser and Harding

ATTORNEYS.

Patented Dec. 14, 1937 2,102,297

UNITED STATES PATENT OFFICE

2,102,297

PROCESS AND APPARATUS FOR SEPARATION OF THE COMPONENTS OF A MIXTURE OF MORE THAN TWO COMPONENTS

Henri Walch and Jean Prélaz, Paris, France, assignors, by mesne assignments, to The De Laval Separator Company, New York, N. Y., a corporation of New Jersey

Application May 11, 1931, Serial No. 536,500
In Sweden June 11, 1930

7 Claims. (Cl. 233—20)

In centrifugal separators of the usual types, which as a rule are constructed for separation of two liquids of different specific gravities, the separated components are discharged from the bowl over level outlets whose radial positions are fixed. If, however, three or more liquids of different specific gravities are to be continuously discharged from the bowl, the construction of a corresponding number of level outlets offers very considerable difficulties. In addition, the bowl will also be very sensitive to variations in the specific gravities of the components of the liquids.

The object of the present invention is to provide means for securing effective separation and separate discharge of more than two components.

In the drawing, which shows preferred embodiments of the invention:

Fig. 1 is a vertical section of a centrifugal bowl, embodying the invention, which is adapted for continuous separation of three liquids of different specific gravities.

Figs. 2 and 3 are detail sections illustrating different modifications of one of the heavier liquid discharging means.

The invention is mainly characterized by elements in the bowl wall of such a construction that they allow but one of the two heavier components of the original mixture which are being displaced towards the periphery of the bowl to stream out, the lightest component of the mixture discharging in known manner through outlets close to the rotation center of the bowl. The other of the two heavier components of the original mixture which are displaced toward the periphery of the bowl (which component may be the heaviest component or the next heaviest component of the original three components) discharges through outlets arranged in known manner at a radial zone outside the outlet for the lightest component.

The bowl illustrated in Fig. 1 is especially constructed for separating oil from a mixture of goudrons and sulphuric acid, which are residues after the refining, at the same time that the goudrons and sulphuric acid are separated from each other, and for separately removing these three components. Of these three components, the oil has the lowest specific gravity and the acid the highest specific gravity. The mixture is fed into the centrifugal bowl through a central feed tube 1 and then streams through channels 2 into a separating chamber 3, preferably provided with a liner of frusto-conical discs 4. In this chamber the mixture of liquids is at first separated into two main bulks, one of which consists exclusively of the lightest component, and the other of the two heavier components. The lighter component, e. g., the oil, is displaced inward in the separating chamber and discharges through level outlet 5, which may be regulable by well known means. The two heavier components, e. g., the sulphuric acid and the goudrons, are displaced towards the periphery of the bowl under the influence of the centrifugal force. In the bowl wall 9 are outlets 6, which may be capillary nozzles, of such a construction as to allow the escape of the sulphuric acid with but very little or nothing of the goudrons, which have a higher viscosity than the sulphuric acid. The goudrons move inward through channels 7 and are removed from the bowl in known manner through outlet 8, which may also be regulable in known manner.

With other mixtures it is, of course, possible to arrange the nozzles in such a way that the next heaviest component, with but very little or nothing of the heaviest component, will escape through the nozzles, the heaviest liquid discharging through an outlet of known type, for instance, a level outlet like outlet 8.

In the specific mixture given as an example, all three substances to be separated are in liquid state. It must not be understood, however, that the process is limited to substances with comparatively low viscosity. In fact, substances of a consistency between that of a liquid and that of solids are separable in a bowl embodying the invention.

Figure 2 shows a special type of capillary nozzle in the bowl wall 9. The channel 10, whose axis is at right angles to the rotation axis of the bowl, has, at its inner end, the shape of a conical valve seat 11. The channel is partly occupied by a valve body 12, the inner part of which has the shape of a cone 13 fitting on the valve seat 11. During the rotation of the centrifugal bowl the cones of the valve body are pressed outward onto the valve seat so that capillary conical throughflow channels are formed between the cone and the seat.

Figure 3 illustrates still another type of capillary nozzle in the bowl wall. The channel 14 has, in this construction, a boring or countersunk portion 15 at the inner side of the wall. Extending into the channel is the shank of a pin 16, having, at its inner end, a head 17. In the boring, surrounding the shank of the pin, are a number of thin ring-shaped (preferably metal) discs 18. When the centrifugal bowl rotates, the pin is thrown outward by the centrifugal force and presses together the discs 18, so that the desired capillary channels are formed between them.

The effect of the centrifugal force acting on the valve bodies 12 or the pins 16 may be increased by means of springs, arranged in such a manner that they press the said parts outward. The same effect may be reached by the aid of screws forcing these parts outward.

It will be understood that the invention is not limited to the separation of the particular mixture of oil, goudrons and acid specified, since it is applicable to the separation of any mixture of more than two components whereof the two heavier components are of different specific gravities or of substantially different viscosities.

Having now fully described our invention, what we claim and desire to protect by Letters Patent is:

1. A centrifugal bowl for continuous separation and separate discharge of the components of a mixture of more than two components, comprising outlet means for one of the heavier components positioned relatively near the rotation axis of the bowl and communicating directly with the interior of the bowl at only its peripheral zone, and outlet means for the other heavier component, the last named outlet means comprising a hole providing a comparatively free opening when the bowl is stationary and means adapted to so throttle the hole during rotation of the bowl as to provide an outlet of capillary character.

2. A centrifugal bowl for continuous separation and separate discharge of the components of a mixture of more than two components, comprising outlet means for one of the heavier components positioned relatively near the rotation axis of the bowl, and outlet means for the other heavier component, the last named outlet means comprising a frusto-conical valve seat and a valve having a frusto-conical part substantially conforming in shape to the valve seat and which is arranged to press outward due to centrifugal action onto said valve seat during rotation of the bowl to form a capillary throughflow channel between the valve and its seat.

3. A centrifugal bowl for continuous separation and separate discharge of the components of a mixture of more than two components, comprising outlet means for one of the heavier components positioned relatively near the rotation axis of the bowl, and outlet means for the other heavier component, the last named outlet means comprising a countersunk recess, a headed pin, and ring-shaped discs sleeved on the pin between its head and the base of the recess and arranged to be pressed together by centrifugal action during the rotation of the bowl to form capillary channels between them.

4. The process of separating a mixture of more than two constituents of which one of the heavier constituents is a relatively free flowing liquid and the other of the heavier constituents is a relatively viscous material, which comprises subjecting the mixture to centrifugal force, effecting separate discharge of the three constituents by so throttling the discharge through which the two heavier constituents tend to escape as to allow the escape therethrough of only the more free flowing of the two heavier constituents and compel separate outflow of the other heavier constituent.

5. A centrifugal bowl for continuous separation and separate discharge of a mixture of three constituents one of the two heavier of which is a relatively free flowing liquid and the other a relatively viscous material, said bowl having outlets, relatively near the axis, communicating respectively with the central portion and peripheral portion of the separating space of the bowl, said bowl having an outlet in its peripheral wall through which both of said heavier constituents tend to escape, said peripheral outlet being formed by members presenting opposing surfaces and which are movable one relatively to another to afford between said surfaces an outlet of variable size but which, under the influence of centrifugal force, tend to close and so closely contact as to provide an outlet of capillary character through which only the relatively free flowing liquid can escape, thereby compelling the discharge of the other heavier ingredient through the outlet, relatively near the bowl's axis, communicating with the peripheral portion of the separating space of the bowl.

6. A centrifugal bowl for continuous separation and separate discharge of a mixture of two constituents one of which is a relatively free flowing fluid and the other of which is a relatively viscous material, said bowl having an outlet in its peripheral wall through which both constituents tend to escape and an outlet, relatively near its axis, which communicates directly with only that part of the bowl adjacent its periphery, said peripheral outlet being formed by members presenting opposing surfaces and which are movable one relatively to another to afford between said surfaces an outlet of variable size but which, under the influence of centrifugal force, tend to close and so closely contact as to provide an outlet of capillary character through which only the relatively free flowing liquid can escape, thereby compelling the discharge of the other specified constituent through the other outlet.

7. The process of separating a mixture produced by the treatment of oil with a mineral acid to thereby form a mixture of oil, acid sludge and free acid, the acid sludge and free acid being of substantially greater specific gravity than the oil and the acid sludge being comparatively viscous and the free acid being relatively free-flowing, which comprises subjecting the mixture to centrifugal force and effecting separate discharge of the three constituents by so throttling the discharge through which the acid sludge and free acid tend to escape as to allow the escape of only the relatively free-flowing acid and compel separate outflow of the acid sludge.

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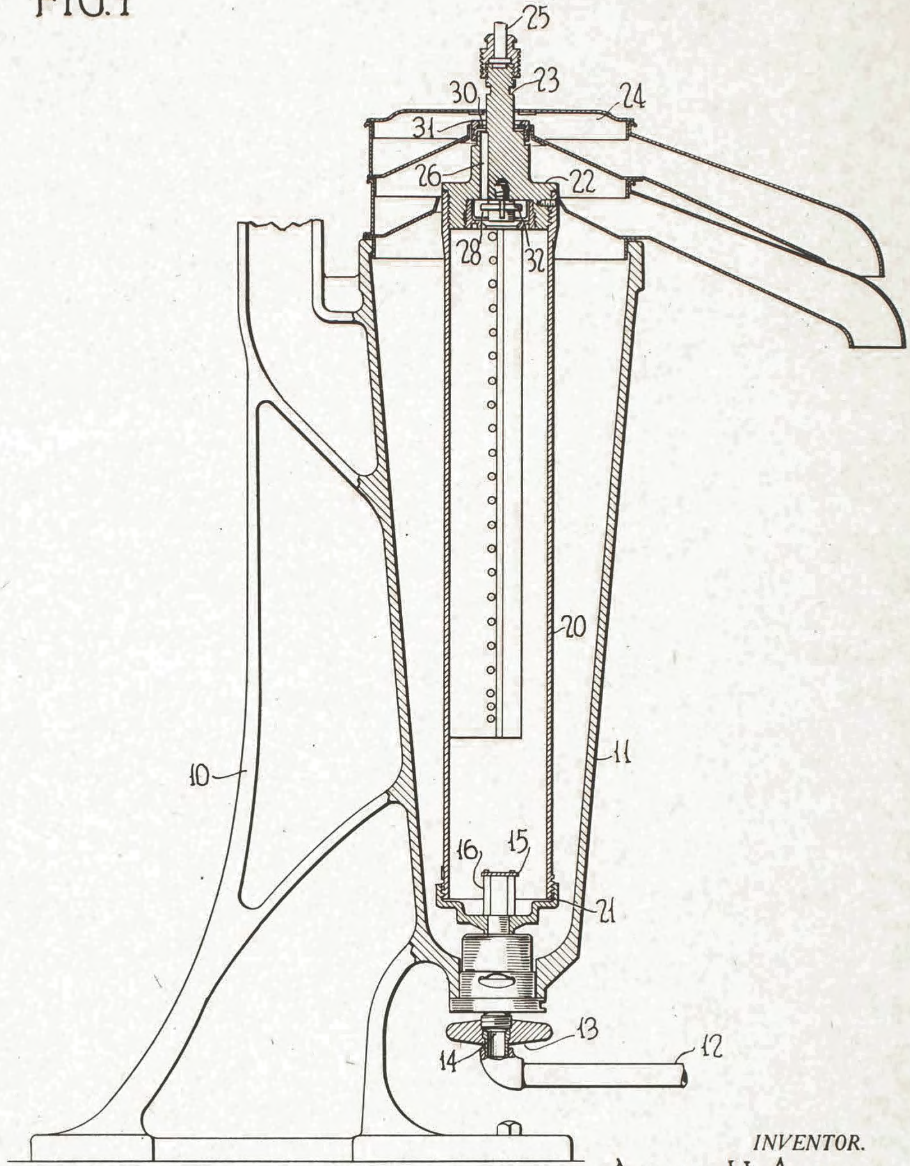
Jan. 12, 1937. A. U. AYRES 2,067,590

CENTRIFUGAL SEPARATOR

Filed Sept. 12, 1932 4 Sheets-Sheet 1

FIG. 1



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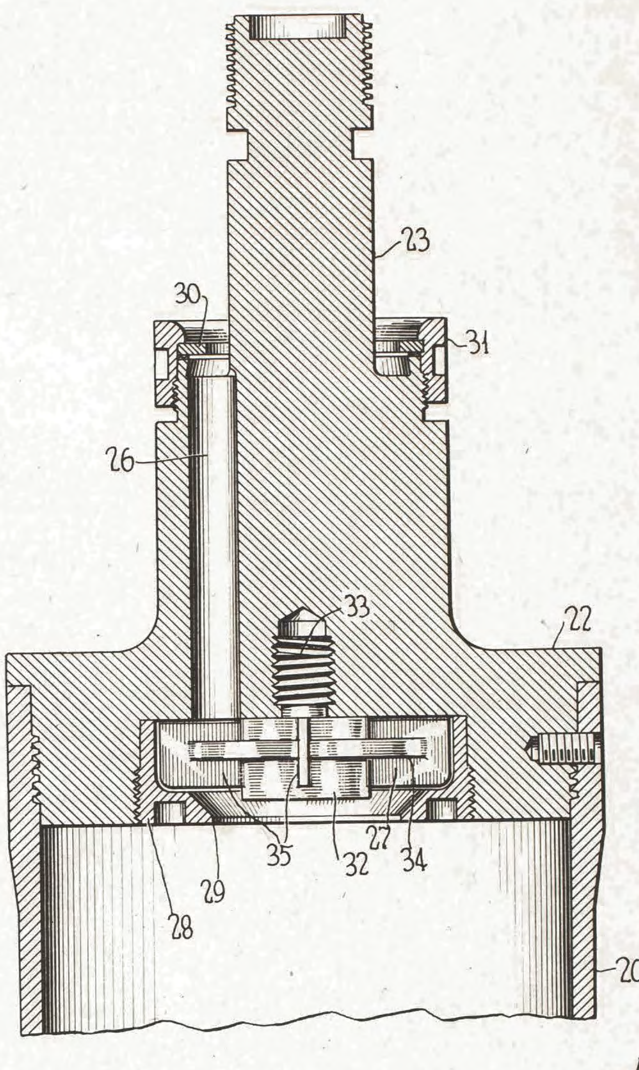
CENTRIFUGAL SEPARATOR

Filed Sept. 12, 1932 4 Sheets-Sheet 2

FIG.2



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CENTRIFUGAL SEPARATOR

Filed Sept. 12, 1932 4 Sheets-Sheet 3

FIG.3

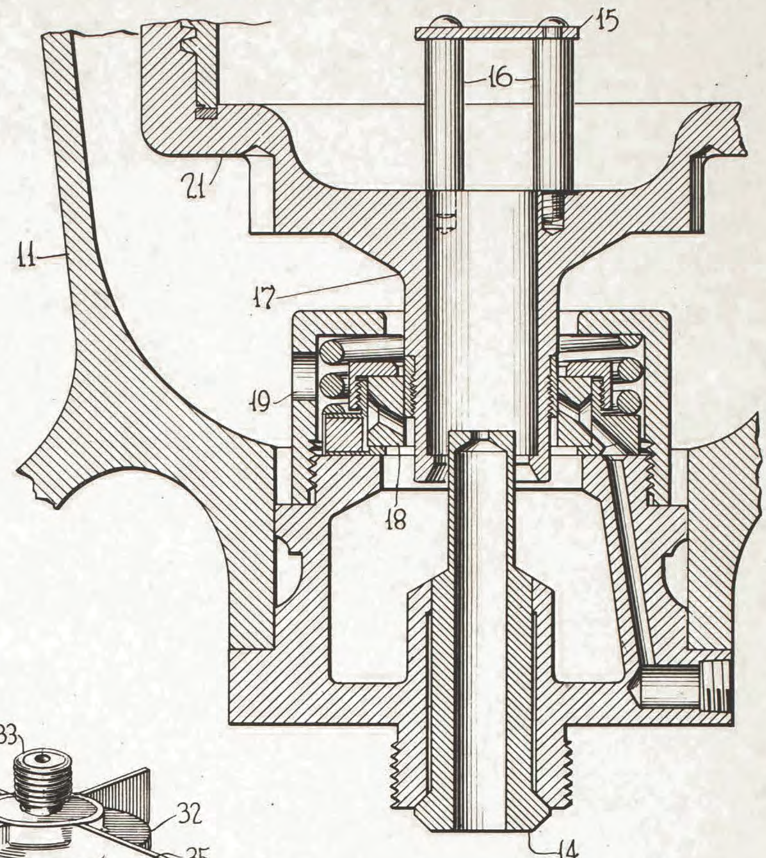
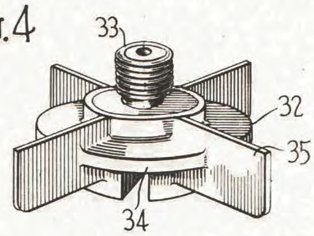


FIG.4



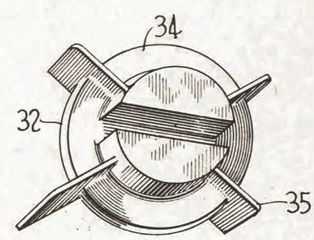


FIG.5

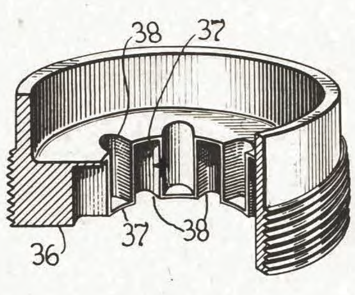


FIG.6

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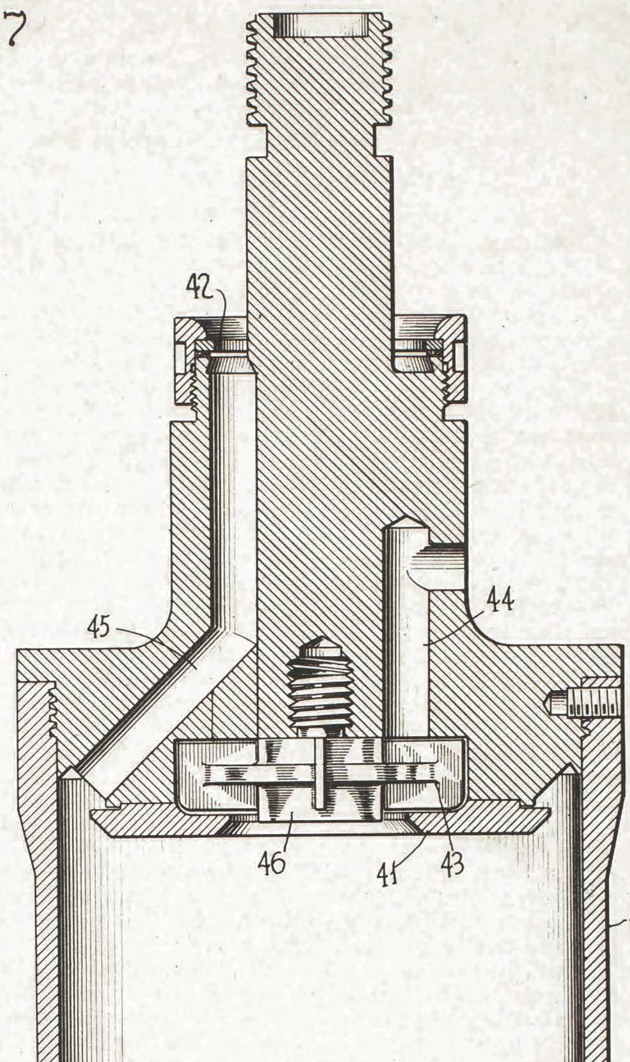
CENTRIFUGAL SEPARATOR

Filed Sept. 12, 1932 4 Sheets-Sheet 4

FIG. 7



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Patented Jan. 12, 1937 2,067,590

UNITED STATES PATENT OFFICE

2,067,590

CENTRIFUGAL SEPARATOR

Arthur U. Ayres, Chestnut Hill, Pa., assignor to The Sharples Specialty Company, Philadelphia, Pa., a corporation of Delaware

Application September 12, 1932, Serial No. 632,730

8 Claims. (Cl. 233—13)

The present invention relates to methods of effecting separation of mixtures of solids and liquids or of a plurality of liquids into their constituents and to apparatus for carrying out such methods. The principal feature of the invention consists in a design of centrifugal bowl for effecting such a separation with a high degree of efficiency.

In the centrifugal separation of substances involving a continuous discharge of one or more of the substances from the bowl, and particularly in the centrifugal separation of solids from liquids, considerable difficulty has been encountered in attempting to effect an efficient elimination of impurities from the substances continuously discharged. Thus, in the separation of solids from liquids in which they are suspended, by the centrifugal sedimentation of the solids against the rotor of a centrifugal machine and the continuous discharge of liquids from a zone spaced radially inwardly of the wall of such rotor, it has been difficult to avoid the discharge of some solid particles with the liquid leaving the bowl even though it is known that their mass and size are such that deposition should occur under the force generated. Various theories have been advanced for the difficulty encountered in this connection. It was believed that the trouble was caused by turbulence within the rotor which impaired the flow of solids toward the bowl wall and tended to cause a re-suspension of solids which had already reached that wall under the influence of centrifugal sedimentation. While this phenomenon doubtless has an adverse effect upon the operation of the machine, I have found that it does not have such an important effect as does the tendency of air and other gases within the bowl to flow from the feed to the discharge outlets through the bowl. The velocity of the discharge of liquid from the bowl naturally causes a suction of gases in the direction of the flow of the liquid through the bowl. This suction induces air currents which flow directly from the feed opening through the discharge openings and gases carried into the rotor with the feed liquid or drawn in around the feed nozzle tend to entrain solid and liquid particles from the mixture entering the bowl and carry them directly through the bowl without permitting them to be subjected to the centrifugal action of the rotor.

My invention involves a solution of this difficulty by the provision of a zone of high pressure spaced from the feed opening of the bowl and thereby precluding the suction of gases through the bowl in the manner discussed above.

More specifically, I have provided a liquid seal which is adapted to prevent the flow of gases between these points. Thus, the invention contemplates in its preferred embodiment the provision of an imperforate disc secured to an imperforate central portion of the bowl and having sufficient diameter to enable its periphery to be submerged in at least the innermost zone of liquid which is being subjected to centrifugal treatment within the bowl. In order that such a disc may be submerged within the liquid, it is necessary that the pressure at its periphery be greater than the pressure of the atmosphere surrounding it. Since every particle of material which leaves the rotor must be subjected to this or a greater pressure, it will be obvious that there is no tendency to suck gases from the feed opening through this zone.

My invention will be better understood by a reference to the following specification in the light of the attached drawings, in which,

Figure 1 is a general view, partly in section and partly in elevation, illustrating the general structure of a centrifugal machine for separating solids from a body of liquid by sedimentation,

Fig. 2 is a detail sectional view through the upper end of the centrifugal bowl illustrated in Fig. 1,

Fig. 3 is a similar detail sectional view through the lower end of this bowl,

Fig. 4 is a top perspective view of a sealing disc for use in connection with such a bowl,

Fig. 5 is a bottom perspective view of the part illustrated in Fig. 4,

Fig. 6 is a detail view, partly in section, illustrating a modification, and

Fig. 7 is a view corresponding to Fig. 2, illustrating the construction of a bowl adapted to effect a separation of two liquids from each other in accordance with my invention.

Referring to the drawings by reference characters, the numeral **10** designates the frame of a centrifugal separator which includes a casing **11** for the rotor of such a machine. The substance under treatment is fed to the rotor **20** which rotates within the casing **11** by means of a conduit **12** which is attached to a feed nozzle **14** by means of a removable connection **13**. The feed and bearing features of the base portion of the rotor may be of any desired type but I prefer to employ connections of the type illustrated in the patent to W. H. Bath No.

1,750,154, March 11, 1930, for "Centrifugal machine." Such an arrangement involves a spreader disc 15 which is adapted to be secured within the body of the rotor by means of a plurality of posts 16 which space this spreader disc from the base of the rotor. The base 21 of the rotor is provided with a downwardly projecting boss 17 which bears within a bushing 18 which is secured within cushioned drag mechanism 19 of the general type illustrated in the aforementioned patent. Both the base 21 and the head 22 of the bowl are secured to its main body by means of screw-threaded connections. The head of the bowl is provided with a reduced neck 23 which passes through an arrangement of covers 24 adapted to receive the discharge from the bowl and direct this discharge outwardly. The neck 23 is secured to the drive spindle 25 by any suitable coupling connection and this drive spindle 25 is in turn connected to a source of power for rotating the bowl. A plurality of axially extending discharge passages 26 are arranged within the neck of the head of the bowl and are adapted to direct liquid passing from the main body of the bowl into the covers.

Insofar as it has been described above, the centrifugal separator to which my invention is applied conforms to well known principles of design. In the operation of such a machine liquid is injected through a reduced opening in the upper end of the feed nozzle 14 under pressure and impinges against the spreader disc 15 which causes it to flow outwardly against the periphery of the rapidly rotating bowl in the form of a thin spray. Such liquid will gradually fill the bowl, forming a vertically extending substantially cylindrical layer within the inner circumference thereof. The rotation of the bowl will be imparted to this cylindrical layer of liquid within it and this rotation will effect a movement of the solid particles suspended within the liquid against the periphery of the bowl under the influence of centrifugal force. When a layer of liquid sufficiently deep to overflow the discharge passages 26 and the ring dam controlling the depth of liquid has collected in the bowl, this liquid will begin to be discharged continuously into the cover 24. Solids which have been projected radially outwardly toward the peripheral wall of the bowl under the influence of centrifugal force will be retained within the bowl. In the use of such a machine in the manner just described a suction effect is induced by reason of the discharge of liquid from the bowl through the discharge passages 26. A further gas flow is caused by the action of centrifugal force induced by the bowl rotation upon the gas within the bowl. Such gases carry with them certain amounts of solid and liquid material, and material so entrained in the gas current is not thrown against the liquid layer and is not, therefore, subjected to the normal influence of the rotation of the bowl. As a consequence of this fact some solids are discharged with the liquids leaving the passages 26. The air current which constantly flows in a direction longitudinally of the bowl from its feed through its discharge opening, in turn causes a rapid flow of a thin liquid layer adjacent the innermost circumference of the liquid within the bowl in the same direction and neither this thin layer of liquid nor the solids entrained in it are subjected to adequate centrifugal treatment.

My invention comprises means for effectively precluding the flow of gases through the bowl in the manner above described. In order to attain this result I have formed an annular space 27 in the base of the head of the bowl and arranged a liquid sealing member within this space. The flow of liquid into this space is controlled by means of a discharge weir 28 which is provided with a thin annular lip 29 over which liquid is adapted to overflow into the space 27. A ring dam 30 secured to the neck of the bowl head adjacent its uppermost end controls the level of liquid within the main body of the bowl and the space 27, this ring dam being secured in position by an annular clamping nut 31. Within the annular space 27 I have secured a sealing member 32. This sealing member is provided with a threaded extension 33 through which it is secured to the head of the bowl and has an annular flange 34 which is of larger external diameter than the internal diameter of the ring dam 30 and therefore constantly dips into the liquid within the space 27 and constitutes a sealing disc to prevent the escape of gases with the liquid discharged. A plurality of wings 35 extending in a direction longitudinally and radially of the bowl are formed integrally with the sealing member or secured thereto and tend to effect the necessary acceleration and deceleration of the liquid incident to its passage around the annular flange 34.

In the operation of a centrifugal bowl provided with a sealing member of the above described type, it will be evident that every particle of material passing through the bowl must pass around the disc 34 constituting the flange of the sealing member and that this disc therefore embodies an effective liquid seal for the prevention of air currents within the bowl. As liquid entering the bowl is likewise under substantially constant pressure, it will be seen that there is no tendency to set up either a draft of air directly through the bowl or eddy currents within the bowl discharging through the feed nozzle. It is possible to reduce turbulence and increase the efficiency of the clarifying function by means of the special type of weir illustrated in Fig. 6. This weir 36 involves an extended edge 37 of zigzag form produced by cutting away the main body of the weir, as indicated at 38. By reason of its extended surface a gradual flow of liquid over the weir is possible without reducing the capacity of the machine.

In Fig. 7 I have illustrated the application of my invention to a bowl of the type in which two liquids are separated from each other. It will be understood, of course, that the same problem exists in a machine of this type in connection with the tendency of liquid entering the bowl to be entrained by air which tends to flow directly through the bowl from the feed through the exhaust opening, as exists in connection with the entrainment of solids in the clarifier type of bowl. The bowl 40 illustrated in Fig. 7 is provided with an inner ring dam 41 secured to the base of the bowl head and adapted to regulate the depth of liquid in the bowl and with a ring dam 42 arranged at the uppermost extremity of exhaust passages 45 for controlling the thickness of the heavier layer of liquid. As in the previous design, an annular space 43 is provided in the bowl head and liquid passing from the main body of the bowl into the discharge openings 44 must pass through this space.

The level of liquid within this space is determined by the outermost radial extremity of the openings 44 and a sealing member 46 of the same general type as that illustrated at 32 in the embodiment of Figs. 1 to 5 is provided with a sealing disc which extends radially outwardly into the liquid within the space 43 beyond this radial extremity and thus seals the discharge. It will be understood, of course, that it is only necessary to seal the innermost layer of liquid, for all of the liquid in the outermost layer is subject to the pressure of this innermost layer and the additional pressure caused by the effect of centrifugal force upon the outer layer of liquid and there is no contact between this outermost layer discharging through the openings 45 and the atmosphere within the bowl.

It will thus be seen that my invention contemplates in general means for forcing all of the liquid to pass through a zone of high pressure within the bowl at a zone removed a substantial distance from the feed openings. This high pressure is produced by means of a sealing disc and this disc is preferably arranged in a portion of the bowl beyond the zone of separation. In the two examples illustrated, it is arranged in the very head of the bowl beyond the main body in which such separation occurs. By arranging the disc in this zone, the increased velocity of the liquid passing around the disc does not disturb deposited solids.

While considerable advantages accrue from the arrangement of the sealing device beyond the upper end of the main body of the bowl, it is important to point out that even in cases where the disc dips into liquid in this main body, the sealing zone should be substantially removed from the zone of feed. Liquids entering the bowl are subject to no substantial centrifugal force until they abut the wall of the rotor or the layer of liquid within that wall. Such liquids travel a certain distance longitudinally of the bowl before they have been fully brought up to bowl speed and there is a considerable amount of swirling in the lower portion of the bowl incident to this acceleration of the liquid. During this accelerating period, gases may remain entrained in the liquid within the bowl and provision of a liquid seal adjacent this section of the bowl in which swirling occurs would not, therefore, completely seal the discharge from gases. The provision of a sealing member which dips into the liquid in a zone substantially removed from the zone of feed is therefore important because it avoids the possibility of the production of a suction effect tending to carry solids through the liquid discharge openings. Thus it will be seen that this suction effect has been avoided by locating the sealing zone a substantial distance from the zone of feed and that the disturbance of already deposited solids and the interference with the sedimentation operation by reason of turbulence have been avoided by locating the disc at the opposite end of the bowl from this zone of feed; i. e. in a zone beyond the zone of deposition of solids.

Modifications will be obvious to those skilled in the art and I do not therefore wish to be limited except by the scope of my sub-joined claims as interpreted in the light of the generic spirit of my invention.

What I claim is:

1. In a centrifugal separator, a rotatable bowl in which a separation of constituents of a mixture is adapted to take place under the influence of centrifugal force, means for feeding mixture to the bowl, means for discharging a liquid constituent from the bowl and imperforate means extending from a central portion of the bowl and submerged a relatively small depth in the liquid under treatment for directing all substances passing through the bowl continuously through a zone of high pressure between the zone of feed and the zone of ultimate discharge from the bowl, said last-named means being located adjacent the opposite longitudinal extremity of the separating zone of the bowl from the zone of feed.

2. In a centrifugal separator, a rotatable bowl in which a separation of constituents of a mixture is adapted to take place under the influence of centrifugal force, means for feeding mixture to the bowl, means for discharging a liquid constituent from the bowl, means for maintaining a given depth of liquid within the bowl, and an imperforate centrally arranged sealing member having a periphery of sufficient diameter to be submerged a relatively small depth in the liquid whose level is controlled by said last-named means, said sealing member being located adjacent the opposite longitudinal extremity of the separating zone of the bowl from the zone of feed.

3. In a centrifugal separator, a rotatable bowl having a main body portion in which a separation of constituents of a mixture is adapted to take place under the influence of centrifugal force, a head at one end of said main body portion for discharging a liquid constituent from the bowl, a base including feeding means at the opposite end of said main body portion, means for maintaining a given depth of liquid within the bowl, and a centrally arranged imperforate sealing member carried by said head, said sealing member having a periphery of sufficient diameter to be submerged a relatively small depth in the liquid within the bowl.

4. In a centrifugal separator, a rotatable bowl having a main body portion in which a separation of constituents of a mixture is adapted to take place under the influence of centrifugal force, means beyond said main body portion for discharging a liquid constituent from the bowl, means for maintaining a given depth of liquid within the bowl, a centrally arranged imperforate sealing member associated with a portion of the bowl opposite said main body portion with respect to said feeding means, said sealing member having a periphery of sufficient diameter to be submerged a relatively small depth in the liquid within the bowl, and means for maintaining the angular velocity of the liquid passing around said sealing member constant in the zone of said sealing member.

5. In a centrifugal separator, a rotatable bowl having a main body portion in which a separation of constituents of a mixture is adapted to take place under the influence of centrifugal force, means beyond said main body portion for discharging a liquid constituent from the bowl, means for maintaining a given depth of liquid within the bowl, a centrally arranged imperforate sealing member associated with a portion of the bowl opposite said main body portion with respect to said feeding means, said sealing member having a periphery of sufficient diameter to be submerged a relatively small depth in the liquid within the bowl, and means associated with said sealing member for maintaining the angular velocity of the liquid passing around

said sealing member constant in the zone of said sealing member.

6. In a centrifugal separator, a rotatable bowl comprising a main body portion in which a separation of constituents is adapted to take place under the influence of centrifugal force, a head upon said main body portion, said head being provided with discharge passages, a sealing chamber within said head and connecting with said discharge passages, a centrally arranged sealing disc within said sealing chamber and having a circumference sufficient to immerse its periphery within the body of liquid within said sealing chamber, and an annular weir controlling the flow of liquid from said main body portion to said sealing chamber.

7. In a centrifugal separator, a rotatable bowl comprising a main body portion in which a separation of constituents is adapted to take place under the influence of centrifugal force, a head upon said main body portion, said head being provided with discharge passages, a sealing chamber within said head and connecting with said discharge passages, a centrally arranged sealing disc within said sealing chamber and having a circumference sufficient to immerse its periphery within the body of liquid within said sealing chamber, and an extended annular weir controlling the flow of liquid from said main body portion to said sealing chamber.

8. In a centrifugal separator, a rotatable bowl comprising a main body portion in which a separation of constituents is adapted to take place under the influence of centrifugal force, a head upon said main body portion, said head being provided with discharge passages, a sealing chamber within said head and connecting with said discharge passages, a centrally arranged sealing disc within said sealing chamber and having a circumference sufficient to immerse its periphery within the body of liquid within said sealing chamber, and an annular weir of zigzag shape controlling the flow of liquid from said main body portion to said sealing chamber.

ARTHUR U. AYRES.

Dec. 30, 1930. C. SCHMITZ 1,786,921

CENTRIFUGAL BOWL SEPARATOR

Filed April 22, 1929

Fig. 1.

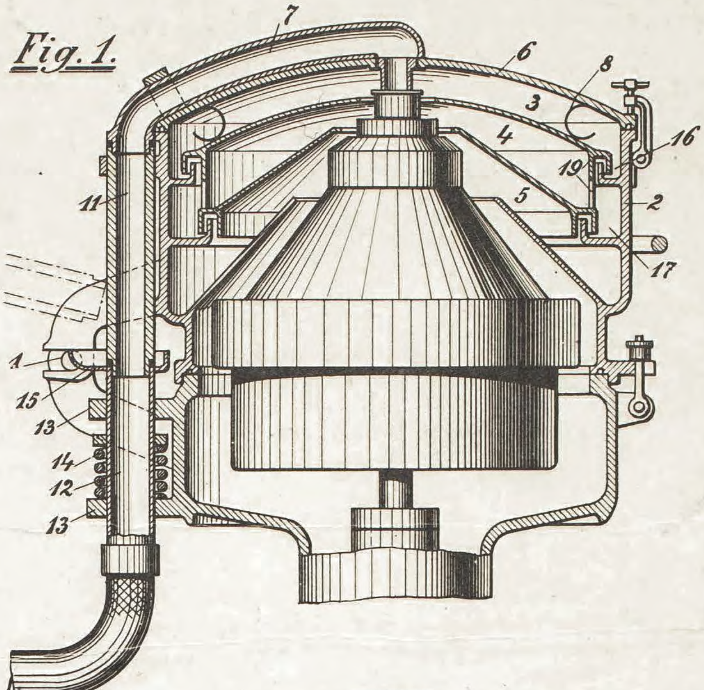
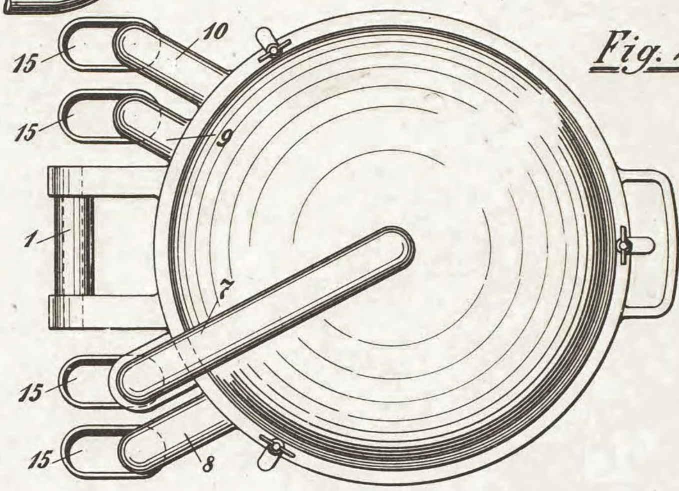


Fig. 2.



Inventor:
Carl Schmitz
By [signature]
Attorney

Patented Dec. 30, 1930 1,786,921

UNITED STATES PATENT OFFICE

CARL SCHMITZ, OF OELDE, GERMANY

CENTRIFUGAL-BOWL SEPARATOR

Application filed April 22, 1929, Serial No. 357,159, and in Germany April 27, 1928.

My invention relates to a collecting vessel for centrifugals working under air-tight conditions, and especially to the coupling of the pipes for the material to be treated with said collecting vessel.

This novel collecting vessel is substantially characterized in that pipe bends are arranged on the one-piece external casing of the hinged collecting vessel, feed and discharge pipes, which are movable axially and at the same time subjected to longitudinal pressure, being coupled to said pipe bends.

The advantage of this novel device lies in the possibility of cleaning not only the collecting vessel, but also that feed and discharge pipes, also in the reliable sealing of the pipes with the vessel at the coupling and connection points, thus securing reliable and simple manipulation.

The accompanying drawing shows an embodiment of the invention by way of example, in which—

Fig. 1 is a cross section and Fig. 2 a plan.

The hinged collecting vessel 2, pivoted at the point 1, is provided with three collecting chambers 3, 4 and 5 for the discharge and for separating the materials to be treated, also a feed pipe 7 connected with the cover 6. Discharge bends 8, 9 and 10, connected with the collecting chambers 3, 4 and 5, and a vertical extension 11 of the feed pipe 7, are coupled to corresponding pipes when the collecting vessel 2 is fixed. Air-tightness of the couplings is secured by the pipes being made movable axially, and by their being subjected to pressure through a spring, sealing being thus effected by them independently of one another with the possibility of compensating for possible faulty workmanship and other changes.

The drawing only shows the pipe 12 of the feed pipe 7, said pipe 12 being similarly formed as the other pipes of the discharge bends 8, 9 and 10. They are movable axially and guided in the holders 13 which may be attached to the casing of the centrifugal. Springs 14 seal the coupling by exerting a constant upward pressure, if need be, by the interposition of a jointing ring. The spring pressure may also be obtained through correspondingly formed pipe bends and by the yielding of the collecting vessel, also through elastic elements. The extension 11 of the feed pipe 7 may either be rigidly connected with the pipe 7, or, as shown in the drawing, it may be a separate piece and likewise arranged to be movable axially, in which case the spring 14 at the same time closes the connection between the extension 11 and the feed pipe 7.

The pipe couplings of the discharge bends 8, 9 and 10, also the feed pipe 11, are preferably arranged in proximity to the pivoting point 1, thus enabling the collecting chambers to be drained when tilting the collecting vessel 2. In the open position the remaining contents are returned to the respective pipes through drip troughs 15 disposed on top of the pipes. The drip troughs may be omitted in certain positions. In Fig. 1 the dripping position is shown by chain-dotted lines. If the couplings are in alignment, or in a similar position relative to one another in proximity to the pivoting axis, the application of the pressure for tightening the joint is facilitated by reason of the greater leverage so that in most cases the deadweight of the collecting vessel suffices to produce the tightening pressure. Moreover, adjustment is hereby more easily effected in case the spring pressure is obtained by the bends or other auxiliary means with limited spring pressure. The pivot 1 is preferably open at the back to permit the whole collecting vessel 2 being lifted off while in the raised position without slackening the bolt. If the device is to be cleaned, the cover 6, which is secured by screw clamps, is taken off, and the collecting bottoms, which are loosely fitted, removed separately. The outside edges of the collecting bottoms are bent downwards and open into annular collecting chambers 16 and 17 disposed on the inner wall of the collecting vessel 2, and communicating with the discharge bends 8, 9 and 10. The upper bottom is held by compression springs 18 attached to the cover 6, the lower bottom, the diameter of which is smaller, being held by intermediate ribs 19. Owing to this arrangement, the possibility is given of extending the outer casing of the collecting vessel over all collecting chambers without any interruption, and thus locating the discharge bends in an unchangeable, secure position relative to one another without impairing the cleaning of the discharge bends. Special jointings between the collecting chambers may be dispensed with, and the collecting vessel may be made of great strength, a favorable point of the invention. The invention is also applicable without the hinge 1, in which case the collecting vessel 2 is lifted off vertically in the known manner.

In all cases the possibility is given of thoroughly cleaning the collecting vessel and the pipes, combined with easy and safe manipulation.

What I claim is:—

1. A feed and collecting vessel for centrifugal apparatus, comprising an integral outer casing having a plurality of troughs one over the other and decreasing in size from the bottom to the top; a collecting chamber lid for each trough; a pipe connected to each trough decreasing in size from the top to the bottom; a cover for the casing; and a pipe secured to the center of the cover.

2. A feed and collecting vessel for centrifugal apparatus, comprising an integral outer casing having a plurality of troughs one over the other and decreasing in size from the bottom to the top; a collecting chamber lid for each trough; a pipe connected to each trough; a cover for the casing; and a pipe secured to the center of the cover, each pipe having a drip trough to permit axial movement of the pipes.

3. A feed and collecting vessel for centrifugal apparatus, comprising an integral outer casing having a plurality of troughs one over the other and decreasing in size from the bottom to the top, said casing being hinged to the apparatus; a collecting chamber lid for each trough; a pipe connected to each trough; a cover for the casing; a pipe secured to the center of the cover; and a drip trough for each pipe to permit axial movement of the pipes.

4. A feed and collecting vessel for centrifugal apparatus, comprising an integral outer casing having a plurality of troughs one over the other and decreasing in size from the bottom to the top, said casing being hinged to the apparatus; a collecting chamber lid for each trough; a pipe connected to each trough; a cover for the casing; a pipe secured to the center of the cover; a drip trough for each pipe to permit axial movement of the pipes; and a spring for each pipe to provide a tight couple.

In testimony whereof I affix my signature.

CARL SCHMITZ.

D. R. YARNALL.

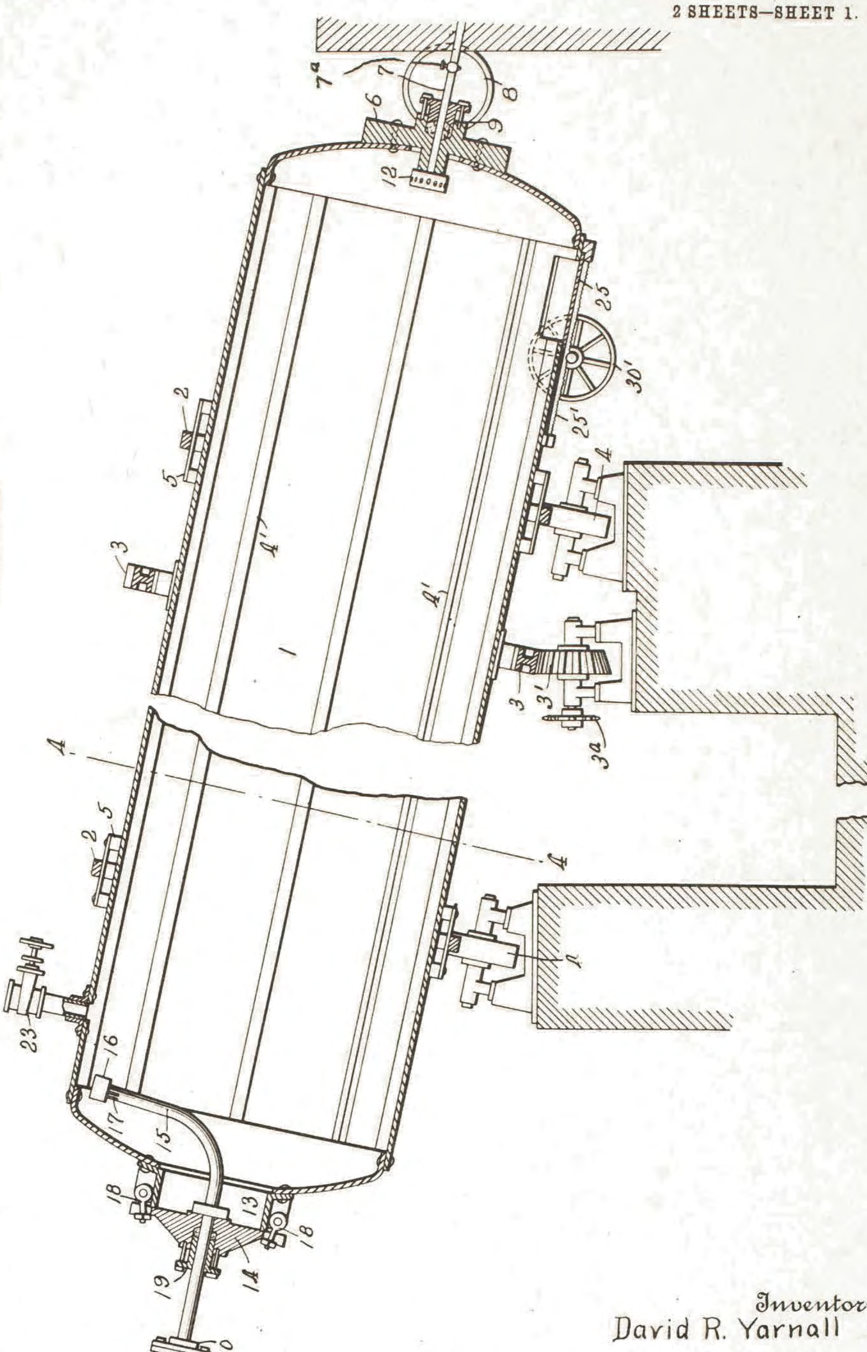
INCLINED ROTARY DIGESTER AND EXTRACTOR.

APPLICATION FILED APR. 12, 1907.

952,224. Patented Mar. 15, 1910.

2 SHEETS—SHEET 1.

Fig 1



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APPLICATION FILED APR. 12, 1907.

952,224.

Patented Mar. 15, 1910.

2 SHEETS—SHEET 2.

Fig 4

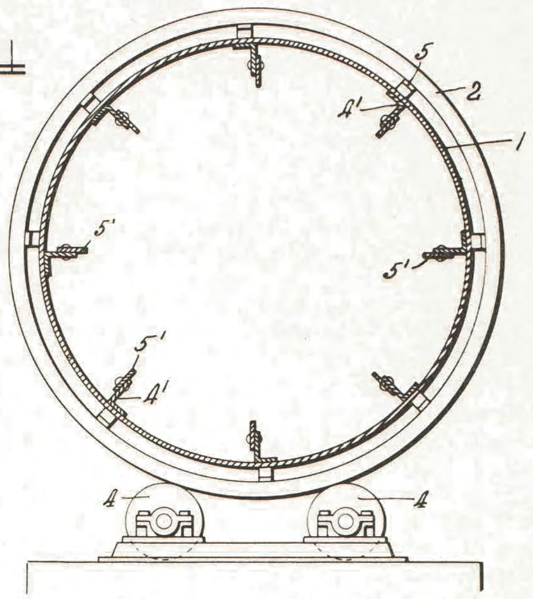


Fig 3

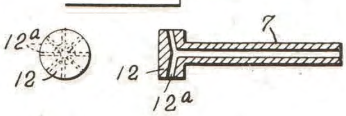


Fig 2

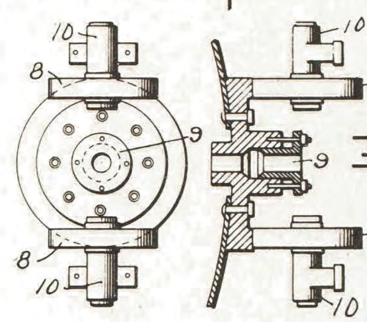
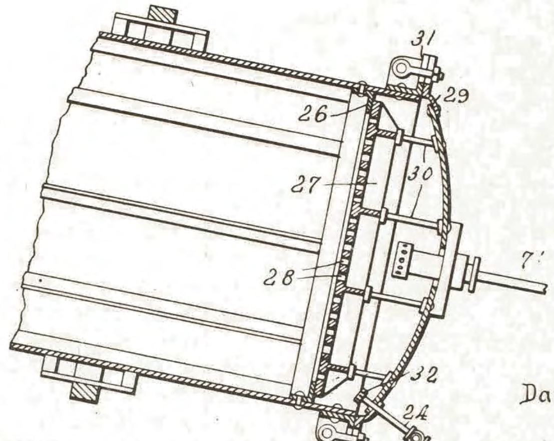


Fig 5



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INCLINED ROTARY DIGESTER AND EXTRACTOR.

952,224. Specification of Letters Patent. **Patented Mar. 15, 1910.**

Application filed April 12, 1907. Serial No. 367,780.

To all whom it may concern:

Be it known that I, David Robert Yarnall, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented new and useful Improvements in Inclined Rotary Digesters and Extractors, of which the following is a specification.

My invention relates to apparatus for digesting or treating certain kinds of material, or for extracting therefrom certain products, and more particularly, it relates to apparatus of this character in which the material is fed into one end of a closed casing, and discharged from the other end, after being treated.

My invention is particularly designed for use in treating butcher scrap, city garbage, and the like, for the purpose of extracting therefrom certain products, such as grease, but obviously is not confined to such use, as it may be employed with equal advantage in digesting wood pulp, etc.

The object of my invention is to provide a device of the class described, by means of which the treatment of a given amount of material may be accomplished much more rapidly and conveniently than heretofore, and at the same time more effectively and economically.

With the above and other objects in view my invention consists in the construction hereinafter described, and illustrated in the accompanying drawings, in which:—

Figure 1 is a longitudinal sectional elevation, showing the complete device. Fig. 2 shows, in detail, plan and sectional elevation of the thrust bearing, hereinafter described. Fig. 3 shows detail views of the sprayer head, hereinafter described. Fig. 4 is a transverse section along the line 4—4, of Fig. 1, looking in the direction of the arrow. Fig. 5 is a fragmentary view similar to Fig. 1, and showing a modified construction.

Referring to the drawings in detail, the main feature of the device consists of a cylindrical drum, shell, or casing, 1. This is supported in an inclined position, so as to be capable of rotation. To this end the drum carries on its periphery two or more circular rails, 2, supported on expansion pads 5. These rails rest on supporting rolls, 4, suitably journaled in fixed bearings.

The drum 1 is provided with dished or dome shaped ends, to the lower one of which is riveted a circular plate 6, constituting an end bearing. This plate abuts against and coöperates with a pair of parallel rolls, 8, arranged at right angles to the plate 6, and journaled in bearings 10, carried on a fixed abutment. The plate 6 has mounted at its center a packing gland or stuffing box 9, and a fixed pipe 7 extends through and is journaled in this gland. This pipe 7 carries at its inner end a sprayer head, 12, which consists of a cylindrical head, provided with a plurality of radial passages 12^a, communicating with the pipe 7. To the other end of the drum or casing is attached a collar 13, against which seats a charging door 14, held against its seat by means of swinging eye-bolts, 18, taking in notches in the door, in a well known manner. A packing gland 19 is mounted in the head or door 14, and journaled in this gland is a pipe 15, bent upwardly, and carrying at its upper end a cap 16, just below which, perforations 17 are formed in the pipe. Outside of the head 14, the pipe 15 is provided with a union, 20, which connects it, through an elbow 21, with another pipe 22, connecting with a suitable jet condenser indicated conventionally at 23^a in Fig. 1. The pipe 15 constitutes the exhaust, while the pipe 7 constitutes the supply means for the casing. A stub pipe and hand valve 23, may also be mounted in the casing, if desired.

Secured to the inside of the drum or casing, and extending longitudinally thereof are a number of baffle plates 4′, preferably consisting of angle irons riveted to the casing. As clearly shown in Fig. 4, I secure wear strips, 5′ to each of the baffle plates, and these, when worn, can be readily removed, and new ones substituted, thus greatly facilitating repairs, and reducing the cost of maintenance of the apparatus.

In the side of the casing near its lower end is mounted a discharge gate, 25, and secured thereto is a rearwardly extending rack, 25′, coöperating with a pinion (not shown) connected with a hand wheel 30′.

Means for rotating the drum or casing are provided, and, as shown, consist of a large annular pinion, 3, secured to the drum, and meshing with a pinion 3′, connected with a sprocket wheel 3^a, which, in turn, may be driven by any suitable means.

The operation of the device is as follows:—The union 20 being uncoupled, and the head 14 being removed, the material to be treated is charged into the drum either from a conveniently arranged conveyer, or by hand, through a hopper, temporarily placed in the opening. At the same time the driving means is thrown in, and the drum started revolving. The baffle plates pick up the material, as it enters, and, as the drum continues to revolve, the material is dropped, and picked up again, and dropped, each time nearer the lower end. This process continues, until the drum is finally filled, up to the edge of the door 14, and the material establishes itself along some such level as that indicated by the line A—A of Fig. 1. The driving mechanism is now thrown out of gear, and the head 14, and attached pipe, replaced and secured in position. The digester is now started revolving again, and steam is admitted to the casing through pipe 7. The sprayer head 12 causes the steam to escape in diverging jets and to throughly permeate the mass of material. In practice it is found advantageous to use reducing valves in the pipe 7, to supply superheated steam at comparatively low pressure. Any vapors or obnoxious fumes are carried off through the exhaust line 15, 21, 22; a conventional form of valve for this purpose is indicated at 7^a in Fig. 1. By having the digester inclined but slightly from the horizontal, it will be seen that there is a very small pressure on the material at the lower end, due to the weight of superposed matter, and therefore it is found in practice, that the particles are carried up and over by the steam, and thus caused to circulate, thereby bringing constantly fresh portions of the charge into contact with the steam jets. Thus it will be seen that the time for treating a charge is comparatively short. After the material is properly digested, steam is turned off, the drum stopped and relieved of all pressure, through exhaust line 15, and try valve 23, (the latter providing an auxiliary or additional pressure relief to more rapidly reduce the pressure within the digester) and the gate valve 25 opened by means of the rack and hand wheel. The contained mass then runs out into a suitable receiving tank, where the grease and water are pressed out by any well known methods. If the material tends to clog, it may be dislodged by turning the digester back and forth through 90 degrees.

In Fig. 5 I have shown a modification of my device designed for use as an extractor. In this construction, the lower end of the drum, instead of being riveted on, as in Fig. 1, is riveted to a cast iron ring, 29. This is adapted to seat against a cast iron flange 31, attached to the drum, and to be secured to said flange by means of swing or eye-bolts. To the dished head is riveted by means of stay bolts 30, a circular header, 27, perforated over its entire surface with small holes, 28. An annular internal flange, 26, preferably formed of an angle iron, is secured to the shell or drum at such a distance from the lower end thereof, that when the head is bolted on tight, the edge of the perforated header 27 will seat snugly against said flange 26. At the extreme bottom of the drum, a discharge pipe 24 is fixed in the head, and is provided with a cap 32, and perforations, similar to the pipe 15 in Fig. 1. In operation, the drum is filled with the material to be operated upon, as in the previous case, but in this case, the space between the head and perforated header is empty. A suitable solvent is now admitted through pipe 7′, to any desired depth, and the device is then rotated. After the solvent has had time to dissolve out the grease or other product, the pipe 24 is opened, and the liquid run out into suitable tanks. Pressure may now be applied to the contents of the drum by admitting steam through the valve 23, (shown in Fig. 1). This pressure tends to drive out the grease held in solution in the mass through the perforated header, and from thence it flows out through the drain pipe 24. After the grease has been extracted, the lower head of the drum is removed, and the solid matter is run out into suitable receptacles.

It will thus be seen that I have provided a simple and highly efficient apparatus for the treatment of grease bearing and other material, and it is thought the many advantages of my construction will be readily appreciated by those skilled in the art.

What I claim is;—

1. In a device of the class described, an inclined drum or shell, means for rotating the same, and a thrust bearing secured to the end thereof, and supported on a pair of rollers carried by a fixed abutment, one disposed on each side of the axis of the drum.

2. In a device of the class described, an inclined cylindrical drum, means on its periphery for rotatably supporting the same, a thrust bearing secured to one end of the drum, rollers coöperating with the same, and a stuffing box carried by said thrust bearing.

3. In a device of the class described, an inclined cylinder provided with dome shaped ends, means for rotating said cylinder, a plurality of annular rails surrounding the same, rollers supporting said rails, and a thrust bearing independent of said rails carried by the lower end of said cylinder.

4. In a device of the class described, a closed, inclined, rotary casing, means for charging thereinto material to be treated, a feed pipe for supplying fluid under pressure to the center of the interior of said casing through the lower end thereof, a spray nozzle carried by said pipe, and a removable

exhaust pipe communicating with the interior of said casing at the highest point thereof.

5. In a device of the class described, an inclined cylindrical casing provided with dome shaped ends, means for rotating said cylinder, a thrust bearing secured to one end, a packing gland mounted in said bearing, a removable head secured to the other end, and a packing gland also mounted in said head.

6. In a device of the class described, a closed, inclined, rotary drum, means at the upper end for inserting a charge of material to be treated, means at the lower end of and movable with the drum for discharging such material after treatment, and means for supplying fluid under pressure to the interior of the body of the drum through the lower end thereof, so as to thoroughly diffuse the fluid through said charge of material.

7. In a device of the class described, a closed, inclined, rotary drum and means for supporting and rotating the same, means for charging material into the upper end of said drum so as to fill the lower portion thereof, a fluid supply pipe journaled in the lower end of the drum and arranged to discharge directly into the material being treated, and a removable fluid exhaust pipe journaled in the upper end of said drum, and communicating always with the highest point thereof, such point being above the level of the material being treated.

8. In a device of the character described, a closed, inclined rotary cylinder, a fluid supply pipe journaled in the lower end thereof, a head detachably connected to the upper end of the cylinder to permit changing thereof, a packing gland mounted in said head, and a fluid exhaust pipe journaled in said gland and removable with the head, said exhaust pipe having its inlet end substantially at the highest point of the interior of the cylinder.

9. In a device of the character described, a rotary inclined cylinder, a detachable head secured to the upper end thereof, said head forming an opening through which the cylinder may be charged, a packing gland mounted in said head, a pipe journaled in said gland, a union carried by one end of said pipe, the opposite end of said pipe extending within the cylinder and opening therein substantially at the highest point within the cylinder, and a perforated cap at the inlet end of said pipe, said pipe being removable with said head.

10. In a device of the class described, a closed, rotary, inclined drum, a charging door at the upper end of said drum so situated that a horizontal line through the edge thereof lies wholly above the lower head of the drum, a packing gland centrally mounted in said lower head, a supply pipe journaled in said gland, and a sprayer head carried by the end of said pipe and arranged to discharge directly into the material being treated, and below the horizontal line through said charging door.

11. In a device of the class described, an inclined casing, a packing gland mounted in said casing, a fluid supply pipe journaled in said gland, and a sprayer head secured to the end of said pipe, said head being provided with a plurality of radial openings, and located below a horizontal line through the center of said casing, whereby the fluid is discharged directly into the mass of material being treated.

12. In a device of the class described, an inclined closed receptacle having a filling opening positioned to limit the amount of space occupied by the material within the receptacle to provide a permanent space at the top of the receptacle free from the material, means for normally closing said filling opening, a feed pipe for supplying fluid under pressure to the lower end of said receptacle beneath the material, and a removable exhaust pipe communicating with said permanent space.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

DAVID ROBERT YARNALL.

Witnesses:
WILLIAM BANSBACK,
GEO. H. PEIRCE.

Aug. 27, 1935. J. BERGÉ 2,012,298

APPARATUS FOR DIFFUSION

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Fig. 1

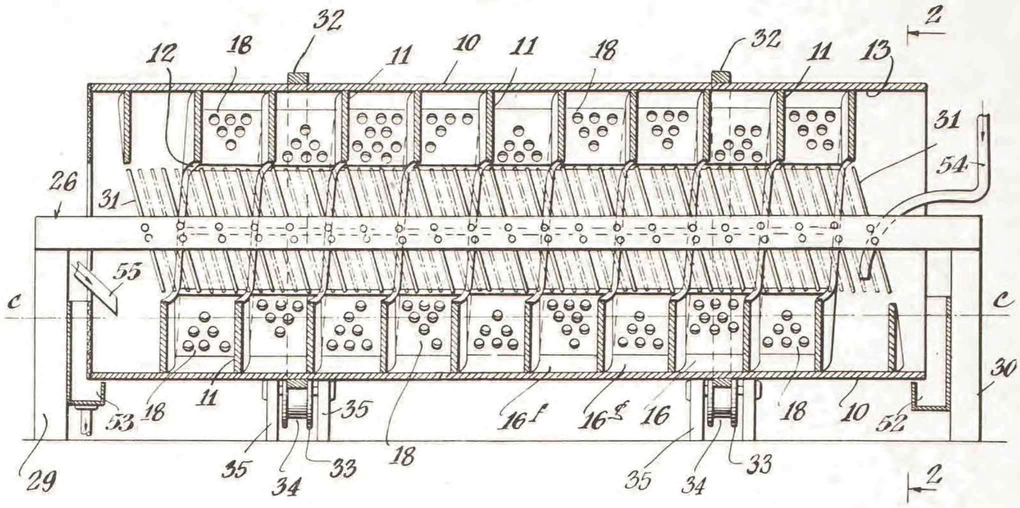

Fig. 2

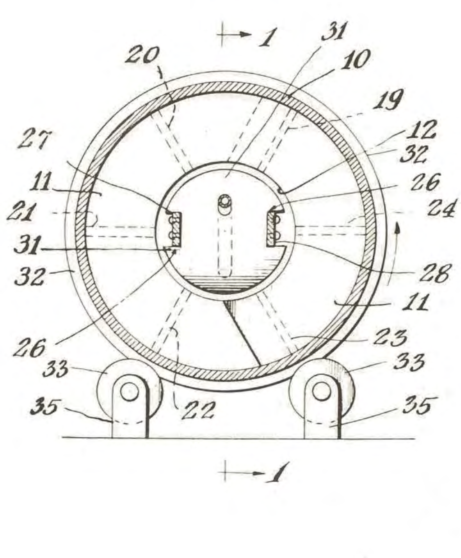

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Fig. 3

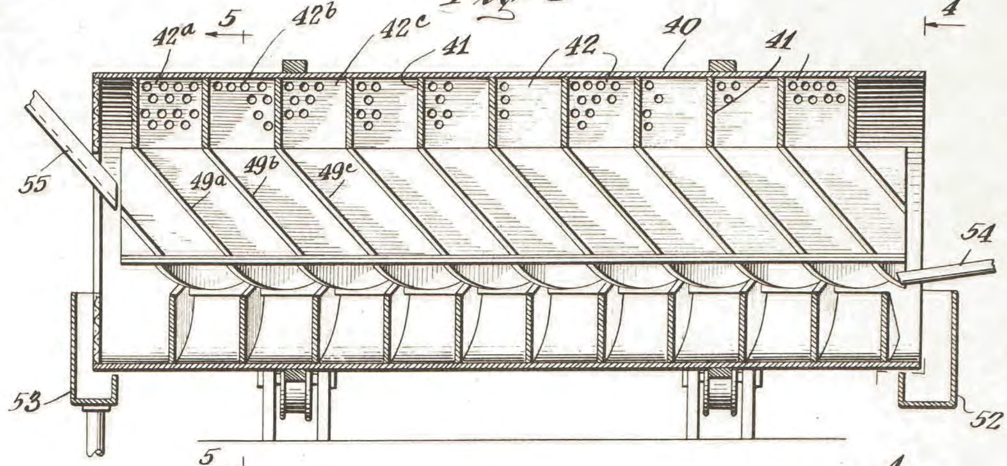

Fig. 4

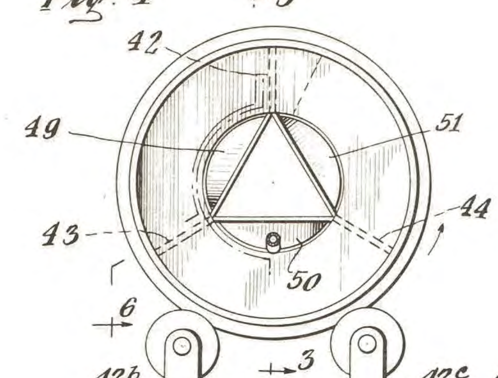

Fig. 5

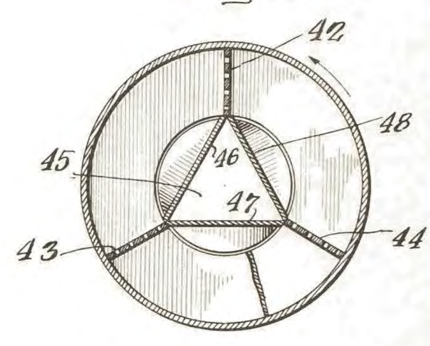

Fig. 6

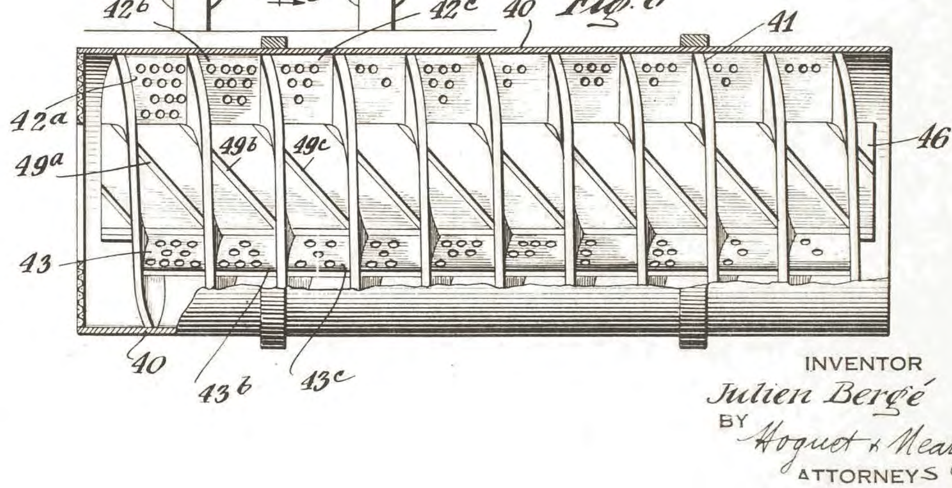

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Fig. 7

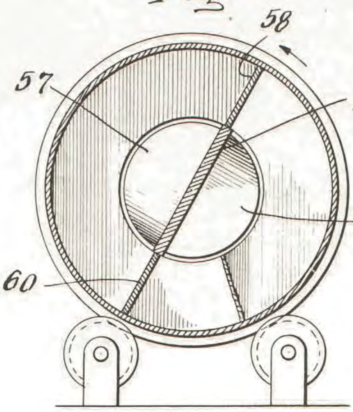

Fig. 8

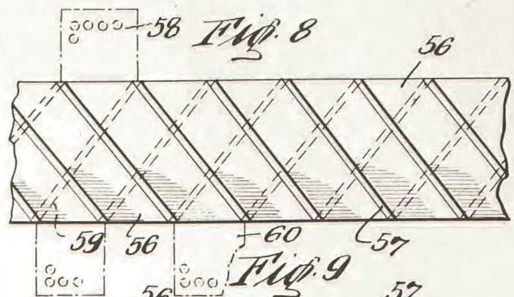

Fig. 9

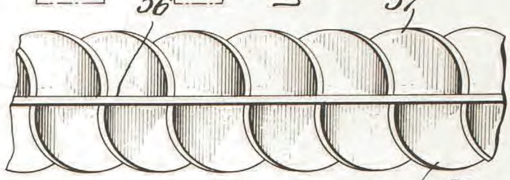

Fig. 10

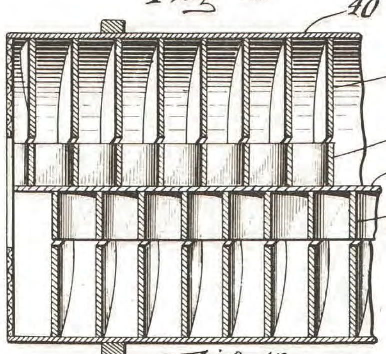

Fig. 13

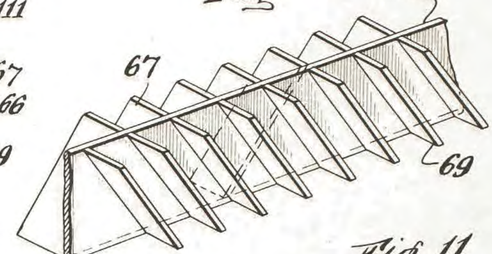

Fig. 12

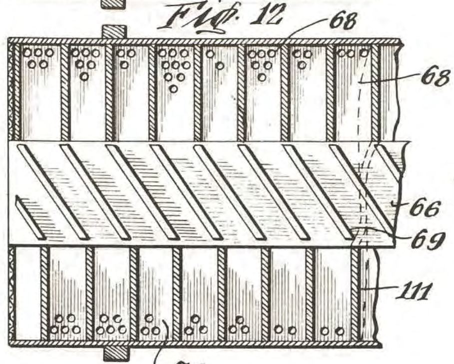

Fig. 11

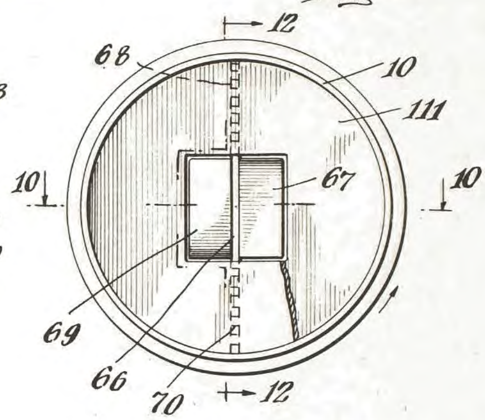

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Fig. 14

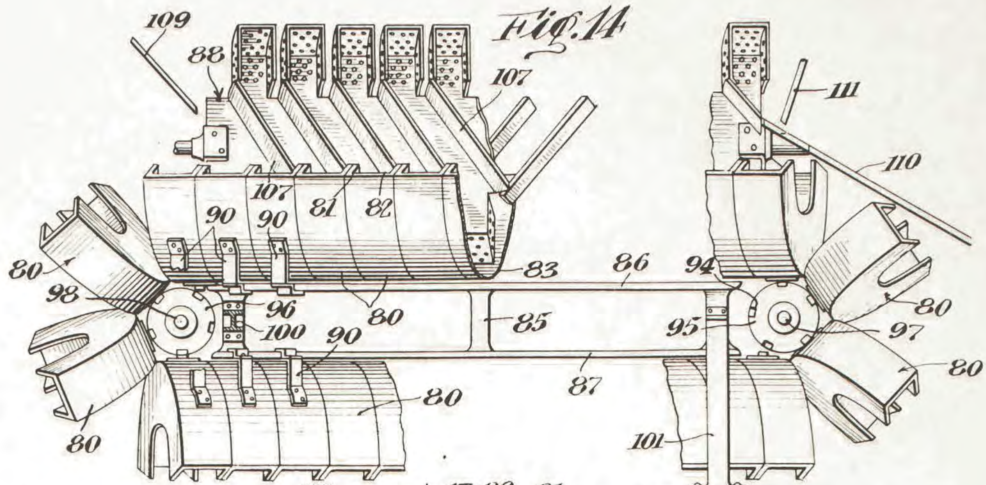


Fig. 15

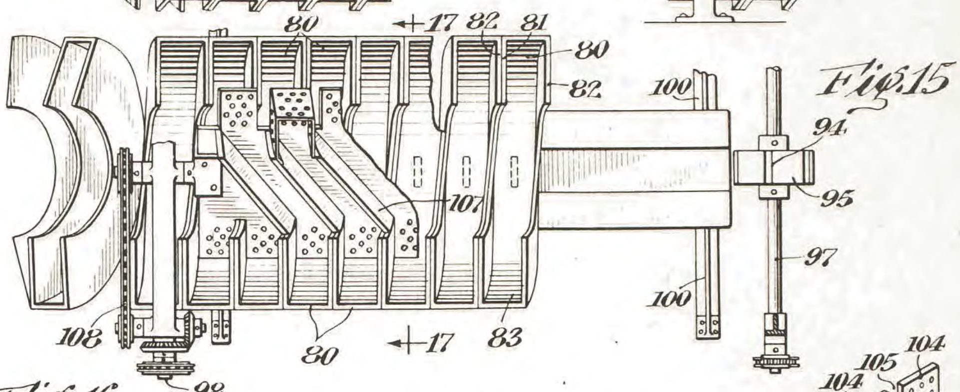


Fig. 16

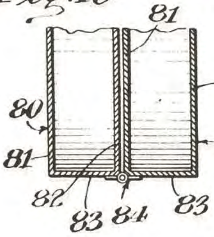


Fig. 17

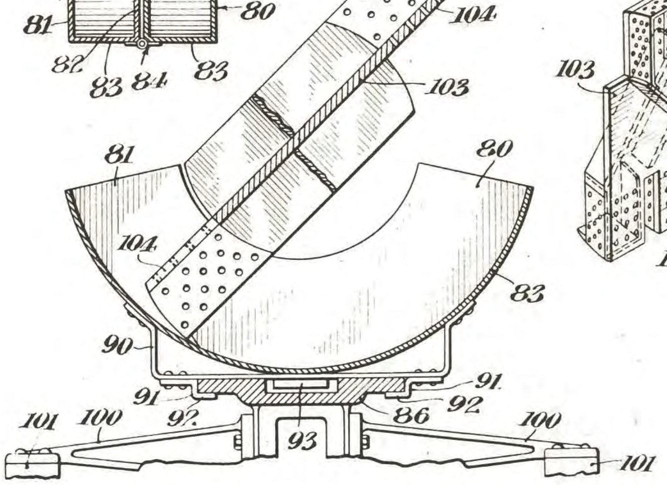
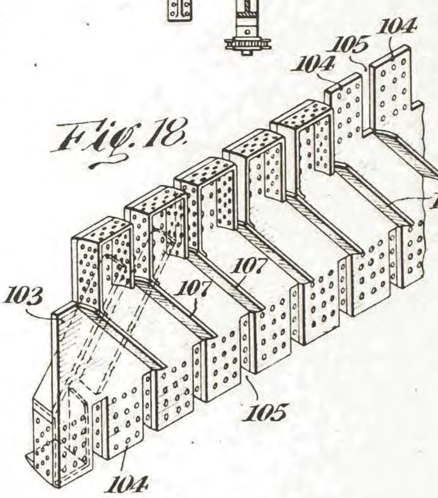


Fig. 18



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Patented Aug. 27, 1935 2,012,298

UNITED STATES PATENT OFFICE

2,012,298

APPARATUS FOR DIFFUSION

Julien Bergé, Tirlemont, Belgium, assignor to Raffinerie Tirlemontoise, Societe Anonyme, Tirlemont, Belgium, a corporation

Application September 3, 1932, Serial No. 631,614
In Belgium February 11, 1930

12 Claims. (Cl. 127—7)

This invention pertains generally to apparatus for extracting solute from a solute-containing solids by means of a solvent, and more particularly to apparatus of such character capable of operating on the counter-current principle.

In my copending application Serial No. 514,515, now Patent No. 2,004,184 dated June 11, 1935, I have described and claimed a process of diffusion employing the countercurrent principle in which the columns of solvent and solids are divided into segregated masses. The procedure is such that each segregated mass of solvent comes consecutively into contact with a predetermined number of segregated masses of solids of progressively increasing percentages of solute content, and such that each segregated mass of solids comes consecutively into contact with a predetermined number of segregated masses of solvent of progressively decreasing percentages of solute concentration.

As set forth in said copending application, new, unexpected and highly beneficial results are obtained by conducting the process so that the segregated masses of solvent do not become mixed with each other and so that the segregated masses of solids do not become mixed with each other.

This application is in part a division of said above mentioned copending application and in part a continuation of my copending application, Serial No. 550,749 filed July 14, 1931, both of which applications disclose apparatus of the above mentained character.

The above mentioned process makes it feasible to add diffusers without limit in view of the fact that the pressure head on the individual diffuser is not increased thereby. In view of the low pressure head on the individual diffuser, circulation difficulties are entirely avoided because there is no tendency for the solids to become impacted as is the case with high pressure.

By splitting up the columns of solvent and solids, the solute is more uniformly extracted from the solids throughout each diffuser and a higher percentage of solute is extracted per diffuser.

The process permits large savings in the amount of solvent ordinarily required in diffusion processes, and the solvent leaving the process has a higher degree of solute concentration. The solids are more thoroughly exhausted than in ordinary diffusion processes.

In view of the fact that a simple bathing of the solids is substituted for forced circulation at high pressure, points of low solute exhaustion in the individual diffuser, known as nests, are eliminated.

Many other advantages result from the use of the process, some of which will more particularly appear as the specification proceeds.

The apparatus disclosed herein is particularly adapted for carrying out said process.

In such apparatus each separate mass of solvent is contained within a separate compartment. The compartments are arranged consecutively. Each separate mass of solids, by means of an arrangement of revolving blades or scoops and a series of plates forming troughs or chutes, is caused to pass through the compartments separately from the other masses of solids and countercurrently to the movement of the compartments and consequently countercurrently to the solvent. The compartments are conveniently though not necessarily formed by the turns of a screw which may be disposed within the inside of a cylindrical or otherwise shaped casing which forms a common outer wall for all of the compartments. Each turn of the screw will then bound one compartment. The number of consecutive compartments may thus be multiplied without limit.

Each revolving blade or scoop is perforated and may be conveniently disposed between and attached to adjacent walls of the screw. These blades or scoops do not lift the solvent because of the perforations. Each blade or scoop, however, carries with it any solids that may be in the compartment through which it passes and deposits the same into a trough or chute which in turn deposits such solids into a compartment further on in the series.

The troughs or chutes may be stationary, as disclosed in copending application, Serial No. 514,515, or may revolve with the screw as disclosed in copending application, Serial No. 550,749, or may revolve otherwise.

The invention will be more fully understood upon reference to the drawings in which:

Fig. 1 is a sectional elevation of one form of the invention;

Fig. 2 is a section on line 2—2 of Fig. 1;

Fig. 3 is a sectional elevation on line 3—3 of Fig. 4 of another form of the invention;

Fig. 4 is a section on line 4—4 of Fig. 3;

Fig. 5 is a section on line 5—5 of Fig. 3;

Fig. 6 is an elevation partly in section on the line 6—6 of Fig. 4;

Fig. 7 is a transverse sectional elevation of a further form of the invention;

Fig. 8 is a plan view shown broken of the chute structure of the form shown in Fig. 7;

Fig. 9 is an elevation of the chute structure shown in Fig. 8;

Fig. 10 is a sectional plan view shown broken on line 10—10 of Fig. 11 showing a further form of the invention;

Fig. 11 is an end view;

Fig. 12 is a sectional elevation shown broken on line 12—12 of Fig. 11;

Fig. 13 is a perspective view of the chute structure of the form of the invention shown in Figs. 10, 11 and 12;

Fig. 14 is an elevation of another form of the invention;

Fig. 15 is a top plan view;

Fig. 16 is a sectional view;

Fig. 17 is a section on line 17—17 of Fig. 15; and

Fig. 18 is a perspective view illustrating the revolving scoop and chute structure of the form of the invention shown in Figs. 14, 15, 16 and 17.

Referring now more particularly to Figs. 1 and 2, 10 is a longitudinally disposed casing illustrated as cylindrical, in which is disposed a helical shaped screw 11. Screw 11 is hollow at the center 12 and contacts the inner wall 13 of casing 10 to form a liquid-tight joint. The outer peripheral edge of screw 11 may be welded to the inner periphery of casing 10 for this purpose if desired, or a joint may be effected in any other manner.

Screw 11 may be of any suitable shape and may be very similar to an Archimedean screw.

If casing 10 were filled with liquid to the level represented by the line C—C, each full turn of the screw would bound a compartment 16 containing a segregated mass of liquid.

Now if screw 11 is rotated about its longitudinal axis the level of the liquid in each compartment will remain substantially horizontal and the liquid in each compartment will be moved in a direction parallel to the axis of the casing 10, depending upon the direction of rotation. New compartments will be continuously formed at one end and existing compartments will continuously disappear at the other.

It will be noted that this progression of liquid from one end to the other of the casing 10 takes place without any mixture of the liquid of one compartment with that of another. Upon each complete revolution of the casing 10 the liquid in each compartment advances one step, that is, a distance equal to the pitch of the screw, or in other words, substantially the width of one compartment.

If the rotation is counterclockwise, as shown in Fig. 2, and the screw is right-handed, the liquid will progress from right to left, as seen in Fig. 1.

Upon each revolution one new compartment will be created at the right to receive fresh liquid and one existing compartment will disappear at the left after the discharge of its liquid.

The perforated blades above referred to are shown at 18. These blades 18 are shown arranged between the turns of the screw 11 and are conveniently placed in line longitudinally of the casing 10. In Fig. 2, six longitudinal sets of perforated blades 18 are shown at 19, 20, 21, 22, 23 and 24. However, as will subsequently appear, it is merely necessary to have two diametrically disposed longitudinal sets of blades 18. The additional sets increase the number of individual masses of solids which will be passed through a single compartment per revolution and thereby make it possible to divide each mass of solids of the ordinary diffusion processes into any desired number of parts for better diffusion.

The solvent passes through the perforations of blades 18 and is not raised thereby. Any solids in the compartments, however, will be picked up by the blades 18 and will be carried up out of the solvent to somewhere near the top of casing 10, from which points each individual mass of solids, with the structure so far described, will fall vertically to the bottom of casing 10. Any solvent adhering to any mass of solids will have drained back into its compartment before the solids reach their point of fall.

With diametrically disposed longitudinal sets of blades 18, say, for instance, sets 19 and 22, all solids falling from blades 18 of the set 19 will be deposited within the paths of the blades 18 of the set 22. These solids will then be picked up by the blades 18 of set 22 and redeposited in front of blades 18 of the set 19.

Let us consider the solids occupying a particular compartment, such for instance as compartment 16f. By the time the solids reach the falling point, the liquid from which they have been lifted will have advanced to the left, a distance slightly less than one-half of the pitch of the screw, or in other words the compartment will have advanced to the left, a distance slightly less than one-half of its width. The solids, therefore, just prior to falling, will be above compartments 16f and 16g, with the compartment division line about half way between, and the solids, upon falling, will divide between the two compartments. Because the solids do not slide materially on the inner wall of casing 10 between turns of the screw 11, there will be no movement of the solids longitudinally of the casing 10.

In order to effect a longitudinal movement of the solids through the casing 10 contra to the movement of the solvent, I provide a plurality of inclined plates 31. Plates 31 are shown mounted on a longitudinal support 26 comprising spaced members 27 and 28 at the center of casing 10. Members 27 and 28 are shown supported upon uprights 29 and 30. This construction is merely for the purposes of illustration, and any other construction may be substituted therefor.

The longitudinal component of the inclination of each plate is equal to approximately one-half of the pitch of the screw. Each plate 31, therefore, will advance solids falling thereon longitudinally to the right as seen in Fig. 1, a distance approximately equal to one-half the pitch of the screw.

As previously pointed out, during the time in which the solids from any one compartment travel from the bottom to the top of the casing 10, the compartment itself advances to the left as seen in Fig. 1 a distance approximately equal to one-half the pitch of the screw. Therefore, such solids, upon being advanced longitudinally to the right by virtue of the inclined plates 31, will be completely deposited into the next compartment on the right. This compartment contains no other solids at the time of such deposit. The solids, therefore, progress from left to right from one compartment to the next without a mixing of the solids from one compartment with those from another.

Plates 31 may have any desired shape and angle as long as the function above set forth is accomplished. That is, they may be flat, or curved to conform to the shape of the screw at their edges, or may be of any other suitable shape and/or inclination.

From the foregoing it will be seen that each individual mass of solids passes through two compartments per revolution of casing 10 and advances to the right a distance equal to the pitch of the screw. In other words, each individual mass passes twice over the slanting plates 31 per revolution.

From this it will be seen that if there are ten blades 18 in each of the sets 19 and 22 capable of picking up solids out of compartments holding solvent, each individual mass of solids will pass through twenty individual masses of solvent before being discharged at the right, and each individual mass of solvent will have been in contact with 20 separate masses of solids before discharge at the left. This is the equivalent of twenty diffusers.

By increasing the number of oppositely disposed longitudinal sets of blades 18, that is, by adding sets 20 and 23 and sets 21 and 24 and increasing the number of plates 31 per turn of the screw from two to six as shown in dotted lines, so that one plate 31 per turn of the screw is always available to completely deposit the solids into the next compartment, the number of individual masses which can be handled by the device is multiplied by three. That is, instead of one mass of solids passing through each mass of solvent per half revolution, there are three masses.

The weight or volume of these masses of solids is, of course, dependent upon the rate of feeding of solids at the left and the weight or volume of each mass of solvent depends upon the rate of feeding of solvent at the right. This makes it possible to adjust the weight of volume of one with respect to the other.

If it is desired to approximate prior practice in the beet sugar industry, for instance, in which the weight of water per diffuser is about equal to the weight of beet slices, if the sets 19 and 22 of blades 18 only are used, the weight of each new mass of beet slices would be adjusted so as to be about equal to the weight of each new mass of water. If all six sets of blades 18 were employed, the weight of each new mass of beet slices would be about one-third the weight of each new mass of water, etc. In the latter case three masses of beet slices would be the equivalent of the beet slices of one diffuser and considering the masses of beet slices as being divided into sets of three, the first mass of each set may be compared to the top one-third, the second mass to the middle one-third, and the third mass to the bottom one-third of beet slices in an ordinary diffuser.

It should be strictly understood that this is merely by way of illustration and that the weights of the masses of beet slices and of the masses of water may be varied in any manner desired.

From the foregoing it will be seen that the device permits continuous diffusion in any desired manner, prevents undesirable mixtures, and takes the place of twice as many consecutive diffusers as there are spires in the helical screw 11.

Furthermore, the solids of each diffuser may be divided up into any desired number of separate masses by increasing the number of oppositely disposed sets of blades 18, and preferably the number of plates 31 so that the latter may conform to the former.

Undesirable mixtures are eliminated because the solvent of any one compartment does not come into contact at any time with the solvent of any other compartment and the individual masses of solids do not become mixed with each other.

The masses of solids travel through the apparatus at exactly the same rate and each mass is therefore exposed to diffusion for the same period of time.

The solvent and the solids progress simultaneously in opposite directions. The feeding of fresh solids and the discharge of exhausted solids takes place at opposite ends of the casing 10. The feeding of solvent and the removal of liquor also takes place at opposite ends of the casing 10.

For the purposes of illustration, casing 10 is shown provided with circumferential flanges 32, which fit between flanges 33 on rollers 34 mounted between supports 35. Four sets of rollers 34 are illustrated in spaced relation.

It is, of course, understood that any other structure may be substituted for rotation purposes as well as for the other parts specifically described in connection with the description of Figs. 1 and 2 without departing from the spirit of the invention.

Referring now to Figs. 3, 4, 5 and 6, it will be seen that in this form of the invention each perforated blade has a corresponding chute arranged within the casing 40 and that each chute revolves with the screw. The masses of solids are lifted from the respective compartments by the perforated blades leaving the masses of solvent behind, and then each mass of solids is caused to move through a chute to a compartment further on in the series. Inasmuch as there is one chute for each blade there will be, of course, a plurality of chutes arranged longitudinally through the center of the casing. The construction will be simplified by keeping the number of blades per turn of the screw at a minimum. Complicated structure and construction difficulties are thus avoided.

In the form of the invention shown in Figs. 1 and 2 I have shown that two, four or six blades per turn of the screw, and perhaps more, may be employed. In this form of the invention, I show three blades per turn of the screw. However, more may be added, particularly if complicated structure is not of importance.

Helical screw 41 may be in all respects similar to screw 11. The perforated blades may be in all respects similar to the blades 18. Three longitudinal sets, to wit: sets 42, 43 and 44, are shown, spaced at regular intervals.

Longitudinally arranged at the center of screw 41 is a triangular construction 45 comprising three plates, 46, 47 and 48. The structure 45 is shown secured in place so that the meeting edges of the supporting plates 46, 47 and 48 are adjacent the blades of sets 42, 43 and 44.

Mounted upon each supporting plate 46, 47 and 48 are slanting plates 49, 50 and 51 respectively. The slanting plates are shown substantially vertically arranged with respect to their supporting surfaces and form the inclines chutes through which the solids such as beet slices or other particles are caused to fall or slide by gravity into the next turn of the screw. The arrangement of the inclined plates may be best seen in Figs. 3 and 6.

Let is be assumed that the casing 40 rotates counterclockwise as seen in Figs. 4 and 5 or as seen in Figs. 3 and 6, the top of casing 40 moves toward the observer.

The blades 42 are at their highest points in Figs. 3 and 6. The group of solids which will be carried up by the blade 42*a*, for instance, will fall or slide into the chute formed by the inclined plates 49*a* and 49*b* and will fall upon a blade 43*b* not shown in Fig. 3 but shown in Fig. 6 in the next turn of the screw to the right. This group of solids will follow the blade 43*b* to the bottom of casing 40 where it will remain until it is picked up and raised to the top of the casing 40 by the blade 42*b*. This group of solids will then fall or slide through the chute formed by the inclined plates 49*b* and 49*c* on to the next blade 43 in the next turn of the screw toward the right, that is, upon the blade 43*c*. This group of solids will then be relowered to the bottom of the casing 40 where it will remain until it is picked up by the blade 42*c* and is again advanced a unit distance to the right. This mass or group of solids will eventually arrive at the righthand end of the drum, and will be discharged for instance into a receptacle shown diagrammatically at 52.

During this time solvent, which will enter at the righthand end of casing 40 in a continuous column and will be divided into segregated masses by virtue of the turns of the screw 41, will have advanced through the casing 40 to the left between the turns of the screw 41 and will have been discharging at the lefthand end, for instance into a receptacle shown diagrammatically at 53. Inasmuch as any single group of solids moves to the right a distance equal to the pitch of the screw per revolution of casing 40 and any single mass of solvent moves to the left an equal amount, the relative movement between groups of solids and masses of solvent per revolution is twice the pitch of the screw. If it is assumed that there are ten full operative turns of screw 41, any single group of solids will move relatively to twenty consecutive masses of solvent and will come into contact with every other mass of solvent. The very next group of solids will come into contact with the alternate masses of solvent not contacted by the first mentioned group. The third group of solids will come into contact with the same masses of solvent as the first mentioned group of solids. The fourth group of solids will come into contact with the alternate masses the same as the second group of solids, etc.

Means for supplying solvent, which generally will be plain water, at the righthand end of the casing 40 is shown diagrammatically at 54.

It is, of course, understood that when the device is in full operation each blade 42 carries solids to the top of the casing 40 during each revolution of the casing 40, and that each mass or group of solids is advanced to the right a distance equal to the pitch of the screw.

Means for charging solids at the lefthand end of the casing 40 is shown diagrammatically at 55.

The blades 43 operate in a manner similar to the blades 42. In this instance, the inclined plates 50 form the troughs or chutes and precipitate the solids to the right on to the backs of the blades 44 which in turn lower the solids to the bottom of the casing 40 where they remain until picked up by the next blade 43 on the right in each instance.

The blades 44 also operate in a manner similar to the blades 42 and 43 by raising the solids to the top whereupon they are precipitated to the right onto the backs of blades 42 through chutes formed by the inclined plates 51.

It is, of course, understood that the solids may be fed at the left at any desired rate within the capacity of the device and that the solvent may be fed at the right at any desired rate within the capacity of the device. The solvent, of course, preferably does not overrun the inner edge of the screw 41, otherwise the solvent of the compartments will become mixed.

The horizontal component of the inclination of the plates 49, 50 and 51 is approximately equal to one and one-third of the pitch of the screw 41. That is, when a group of solids is raised to the top by the blade 42*a*, for instance, and is deposited on to the back of the blade 43*b*, the mass of solids advances to the right a distance approximately equal to one and one-third of the pitch of the screw 41. By the time this mass of solids is picked up by the blade 42*b*, it will have moved back to the left a distance approximately equal to one-third the pitch of the screw so that the resultant advance to the right is equal to the pitch of the screw.

During each complete revolution, three separate masses of solids pass through each compartment. One of these masses will be manipulated between a blade 42 and a blade 43, a second of these masses will be manipulated between a blade 43 and a blade 44, and a third of these masses will be manipulated between a blade 44 and a blade 42.

The ratio of the weight or volume of solids per segregated mass to the weight or volume of solvent per segregated mass may be controlled by the rate of feeding of solids and solvent at 55 and 54 respectively. One may be varied at will with respect to the other within the capacity of the particular device in use. It will be seen that the capacity of the device is a mere matter of dimensions and will be taken into consideration at the time the device is constructed.

The form shown in Figs. 7, 8 and 9 is similar in all respects to the form shown in Figs. 3 to 6 inclusive except that a single supporting plate 56 is arranged within the hollow center of the screw. The supporting plate 56 has inclined plates on each surface so that in effect it takes the place of two of the supporting plates 46, 47 and 48 arranged back to back. The chutes formed by the inclined plates 57 on one side of the supporting plate 56 are fed by the perforated blades 58 and the chutes formed by the inclined plates 59 on the other side of supporting plate 56 are fed by the perforated blades 60. The inclination of the plates 57 and 59 is such that the chutes formed thereby will advance the solids such as beet slices or other particles in a direction opposite to the flow of the solvent propelled by the screw. The horizontal component of the slanting plates 57 and 59 is approximately equal to one and one-half the pitch of the screw instead of one and one-third the pitch of the screw as is the case in the form shown in Figs. 3 to 6 inclusive. Any mass of solids precipitated, for instance, from a perforated blade 58 to the right as indicated in Fig. 8 on to the back of a perforated blade 60 will be moved backwardly to the left by the screw a distance approximately equal to one-half the pitch of the screw before such mass will be picked up by the next perforated blade 58 on the right. The resulting movement to the right, therefore, is equal to the pitch of the screw.

In the forms of the invention shown in Figs. 3 to 6 and Figs. 7 to 9, the opening at the center of the screw has been shown circular and the inclined plates have been shown as having a curved periphery. The opening at the center of the screw and/or the inclined plates may have any other suitable peripheral shape such, for instance, as rectangular.

In Figs. 10 to 13 inclusive is shown a form of the invention very similar to that shown in Figs. 7 to 9 except that the central opening of the screw is square in shape and the inclined plates are rectangular. Screw 111 is secured to the inner wall of the casing 40 as in the other forms. The inner supporting plate is illustrated at 66 having quadrilateral inclined plates 67 on one side and similar plates 69 on the other side.

Perforated blades 68 feed the chutes formed by the inclined plates 69 and perforated blades 70 feed the chutes formed by inclined plates 67 when the device is rotated counterclockwise as seen in Fig. 11. The position of the inclined plates 67 and 69 with respect to the screw 111 is illustrated in Figs. 10 and 12. The position of the inclined plates 67 and 69 on the supporting plate 66 is illustrated in perspective at Fig. 13. The form shown in Figs. 10 to 13 inclusive is otherwise similar to the form shown in Figs. 3 to 6 and the form shown in Figs. 7 to 9.

I have for the purpose of illustration considered the casing 40 as rotating counterclockwise. However, it is obvious that it may be rotated clockwise if desired in which case the feeding of solids and the feeding of solvent would each take place at the opposite end of casing 40 from that shown.

It is obvious that the screw might be left-handed or righthanded as desired, the other parts being made to conform therewith.

While the invention is shown and described in connection with a construction in which the screw is attached to the casing so that both the screw and the casing rotate, the invention is in no way limited thereto. If the screw should fit tightly within the casing so as to form a substantially liquid tight joint at the bottom and if frictional difficulties should be overcome, it is obvious that the screw and the perforated blades might turn and the casing might be stationary, in which case part of the top of the casing might be removed, if desired, particularly if the perforated blades were made in the shape of scoops, or that one might otherwise move relatively to the other, all of which modified forms are within the scope of the invention.

The fundamental features of the invention comprise a construction in which separate compartments are employed for moving solvent in separate masses and in which means are provided for automatically lowering and raising separate masses of solids into and out of the compartments and for moving the solids in separate masses. The moving of the solids and solvent countercurrently applies the countercurrent principle of extraction as described in my copending application. However, the structure can be modified to move both in the same direction. This will take place in the form of Figs. 1 and 2, for instance, by reversing the rotation of casing 10.

The forms shown in Figs. 3 to 13 inclusive wherein the chute structure is supported within the casing so as to eliminate stationary supports outside of the casing, permit the casing to be made of any length and the screw to have any number of turns without involving constructional difficulties which may result from the necessity of having stationary end supports for the chute structure.

In the forms shown in Figs. 3 to 13 inclusive each turn of the screw corresponds to one diffuser so that if the screw has 40 turns, for instance, the device corresponds to a battery of 40 diffusers. Inasmuch as the solids in the forms shown in Figs. 3 to 13 inclusive move a total distance equal to the pitch of the screw per revolution of the casing, each mass of solids would pass successively through forty different bodies of solvent, the solute content of which decreases progressively as the solids advance.

The chute forming plates may, of course, have any other suitable shape and/or inclination or be of any other suitable number.

As previously pointed out, I prefer to employ a revolving screw for the purpose of creating the moving compartments for the solvent. However, this may be accomplished in other ways. For instance, the compartments might be formed by separate containers having screw-shaped side walls of about one-half a spire or less in length. Such containers might move synchronously with a revolving scoop and chute structure, similar to that suggested in Fig. 8 except that blades 58 and 60 would have side walls to form perforated scoops. Each scoop would thread its way into and out of consecutive containers to lift the solids therefrom and by virtue of the chute structure would deposit the solids into the second next container in the series.

Such an arrangement is suggested in Figs. 14 to 18 in which are shown compartment-forming containers 80 having screw-shaped side walls 81 and 82 and an arcuate bottom 83. Adjacent containers 80 may be joined together at their extreme lower edges by means of a hinge illustrated at 84 in Fig. 16 so as to form an endless construction similar to that of an endless conveyor.

A frame 85 having an upper guiding member 86 and a lower guiding member 87 might be provided for holding the containers 80 in contiguous relationship particularly when the same are passing underneath the revolving scoop and chute structure illustrated at 88.

It will be seen that while the compartments 80 are underneath the revolving scoop and chute structure illustrated at 88, they are in close contact with each other and are in most respects very similar to the lower portion of the screw and casing structure previously described.

Containers 80 might be provided with U-shaped straps 90 for sliding upon the guide member 86 and with angular members 91 attached to straps 90 having ends 92 for sliding underneath the longitudinal edges of the guide member 86 for holding the containers 80 in upright position.

Straps 90 might be provided with lugs 93 for engagement by transverse slots 94 in spaced wheels 95 and 96 attached to shafts 97 and 98 respectively.

The framework 85 might be supported at opposite ends by outwardly extending members 100 on opposite sides which in turn might rest on uprights 101.

The revolving scoop and chute structure 88 would comprise a central plate 103 having staggered extensions 104 on opposite longitudinal edges. It would be in shape very similar to a longitudinal cross section of a male thread of which the contiguous containers would form the lower half or less of the corresponding female thread. The staggered spaces 105 between extensions 104 would be in width approximately equal to the thickness of a side wall 81 plus the thickness of a side wall 82 and spaced so as to permit the side walls to pass therebetween and so that the extensions 104 would be of a width to permit them to thread through containers 80.

The extensions 104 would, of course, be perforated and might have three side walls to form a scoop at the entrance end of each chute.

The chutes formed by plates 107 would advance the solids to the right as seen in Figs. 14 and 15, the containers 80 moving to the left along the top stretch.

The inclination of plates 107 would be such that the horizontal component would be approximately equal to one and one half the pitch of the theoretical screw.

The revolution of the scoop and chute structure 88 would be synchronized with respect to the movement of the containers 80, for instance by the drive suggested at 108, so that the extensions 104 would thread their way in and out of the containers 80.

Solids could be fed at 109 and removed at 110. The containers could be filled with solvent by any means such as a pipe suggested at 111. The containers would, of course, automatically discharge their contents at the left.

It will be seen that the operation would be very similar to the forms shown in Figs. 3 to 13 inclusive.

The containers, of course, need not be fastened into an endless conveyor but might be separately handled and placed upon a conveyor at the right of Figs. 14 and 15 and removed at the left.

Any other structure might be substituted for the parts shown in detail.

The invention may be applied to the extraction of any type of solute from any type of solid matter with any type of solvent. It is particularly adapted to the extraction of soluble carbohydrate from vegetable products and more particularly to the extraction of sugar from beet slices, cossettes or chips, the extraction of sugar from sugar cane, etc.

The invention is also adapted to the treatment of chicory root, Jerusalem artichokes, dahlias or other roots and tubercles, for instance, in extracting inuline therefrom.

Other uses of the device herein disclosed will become apparent to persons skilled in the art upon becoming familiar with this invention.

Having described my invention, it is obvious that many other modifications may be made in the same within the scope of the claims without departing from the spirit thereof.

I claim:

1. In a device of the kind described, means for moving segregated masses of liquid in compartments in one direction, said means including a substantially horizontally disposed screw, means associated with said screw for raising and lowering segregated masses of solids in and out of said compartments, and means for advancing said segregated masses of solids in a direction opposite to the movement of said liquid.

2. In a device of the kind described, means for moving segregated masses of liquid in compartments in one direction; said means including a substantially horizontally disposed internal screw, means associated with and revolved with said screw for raising and lowering segregated masses of solids in and out of said compartments, and means comprising inclined stationary plates disposed through the center of said screw for advancing said segregated masses of solids in a direction opposite to the movement of said liquid.

3. In a device of the kind described, means for moving segregated masses of liquid in compartments in one direction, said means including a substantially horizontally disposed internal screw, means associated with and revolving with said screw for raising and lowering segregated masses of solids in and out of said compartments, and means disposed through the center of said screw and revolving therewith for advancing said segregated masses of solids in a direction opposite to the movement of said liquid.

4. In a device of the kind described, a revolving drum, means within said drum for causing the flow of a continuous column of liquid in segregated masses, means within said drum and rotating therewith for raising and lowering a continuous column of divided material in segregated masses in and out of said segregated masses of liquid, and means within said drum for advancing said segregated masses of divided material through said drum countercurrently to said liquid.

5. A device of the kind described comprising a longitudinally disposed drum, a helical screw disposed within said drum and contacting the inner walls thereof, a plurality of spaced perforated blades joining the spires of said screw and forming a plurality of separate compartments with said spires, a plurality of inclined chutes longitudinally arranged along the center of said screw, the inlet of each chute disposed adjacent a perforated blade and the outlet of each chute displaced longitudinally from said inlet, so as to deliver material passing therethrough into an adjacent compartment in a direction countercurrent to the progression of said screw, said chutes being fixed within said drum so as to rotate therewith.

6. In a device of the kind described, means for causing the flow of a continuous column of liquid in segregated masses, and means for causing the flow of a continuous column of divided material in segregated masses countercurrent to said liquid, so that the segregated masses of divided material come progressively into contact with certain segregated masses of liquid, said first and second mentioned means being combined into a unitary revolving structure.

7. In a device of the kind described, revolving means causing the flow of a continuous column of liquid in segregated masses, and means revolving with said last mentioned means for causing the flow of a continuous column of divided material in segregated masses countercurrently to said liquid, so that the segregated masses of divided material come progressively into contact with successive segregated masses of liquid.

8. In a device of the kind described, a horizontally disposed rotating casing, a horizontally disposed screw in said casing, the periphery of said screw forming a tight joint with said casing, a plurality of oppositely disposed longitudinally aligned perforated plates joining spires of said screw, and inclined baffle plates at the center of said screw.

9. In a device of the kind described, a horizontally disposed rotating casing, a horizontally disposed screw in said casing, the periphery of said screw forming a tight joint with said casing, and baffle plates at the center of said screw, said baffle plates inclined so as to move matter falling thereon in a direction along the axis of said screw a distance equal to one-half the pitch

of said screw, and perforated plates interposed between and joining the adjacent turns of said screw.

10. In a device of the kind described, a revolving drum, means within said drum and rotating therewith for dividing a continuous column of liquid into segregated masses, means within said drum and rotating therewith for dividing a continuous column of solid matter into segregated masses, and means within said drum for causing said column of liquid and said column of solid matter to move countercurrently therethrough and in a manner so that the segregated masses of solid matter remain substantially completely segregated from each other and come progressively into contact with the segregated masses of liquid which also remain substantially completely segregated from each other.

11. In a diffusion apparatus for extracting sugar from beet slices and the like, means for producing a column of liquid in segregated masses comprising a series of coaxially associated contiguous compartments each adapted to hold a mass of liquid in segregated relation to the liquid contained in the adjacent compartments of said series, means for moving said separate compartments in a substantially horizontal path, whereby said segregated masses of liquid are moved therewith, said first-mentioned means also forming compartments for producing a column of segregated masses of beet slices, and means for moving said column of beet slices within said first-mentioned means in diffusing relationship and in countercurrent to said column of liquid, said last-mentioned means being operatively associated with said compartments for moving a series of segregated masses of beet slices into and out of said compartments and means communicating with the respective compartments for advancing said segregated masses of beet slices in a direction opposite to the movement of said masses of liquid.

12. In a diffusion apparatus for extracting sugar from beet slices and the like, means for producing a column of liquid in segregated masses comprising a series of coaxially associated contiguous compartments each adapted to hold a mass of liquid in segregated relation to the liquid contained in the adjacent compartments of said series, means for moving said separate compartments in a substantially horizontal path, whereby said segregated masses of liquid are moved therewith, said first-mentioned means also forming compartments for producing a column of segregated masses of beet slices, and means for moving said column of beet slices within said first-mentioned means in diffusing relationship and in countercurrent to said column of liquid, said last-mentioned means being operatively associated with said compartments for moving a series of segregated masses of beet slices into and out of said compartments and revolving means communicating with the respective compartments for advancing said segregated masses of beet slices in a direction opposite to the movement of said masses of liquid.

JULIEN BERGÉ.

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COUNTER CURRENT CONTACTOR

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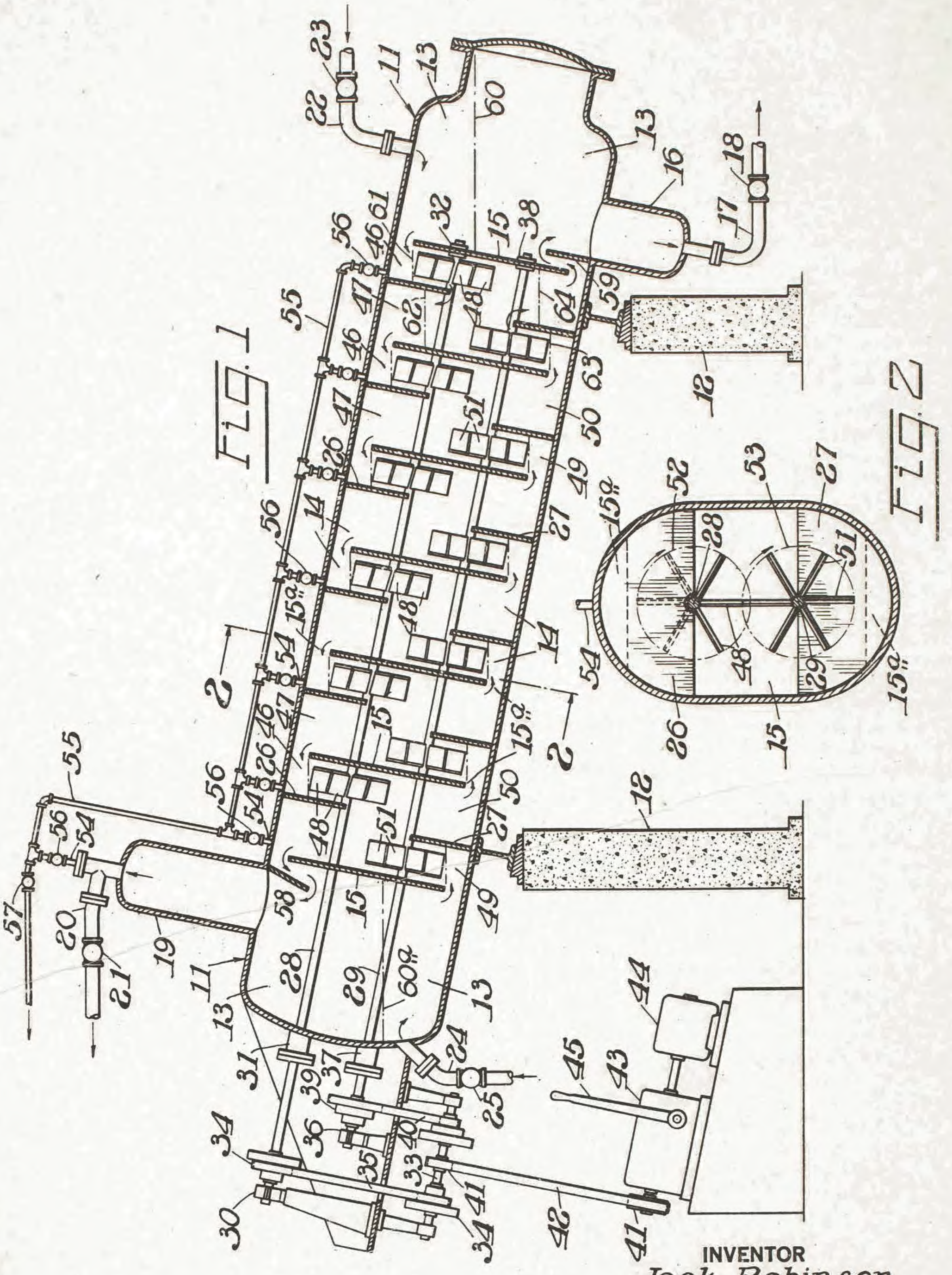

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COUNTERCURRENT CONTACTOR

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9 Claims. (Cl. 196—46)

This invention relates to apparatus for the countercurrent contacting of two fluids, particularly two liquids. It is especially adapted to the extraction of petroleum fractions, for instance a lubricating oil stock, with a selective solvent or solvent mixture.

It is an object of my invention to provide an apparatus of the above type which will accomplish efficient equilibrium contacting of the two fluids in each of a plurality of stages. Another object is to provide an apparatus in which this can be accomplished together with the attainment of maximum throughput. Other and more detailed objects will become apparent as the description of my invention proceeds.

My invention will now be described in detail with reference to the preferred embodiment shown in the accompanying drawing in which

Figure 1 is an elevation of my countercurrent contactor partly in section; and

Figure 2 is a partial elevation taken along the line 2—2 of Figure 1.

Referring now to the drawing in more detail, a generally horizontal casing **11**, which may suitably be of the approximate cross-section shown in Figure 2, rests on supports **12** and is divided into two end compartments **13** and a plurality of intermediate compartments **14** by means of a plurality of baffles **15**. Segmental passages **15***a* are left between baffles **15** and casing **11**. I prefer to use from 3 to 7 intermediate compartments **14**. Downwardly projecting extension **16** opens into the lower end of the right hand compartment **13** and is provided, preferably at the bottom, with a fluid outlet **17** equipped with a valve **18**. Similarly the left hand compartment **13** is provided with upward extension **19** at the top of which is located a fluid outlet **20** equipped with valve **21**. The right hand end compartment **13** is also provided with a fluid inlet **22** equipped with a valve **23** and the left hand end compartment **13** is equipped with a fluid inlet **24** which is provided in turn with a valve **25**. Inlet **22** is preferably, but not necessarily, located near the top of right hand end compartment **13** and inlet **24** is preferably, but not necessarily, located near the bottom of left hand end compartment **13**.

Intermediate compartments **14** are provided with downwardly projecting baffles **26** which may suitably be segmental in form and are preferably approximately perpendicularly disposed with respect to the axis of casing **11**. Baffles **26** may be centrally located in compartments **14** but are preferably located somewhat nearer to the right hand end of the compartment. As will be explained later this may be referred to as the upstream end of the compartment. Compartments **14** are likewise provided with upwardly projecting baffles **27** which may suitably be segmental in shape and are preferably approximately perpendicularly disposed with respect to the axis of casing **11**. Baffles **27** are preferably located somewhat closer to the left or upstream end of the compartment than to the other end.

Casing **11** or a portion of it is traversed by shafts **28** and **29** which are preferably located in vertical alignment with each other and parallel to the axis of casing **11**. Shaft **28**, in the form shown in Figure 1, is journaled at **30**, **31**, and **32** and is driven from drive shaft **33** by means of a pair of variable pulleys **34** and a belt **35**. Similarly, shaft **29** is journaled at **36**, **37** and **38** and is driven through drive shaft **33** by means of a pair of variable pulleys **39** and the belt **40**. Drive shaft **33** is in turn driven through pulleys **41**, belt **42** and variable speed reducer **43** by means of motor **44**. Variable speed reducer **43** is controlled by means of lever **45**. It is thus possible to drive shafts **28** and **29** at a wide range of selected rates of rotation. Furthermore, by means of pulleys **34** and/or pulleys **39** the rates of rotation of the two shafts can be independently varied. It is also possible to change the direction and location of either of the shafts by closing belt **35** or belt **40**.

Baffles **26** divide the upper portions of intermediate compartments **14** into upper upstream zones **46** and upper downstream zones **47**. Shaft **28** carries paddle wheels **48** which are located within or project into upper upstream zones **46**. Similarly, baffles **27** divide the lower portions of intermediate compartments **14** into lower upstream zones **49** and lower downstream zones **50**. Paddle wheels **51** are carried by shaft **29** within or projecting into lower upstream zones **49**. The paths **52** of the tips of paddle wheels **48**, as shown in Figure 2, project upwardly to points above the lower edges of baffles **26** but below the upper edges of baffles **15**. Similarly the paths **53** of the tips of paddle wheels **51** project at their lowest points below the upper edges of baffles **27** but above the lower edges of baffles **15**. The reason for this will become apparent later in the description. Shafts **28** and **29** should be so located that paddle wheels **48** and **51** will fulfill the foregoing requirements and yet not project into the downstream zones **50** and **47** respectively.

Casing **11** is provided with a plurality of gas vents **54** located immediately on the upstream side of the various baffles **26** and above outlet **20**.

These gas vents are connected to manifold 55 by means of valves 56. Manifold 55 is also provided with a master valve 57.

Having described my countercurrent contacting apparatus I will now proceed to outline the processes for which it is adapted and its functional advantages with respect to those processes. The apparatus can be utilized for the contacting of any two fluids, but it is particularly adapted to contacting two liquids which are not completely miscible with each other under the prevailing operating conditions and which are substantially different in specific gravity.

The liquid of lower specific gravity is introduced through inlet 22 by means of valve 23 and flows through casing 11 past and around the various baffles 15 and 26 and finally past baffle 58 up into extension 19 and out through outlet 20 and valve 21. Simultaneously the liquid of higher specific gravity is introduced through inlet 24 by means of valve 25 and flows along the bottom of casing 11 past the various baffles 15 and 27, finally past baffle 59, into downward extension 16 and then out of the apparatus through outlet 17 and valve 18. While the two liquids are thus being flowed through the apparatus in countercurrent contact with each other, shafts 28 and 29 are rotated by means of motor 44, etc. at optimum speeds to be determined as hereinafter described. Paddle wheels 48 and 51 attached to shafts 28 and 29 respectively are rotated thereby. The rotation of these blades tends to promote emulsification between the two liquids being contacted. This is highly desirable since it insures intimate contact and the attainment of equilibrium between the two liquids. Nevertheless, it is desirable that the emulsion after being formed be broken so that the unemulsified liquid can pass on to the next stage of the process and again to undergo emulsification.

My invention makes this desirable result possible and in effect makes each of compartments 14 a distinct stage wherein equilibrium is obtained and the two liquids pass on in opposite directions to the next stages.

The method by which this is accomplished will be described with particular reference to the right hand one of compartments 14 which may be taken as typical. The lighter liquid entering the apparatus through inlet 22 passes over the top of the right hand one of baffles 15 and enters upper upstream zone 46 wherein it is vigorously agitated by paddle wheel 48. This agitation together with the agitation provided by paddle wheel 51 located in the lower left hand portion of compartment 14 produces a central zone of emulsified material wherein the two liquids are in intimate contact within each other. A portion of this emulsified material passes around the lower end of baffle 26 and into the upper downstream zone 47 wherein there is no agitation and the light liquid which has been in contact with the heavy liquid settles out and passes over the top of the next baffle 15 into the next compartment. Simultaneously heavy liquid enters compartment 14 at the lower left and comes into lower upstream zone 49 wherein it is vigorously agitated by means of paddle wheel 51. A portion of the emulsified material passes over the top of baffle 27 and the lower liquid settles out in the lower downstream zone 50 and then passes out of the compartment at the lower right. Both the light and heavy liquids thus first enter a vigorous agitation zone and are contacted with the other liquid and then enter a relatively quiescent zone in which they settle out and pass on in the next compartment. The quiescent zones should preferably be rather larger than the agitation zones.

The approximate preferred interfacial levels between each of the liquids and the emulsification zone are shown by dashed lines in Figure 1. It will be understood, of course, that these lines are approximate only since in many cases the emulsified layer will gradually taper off into the unemulsified layer. In the right hand end compartment 13 interfacial level 60 should be relatively high in order to permit the settling out of entrained light liquid from the heavy liquid being withdrawn through outlet 17. Similarly interfacial level 60*a* in left hand end compartment 13 should be relatively low so as to permit the settling out of entrained heavy liquid from the light liquid being withdrawn through outlet 20. Level 60*a* must in general be above level 60 so that the hydrostatic head necessary to secure flow through the apparatus can be secured. Interfacial level 61 in upper upstream zone 46 represents the approximate interface between the light liquid and the emulsified material. This level should preferably meet baffle 15 near the top thereof. After flowing around baffle 26 into relatively quiescent zone 47, the level 62 between the light liquid and the emulsified material will be somewhat lower than level 61 due to the absence of agitation. Similar considerations apply to levels 63 and 64 representing the approximate interfaces between the heavier liquid and the emulsified material.

These optimum results can be obtained by control of the rates of rotation of shafts 28 and 29, by control of valves 18, 21, 23, and 25 and if desired by the use of interfacial liquid level controls (not shown) located in one or both of end compartments 13 cooperating with one or more of valves 18, 21, 23, and 25. In the preferred method an interfacial liquid level control is used in one of end compartments 13 in cooperation with a pressure control valve located in the outlet from the opposite end compartment.

The provision of gas vents 54 is of great importance when contacting two liquids, since the accumulation of air, vapors, etc. in the upper portions of the various compartments, particularly immediately on the upstream sides of baffles 26 may otherwise interfere seriously with the operation of the apparatus.

While paddle wheels 48 and 51 may suitably be formed of flat blades, cups, etc. facing in the direction of rotation, it is sometimes desirable to slope them slightly so as to help propel the two liquids in their respective downstream directions. This tends to increase the throughput of the device. Too great a propulsion must be avoided however, since it interferes with the attainment of equilibrium in each stage. It is also sometimes desirable to use more than two paddles in each of compartments 14. The paddles should, however, be confined largely to zones 46 and 49.

It is a matter of considerable importance that the angle at which casing 11 is tilted to the horizontal be carefully selected. If this angle is too small the rate of flow through my apparatus will be very small and the aforementioned relationships between the various interfacial levels cannot be obtained. On the other hand, there is an upper limit, angles larger than which cannot be used without sacrifice of efficiency or operability. Angles from about 5° to about 30° can be used although angles from about 8° to about 20° are preferable. The term "generally horizontal" applied herein to casing 11 covers angles from 0° to 20° or 30° to the horizontal.

While my process and apparatus can be used for contacting any two fluids and particularly for the contacting of any two non-miscible liquids differing substantially in specific gravity, it is peculiarly adapted to countercurrent extraction of petroleum fractions and more particularly to countercurrent extraction of lubricating oil stocks. In a preferred embodiment the material introduced through inlet 22 and withdrawn through outlet 20 is a lubricating oil stock, and the material introduced through inlet 24 and withdrawn through outlet 17 is a selective solvent such as dichlorethyl ether, nitrobenzene, cresylic acid, phenol, sulfur dioxide or a mixture of sulfur dioxide and benzol.

Baffles 26 and 27, as well as baffles 15 as shown in Figures 1 and 2 and as hereinbefore described are segmental baffles having approximately horizontal edges. This is theoretically correct and is practically desirable in many cases. I find, however, that if one or both of the liquids being contacted is highly viscous or if paddle wheels 48 and/or 51 are rotated at high speeds a portion of the unemulsified material tends to rotate with the paddles with the result that it is carried under or over one end of the edges of baffles 26 or 27 with consequent "short-circuiting". In other words, a portion of the material passes from agitation zone 46 to quiescent zone 47 or from agitation zone 49 to quiescent zone 50 without having been emulsified. This can be remedied by displacing baffles 26 and/or 27 in the direction of the rotation of the corresponding paddle wheels so that this "short-circuiting" will not occur. Alternatively the baffles can be extended on the edge over or under which the unemulsified liquid passes so that short-circuiting will be prevented.

While I have described my invention in connection with a specific embodiment thereof, I do not wish to be limited thereby but only to the scope of the appended claims in which I have set forth the novel features of my invention.

I claim:

1. Apparatus for the countercurrent contacting of two fluids, comprising a generally horizontal casing, a plurality of baffles partially dividing said casing into a plurality of compartments, and independent agitation means located in and confined to diagonally disposed portions of said compartments.

2. Apparatus for the countercurrent contacting of two fluids, comprising a generally horizontal casing, a plurality of baffles partially dividing said casing into a plurality of compartments, baffles dividing the upper portions of said compartments into two upper zones, baffles dividing the lower portions of said compartments into two lower zones, agitation means located in and confined to one of said upper zones and agitation means located in and confined to one of said lower zones diagonally disposed with respect to said last-mentioned upper zone.

3. Apparatus for the countercurrent contacting of two fluids, comprising a generally horizontal casing, a plurality of baffles disposed approximately perpendicularly to the axis of said casing and dividing said casing into two end compartments and a plurality of intermediate compartments, a plurality of baffles extending from the top of said casing into said intermediate compartments and dividing said intermediate compartment into two upper zones, a plurality of baffles extending from the bottom of said casing into said intermediate compartments and dividing said intermediate compartments into two lower zones, a shaft traversing said upper zones, a second shaft traversing said lower zones, means for rotating said shafts, agitation means carried by said first-mentioned shaft within at least one of said upper zones, agitation means carried by said second shaft within at least one of said lower zones diagonally disposed with respect to said last-mentioned upper zone, a fluid inlet located in each of said end compartments and a fluid outlet located in each of said end compartments.

4. Apparatus for countercurrent contacting comprising a generally horizontal casing, a plurality of baffles disposed approximately perpendicularly to the axis of said casing and dividing said casing into two end compartments and a plurality of intermediate compartments, a plurality of baffles extending from the top of said casing into each of said intermediate compartments and dividing each of said intermediate compartments into a downstream upper zone and an upstream upper zone, a plurality of baffles extending from the bottom of said casing into each of said intermediate compartments and dividing each of said intermediate compartments into a downstream lower zone and an upstream lower zone, a shaft traversing said upper zones, a second shaft traversing said lower zones, means for rotating said shafts, means for controlling the rates of rotation of said shafts, agitation means carried by said first-mentioned shaft within said upstream upper zones, agitation means carried by said second shaft within said upstream lower zones, a fluid inlet located in each of said end compartments and a fluid outlet located in each of said end compartments.

5. Apparatus for countercurrent contacting comprising a generally horizontal casing, a plurality of baffles disposed approximately perpendicularly to the axis of said casing and dividing said casing into two end compartments and a plurality of intermediate compartments, a plurality of baffles extending from the top of said casing into each of said intermediate compartments and dividing each of said intermediate compartments into a downstream upper zone and an upstream upper zone, a plurality of baffles extending from the bottom of said casing into each of said intermediate compartments and dividing each of said intermediate compartments into a downstream lower zone and an upstream lower zone, a shaft traversing said upper zones, a second shaft traversing said lower zones, means for rotating said shafts, means for controlling the rates of rotation of said shafts, means located substantially within said upstream upper zones and carried by said first-mentioned shaft for agitating the material in the upper portion of said casing and propelling it downstream, means located substantially within said upstream lower zones and carried by said second shaft for agitating the material in the lower portion of said casing and propelling it downstream in a direction opposed to the downstream direction of the material in the upper portion of said casing, a fluid inlet located in each of said end compartments and a fluid outlet located in each of said end compartments.

6. Apparatus for countercurrent contacting comprising a generally horizontal casing, a plurality of baffles disposed approximately perpendicularly to the axis of said casing and dividing said casing into two end compartments and a

plurality of intermediate compartments, upper passages located near the tops of said baffles connecting each adjacent pair of said compartments, lower passages located near the bottoms of said baffles connecting each adjacent pair of said compartments, a plurality of baffles extending from the top of said casing into each of said intermediate compartments and dividing each of said intermediate compartments into a downstream upper zone and an upstream upper zone, a plurality of baffles extending from the bottom of said casing into each of said intermediate compartments and dividing each of said intermediate compartments into a downstream lower zone and an upstream lower zone, a shaft traversing said upper zone, agitation means carried by said shaft substantially within said upstream upper zones and extending upward to a maximum height above the lower edges of said second-mentioned baffles and below said upper passages, a second shaft traversing said lower zones, agitation means carried by said second shaft substantially within said upstream lower zones and extending downward to a maximum depth below the upper edges of said third-mentioned baffles and above said lower passages, means for rotating said shafts, means for controlling the rate of rotation of said first-mentioned shaft, means for controlling the rate of rotation of said second shaft, a fluid inlet located in each of said end compartments and a fluid outlet located in each of said end compartments.

7. Apparatus for the countercurrent contacting of two liquids incompletely miscible with each other and differing substantially from each other in specific gravity, comprising a casing inclined to the horizontal, a plurality of baffles partially dividing said casing into a plurality of compartments, and independent agitation means located in and confined to diagonally disposed portions of said compartments.

8. Apparatus for the countercurrent contacting of two liquids incompletely miscible with each other and differing substantially from each other in specific gravity, comprising a casing inclined to the horizontal, a plurality of baffles disposed approximately perpendicularly to the axis of said casing and dividing said casing into two end compartments and a plurality of intermediate compartments, a plurality of baffles extending from the top of said casing into said intermediate compartments and dividing said intermediate compartment into two upper zones, a plurality of baffles extending from the bottom of said casing into said intermediate compartments and dividing said intermediate compartments into two lower zones, a shaft traversing said upper zones, a second shaft traversing said lower zones, means for rotating said shafts, agitation means carried by said first-mentioned shaft within at least one of said upper zones, agitation means carried by said second shaft within at least one of said lower zones diagonally disposed with respect to said last-mentioned upper zone, a liquid inlet located in each of said end compartments and a liquid outlet located in each of said end compartments.

9. Apparatus for the countercurrent contacting of two liquids incompletely miscible with each other and differing substantially from each other in specific gravity comprising a casing inclined to the horizontal, a plurality of baffles disposed approximately perpendicularly to the axis of said casing and dividing said casing into two end compartments and a plurality of intermediate compartments, a plurality of baffles extending from the top of said casing into each of said intermediate compartments and dividing each of said intermediate compartments into a downstream upper zone and an upstream upper zone, a plurality of baffles extending from the bottom of said casing into each of said intermediate compartments and dividing each of said intermediate compartments into a downstream lower zone and an upstream lower zone, a shaft traversing said upper zones, a second shaft traversing said lower zones, means for rotating said shafts, means for controlling the rates of rotation of said shafts, means located substantially within said upstream upper zones and carried by said first-mentioned shaft for agitating the material in the upper portion of said casing and propelling it downstream, means located substantially within said upstream lower zones and carried by said second shaft for agitating the material in the lower portion of said casing and propelling it downstream in a direction opposed to the downstream direction of the material in the upper portion of said casing, a fluid inlet located in each of said end compartments and a fluid outlet located in each of said end compartments.

JACK ROBINSON.

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Oct. 15, 1940.

G. BOTTARO

2,218,080

PROCESS FOR COUNTERCURRENT EXTRACTION

Filed May 23, 1936

4 Sheets-Sheet 1

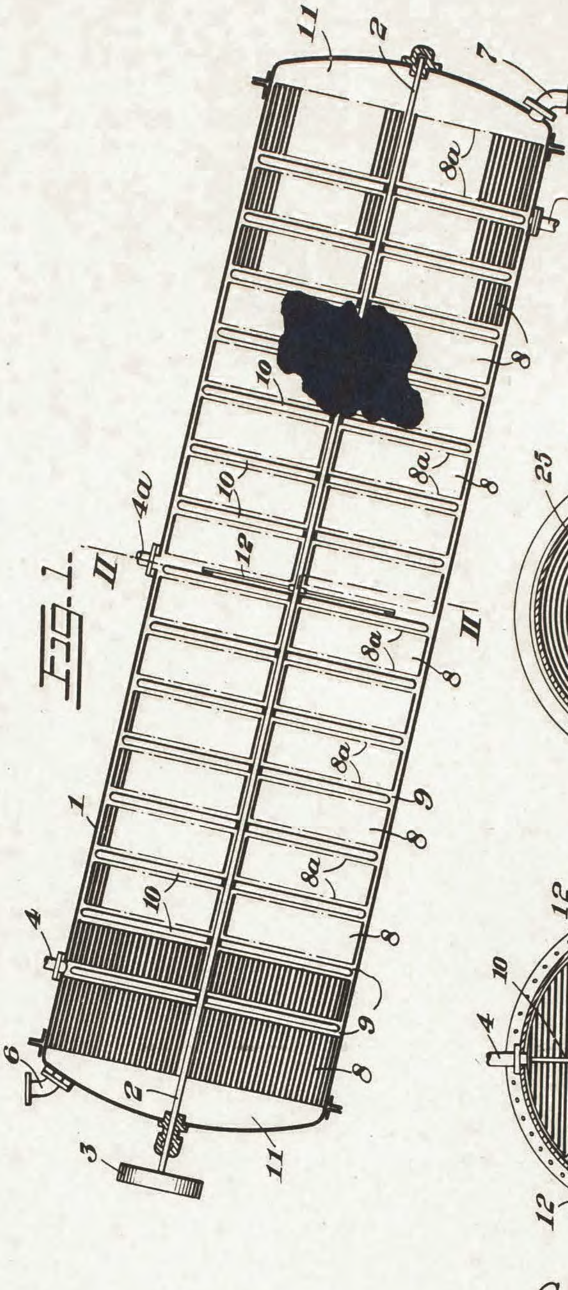

Fig. 1.

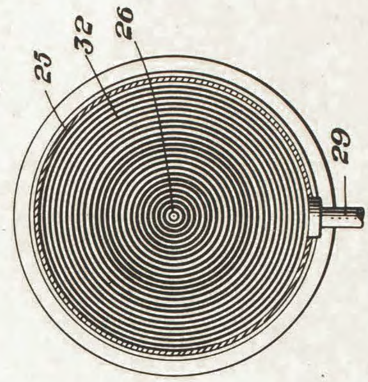

Fig. 5.

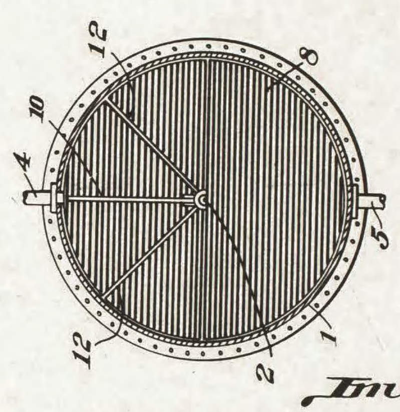

Fig. 2.

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PROCESS FOR COUNTERCURRENT EXTRACTION

Filed May 23, 1936 4 Sheets-Sheet 2

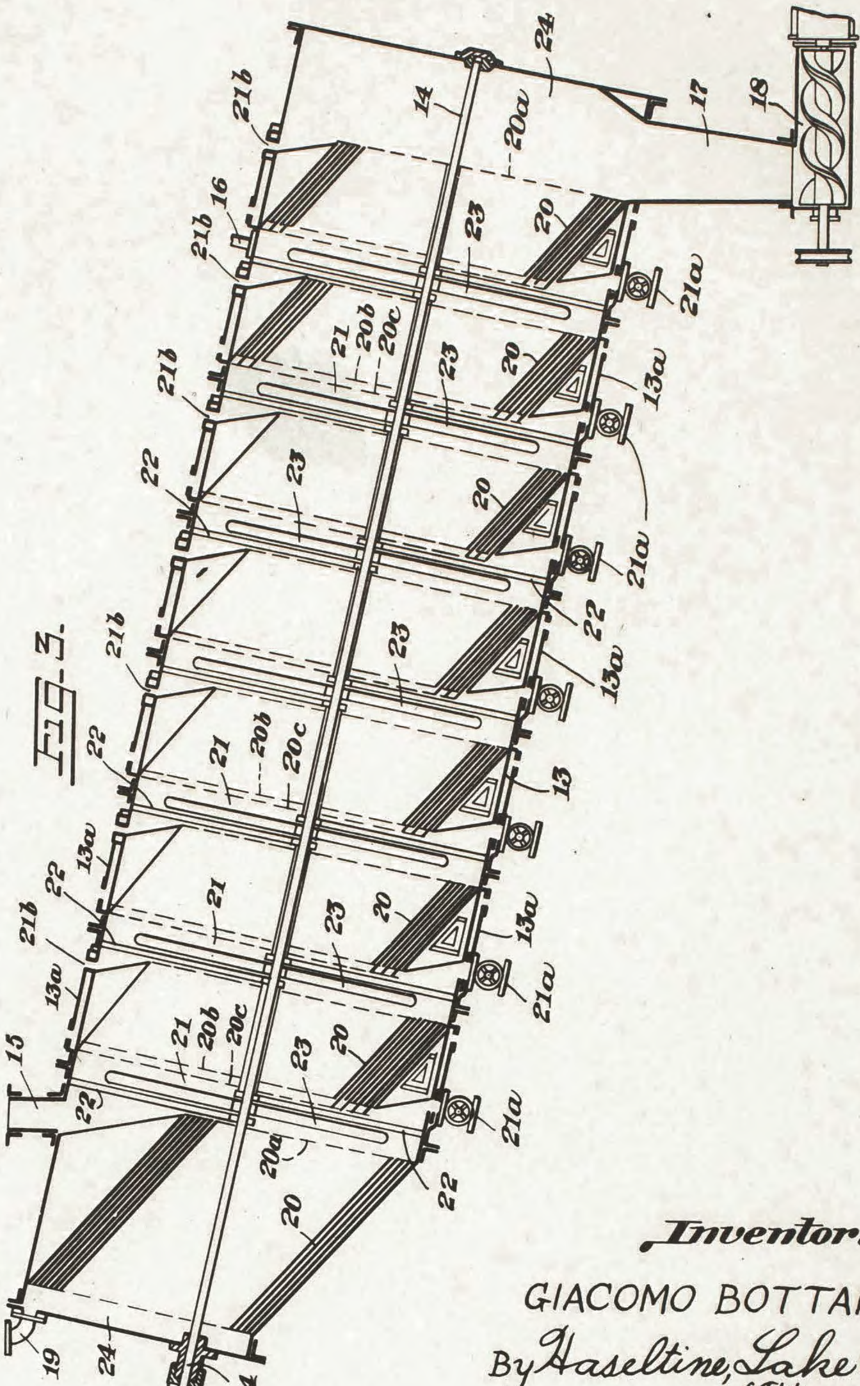

Fig. 3

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PROCESS FOR COUNTERCURRENT EXTRACTION

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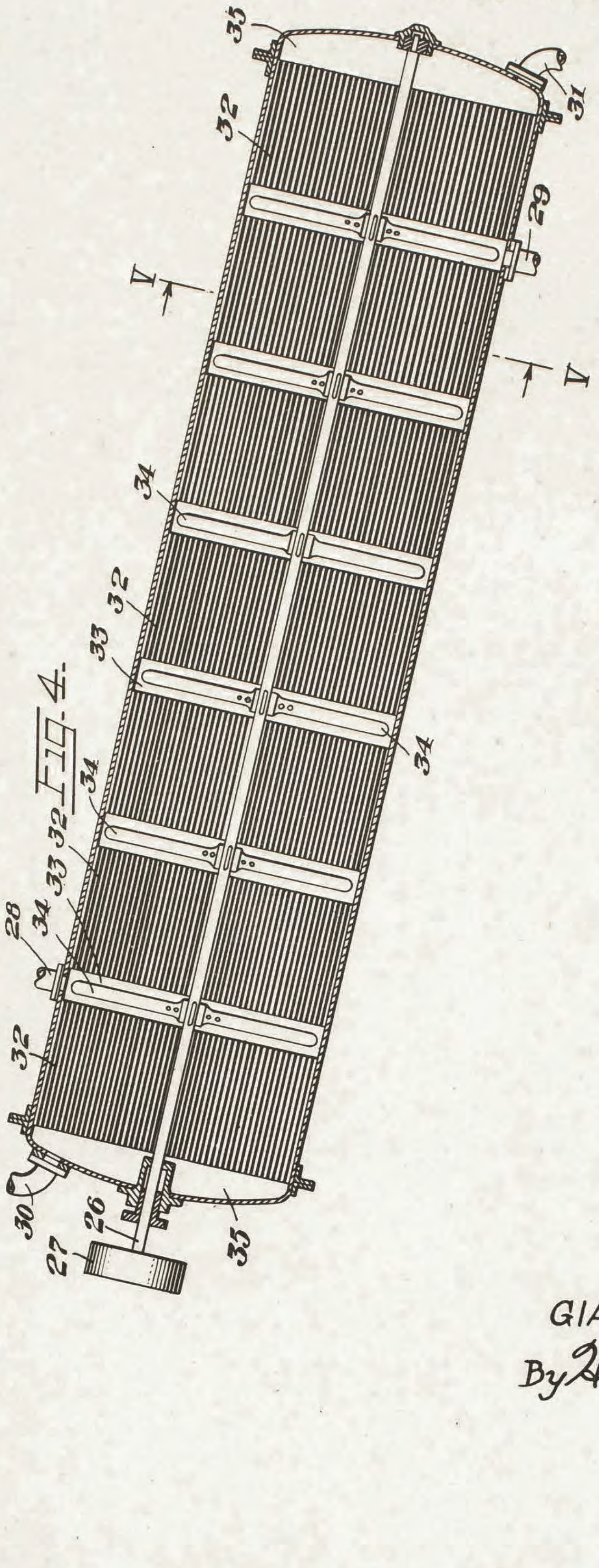

Fig. 4.

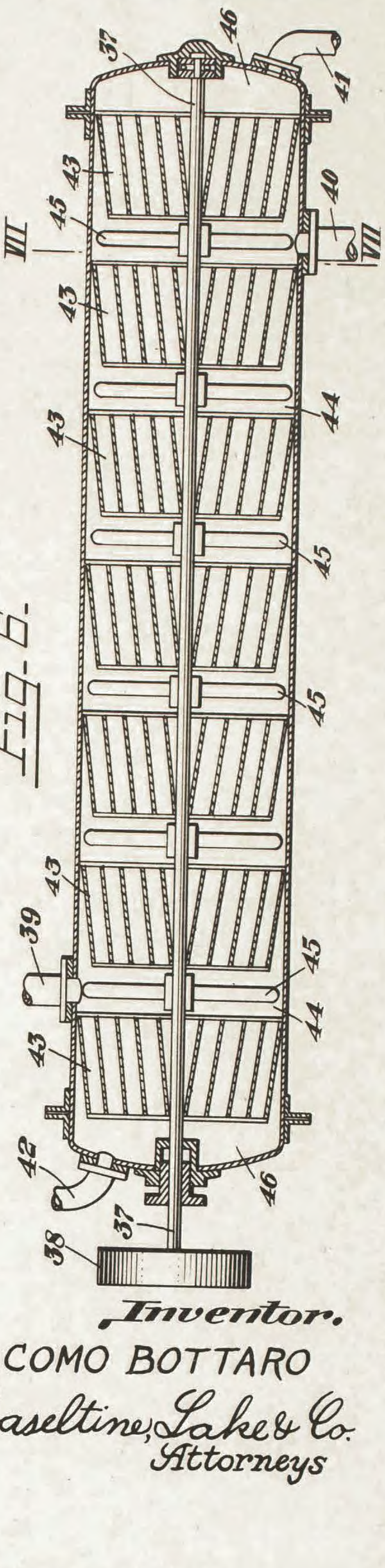

Fig. 6.

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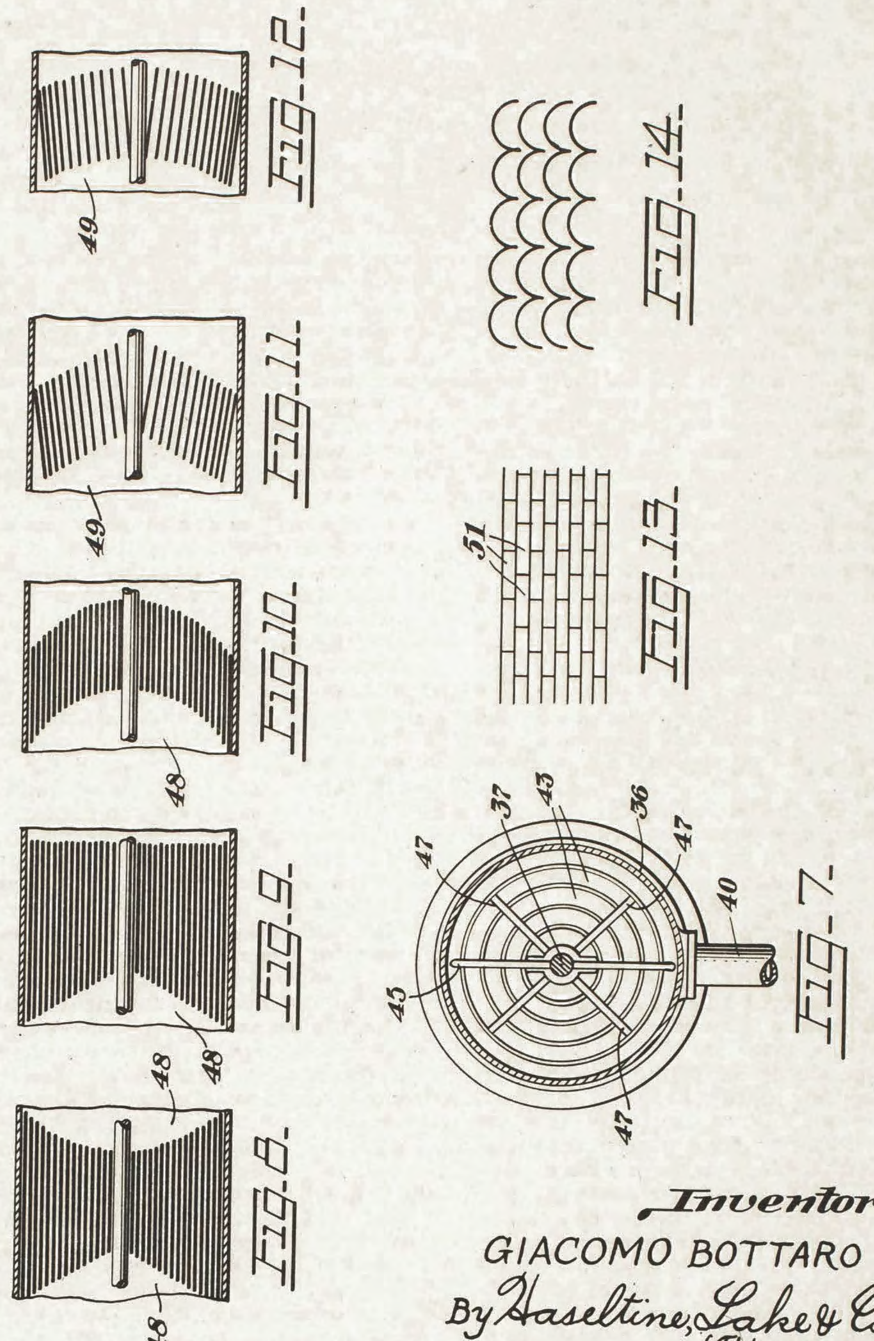
PROCESS FOR COUNTERCURRENT EXTRACTION

Filed May 23, 1936 4 Sheets-Sheet 4



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Patented Oct. 15, 1940 **2,218,080**

UNITED STATES PATENT OFFICE

2,218,080

PROCESS FOR COUNTERCURRENT EXTRACTION

Giacomo Bottaro, Milan, Italy

Application May 23, 1936, Serial No. 81,378
In Italy May 25, 1935

3 Claims. (Cl. 23—268)

This invention pertains to the art of contacting countercurrently one or more liquids with one or more finely divided solids being to a great degree insoluble in the reagent liquids and differing in specific gravity and also to the art of contacting two or more liquids being to a great degree immiscible and differing in specific gravity.

Operations of this type occur very widely in physico-chemical processes as for instance in the extraction of oil from seeds, in contacting oil with bleaching earth, mineral oils with sulphuric acid, mineral oils with selective solvents, such as acetone, sulphur dioxide, furfural, propane and others for purposes of refining or dewaxing.

Apparatuses for the purpose above indicated have never been constructed before because the known mechanisms can serve only for the countercurrent contacting of liquids, but in no case have they been so constructed that their main embodiments can serve equally well for the operation of both liquid-liquid or liquid-solid systems, which feature forms the main object of the present invention.

A further object of this invention is to devise a novel construction whereby a process of countercurrent contacting may be carried out with a minimum of space in the mixing zones and a maximum of demulsifying and diffusion efficiency in the quiescence zones, so that the concentration of the extracted material in the reagent liquids may be the greatest possible while the extracted liquid or solid phases may be after contacting deprived in the greatest proportion of the materials to be extracted.

All these objects and advantages are obtained by operation in the apparatuses herein described, consisting of means forming a succession of alternate zones of turbulence and quiescence, which succession constitutes a widely used form of construction for liquid-liquid countercurrent apparatuses, which has never been employed for solids, while new constructional features are embodied. Particularly do these apparatuses all present a combination of quiescence chambers arranged in a self-contained shell and formed of a plurality of elongated straight conduits equally inclined having a constant small sectional area, extending longitudinally between two stirrer arms disposed in chambers with dimensions restricted to those strictly necessary for the accommodation of said stirrer arms, one conduit chamber being arranged at each end of said alternate succession of chambers, while outlets for the contacted phases are arranged after said terminal conduit chambers, and entrances for the phases to be contacted are arranged on the chambers provided with stirrer arms. In consequence of the reduction of the space capacity in the turbulence zones, the total volume capacity is reduced to a minimum of the points in the apparatus where uniform concentration of the solute in the reagent liquids is unavoidable on account of the necessary agitation of the materials to be contacted. The result is that the highest possible concentration of the solute in the issuing reagent liquid is obtained.

The construction of the quiescence chambers or zones is characterized by the use of a plurality of straight unbaffled conduits of different shapes but all so disposed as to have an elongated form and a constant equal small sectional area which ensures that the materials pass through them in constant equal thinly laminar layers or else are divided into a large number of straight elongated streamlets allowing in both cases the separation of the phases to occur quickly due to their reduced sectional area, and thoroughly due to their elongated form, while the thinness of the laminar layers affords the greatest proportion of interfacial development of contact surface between the phases running counter-currently as against the volume of flow. Furthermore, the constant inclination of the apparatus ranging between 0° and 90° ensures the fall of the solid particles in the form of streamlets and the running of the phases in countercurrent in the quiescence zones sharply divided into two superimposed flows.

The invention completely excludes the vertical position which would destroy the effect of the division into layers of the flowing phases and in certain cases allows the horizontal position for liquids only or also for solids if the heavier phase is forwarded centrifugally. The operation is generally so conducted that the heavier liquid or solid phases are introduced in the apparatus through inlets applied on the superior turbulence zones whereas the lighter liquid phases enter through the inlets applied on the inferior turbulence zonce, care being taken that an equal pressure between the liquid phases exists in all parts of the apparatus comprising inlets and outlets, so that the countercurrent movement of the phases in the quiescence zones only takes place by virtue of their different specific gravities. In a liquid-solid system, the solid phase must always be heavier specifically than the liquid phase and therefore enters the apparatus always from a superior turbulence zone.

The outlets of the reacted phases are located after the quiescence zones which terminate at both ends the alternate succession of turbulence and quiescence chambers, while in case solid phases are to be extracted, screw conveyors are used, which do not allow the escaping liquid phase to leave the apparatus through the same outlet.

The turbulence is caused by a rotatable shaft extending through the whole length of the apparatus, carrying arms which extend in the turbulence chambers, an application which is widely known for liquid-liquid countercurrent systems but which has which has never been applied for liquid-solid systems of phases in a counter-current apparatus.

The aforesaid plurality of conduits in the quiescence zones are immovable and the separation of the phases only takes place there by the action of gravity but the invention also contemplates the application of centrifugal force to cause a quicker and more thorough separation of the phases through a shorter distance.

The apparatus in which centrifugal force is applied to can advantageously also be made to work in horizontal position, thus saving the operation of lifting the phases.

In this case the conduits assume a frustroconical or cylindrical form and they are made to rotate by fixing them on the same rotatable shaft. The heavier phase is then separated by centrifugal force and in the case of frustroconical conduits, also forwarded by it, while the lighter phase is pushed mechanically in the opposite direction of the heavier phase. The frustroconical or cylindrical conduits may have a curved re-entrance on one or both ends in order to facilitate the engagement of the phases therein.

Other details are indicated in the annexed drawings forming part hereof, and wherein several embodiments of the apparatus made according to the present invention are diagrammatically illustrated only by way of example:

Fig. 1 is a vertical axial section of a double countercurrent inclined contacting apparatus for a liquid-liquid system of phases with laminar conduits.

Fig. 2 is a sectional view taken on line II—II of Fig. 1 which shows in its upper portion a turbulence chamber and in its lower portion a quiescence chamber or zone.

Fig. 3 is a vertical axial section of an inclined countercurrent contacting apparatus for a liquid-solid system of phases with inclined laminar conduits.

Fig. 4 is a vertical axial section of a single countercurrent contacting inclined apparatus for a liquid-liquid system of phases with rotating cylindrical conduits.

Fig. 5 is a cross section on line V—V of the apparatus of Fig. 4.

Fig. 6 is a vertical axial section of a single countercurrent, horizontal contacting apparatus for a liquid-liquid system of phases with rotating frustroconical conduits.

Fig. 7 is a cross section on line VII—VII of the apparatus of Fig. 6.

Figs. 8, 9, 10, 11 and 12 are fragmentary vertical axial sections of special forms of construction of rotating cylindrical and frustroconical conduits whose ends are limited by curved surfaces.

Fig. 13 and Fig. 14 are diagrammatic partial cross sections of laminar conduits.

In several figures the design of the conduits has been only partially shown for the sake of simplicity.

Referring now to the embodiment shown in Figs. 1 and 2, 1 designates the outer shell of a cylindrical inclined container; 2 is a rotatable supported shaft extending through its whole length and provided with pulley 3; 4 and 5 designate the inlets into turbulence chambers of the heavier and lighter liquid phases to be contacted; 6 and 7 designate the outlets of the lighter and heavier phases after contacting. The numerals 8 are the laminar quiescence conduits formed by equidistant longitudinal flat plates arranged parallel to shaft 2 and extending in transverse direction over the complete chord of the cross section of the outer shell 1, while in the axial direction the ends of said plates terminate in correspondence to the cross-planes shown by the dotted lines 8*a*. The turbulence zones 9 are therefore determined by two reciprocally facing cross-planes 8*a*, which are only spaced apart by the space necessary to accommodate stirrer arms 10 fixed on a shaft 2. The conduits placed at the two ending quiescence chambers are longer than the intermediate ones. Numerals 11 designate terminal collecting chambers for the contacted liquids, while 12 are arms fixed on shell 1 for the support of shaft 2. Further means at the inlets and outlets may be used for the control of entering and leaving liquids but are not shown. Numeral 4*a* represents a further inlet into an intermediate turbulence chamber whenever a third phase is included in the system.

The operation of the apparatus is as follows: the lighter phase enters through 5 and fills the apparatus up to the level of outlet 6; then shaft 2 is made to rotate and the heavier phases drop through inlets 4 and 4*a* and displace an equal portion of the lighter phase which leaves the apparatus through 6. The heavy phase entering in 4*a* may be or not soluble either in the heavier phase entering through 4 or in the lighter phase entering through 5. If it is soluble in the heavier phase it will descend as a sole solution flowing countercurrently to the lighter phase since the specific gravity of said solution is higher than that of the lighter phase. If it is not soluble it will descend similarly because its own specific gravity is still higher than that of the lighter phase. If it is soluble in the lighter phase, the specific gravity of the ensuing solution must be lower than that of the heavier phase entering through 4 and then said solution rises countercurrently to said descending heavier phase.

Supposing that the heavy phase entering through 4ᵃ is soluble in the lighter phase under said conditions above and determines a sole lighter phase, the heavier phase will descend through the laminar conduits 8 and arrives in the successive turbulence zones 9 while the lighter phase ascends countercurrently through the laminar conduits 8 in the turbulence chambers 9 and from there in the above standing quiescence conduits 8 from where it proceeds to chamber 11 and outlet 6. The heavier phase continues to descend passing alternatively through all quiescence and turbulence zones till it arrives at the inferior collecting chamber 11 and leaves through outlet 7. A controlled proportionate volume of the lighter phase continually enters through inlet 5 and ascends countercurrently to the heavier phase and after dissolving the heavy phase entering through 4ᵃ it reaches outlet 6 and leaves the apparatus. The major length of the terminal quiescence conduits 8 serves to determine a complete separation of the contacted phases before leaving the apparatus.

Referring now to the embodiment shown in Fig. 3, which is particularly intended for the treatment of solids, 13 is the inclined outer shell having a rectangular shape; 14 is a rotating shaft actuated by a pulley, not shown. Numeral 15 designates the entrance into a turbulence chamber 21 of the finely divided solid phases; 16 the inlet into a turbulence chamber 21 of the liquid lighter phase; 17 the outlet of the contacted solid phase; 18 is a screw-conveyor of the contacted solid phase; 19 the outlet of the contacted lighter phase; 20 are the laminar quiescence conduits having an added inclination with the upper one of greater length in order to allow a thorough sedimentation of the finest solid particles. Said conduits are formed by equidistant longitudinal flat plates extending in a transverse direction from one side to the other of the shell 13 while in the direction perpendicular to the above, all plates begin from cross-plane 20^a and terminate alternately in cross-planes 20^b and 20^c.

The turbulence chambers 21 are therefore determined by the two mutually facing crossplanes 20^a and 20^c whose distance is the shortest required for the accommodation of arms 23; said peculiarity being omitted at the upper end of quiescence zone towards the superior chamber 24. Shaft 14 supported by arms 22 carries stirring arms 23 fixed on same, while 24 are the collecting chambers at both ends, and 13^a represent double bottoms which may be provided for the heating of the phases. Cocks 21^a serve for emptying the turbulence chambers when the apparatus is at rest, controlled exhaust openings 21^b allow gases developing from the liquid phase to escape.

The operation of this apparatus is similar to that of apparatus 1 with the sole difference that a second heavy phase is omitted and that the added inclination of the plates constituting the conduits 20 facilitate the downward course of the solid particles, and that the screw-conveyor 18 entirely stops outlet 17 so that the contacted heavier solid phase is evacuated mechanically in a manner that does not allow the lighter phase to leave through said outlet 17. The space comprised between 20^b and 20^c serves for the sedimentation of the coarser solid particles so that they will descend through the quiescence zones separately from the finer ones, thus avoiding disturbance of the course of the last ones. Means 13^a serve for heating means 21^a for the evacuation of liquid and solid materials, while 21^b serve for the evacuation of gases. These particular means 13^a, 21^a, and 21^b are only to be used when necessary.

Referring to the embodiment shown in Figs. 4 and 5, which is particularly intended when there is too little difference in the specific gravity of the phases, 25 represents the outer inclined shell; 26 the rotating shaft with a pulley 27; 28 the inlet of the heavier phase into a turbulence chamber 33; 29 the inlet of the lighter phase in another turbulence chamber 33; 30 the outlet of the contacted lighter phase; 31 the outlet of the contacted heavier phase; 32 are the cylindrical concentric laminar rotating conduits constituted by cylindrically curved plates whose ends lie in planes perpendicular to shaft 26 on which they are fixed by means of arms similar to those relating to the frustroconical embodiment illustrated in Figs. 6 and 7 and indicated by reference 47; 33 are the turbulence chambers; 34 the stirring arms fixed on shaft 36; and 35 the terminal collecting chambers at both ends.

As said before this kind of apparatus can also be made to work in horizontal position.

The mode of operation of the apparatus is similar to that of the apparatus of Fig. 1, omitting a third phase, but the separation of the phases in the quiescence zones is enhanced by the centrifugal effect created by the rotation of the cylindrical conduits in the quiescence zones.

Figs. 6 and 7 illustrate an embodiment with rotating frustroconical quiescence conduits, which is particularly intended to be used when the heavier phase has a tendency to stick and hence is conveniently subjected to a forwarding action. Numeral 36 represents the outer shell and 37 the rotating shaft with pulley 38; 39 is the inlet of the heavier phase in turbulence chamber 44; 40 the inlet of the lighter phase in another turbulence chamber 44 and 41 the outlet of the contacted heavier phase; 42 the outlet of the contacted lighter phase. The frustroconical concentric laminar conduits 43 are constituted by frustroconically curved plates, fixed by means of arms 47 (Fig. 7) on shaft 37 and rotating with same; the ends of said frustroconically curved plates lie in planes which are perpendicular to shaft 37; 44 are the turbulence chambers; 45 the stirring arms fixed on shaft 37; and 46 the terminal collecting chambers at both ends.

This apparatus can also be made to work in an inclined position.

The mode of operation of this apparatus is the following: the heavy phase either solid or liquid enters at 39 and after mixing with the liquid light phase in 44 enters the frustroconical conduits 43 and overcoming the tendency to stick is forwarded centrifugally to the next turbulence chamber 44 and subsequently arrives at outlet 41. The light phase is pushed mechanically through inlet 40 and, overcoming the centrifugal force of the frustroconical rotating quiescence conduits 43, passes successively through the quiescence and turbulence zones till it leaves through outlet 42.

Figs. 8, 9 and 10 show modes of construction of the turbulence zones 33 of the embodiment of Fig. 4, by which said zones may be limited as shown at 48 in a conical or curved manner through a suitable differentiation of the lengths of the cylindrical plates forming the quiescence conduits.

Figs. 11 and 12 show modes of construction of the turbulence zones 44 of the embodiment of Figs. 6 and 7, by which said zones also may be limited in similar manner as shown at 49.

In the case of Figs. 8 to 12, the stirrer arms are preferably enlarged so as to correspond to the dimensions of the enlarged turbulence chambers. An apparatus can be formed out of a sole type of these forms of quiescence zones or of a combination thereof.

Fig. 13 is a sectional view of a type of a diaphragm type of laminar conduit to be used in connection with the embodiments shown in Figs. 1 and 3, and constituted by plates 50 extending longitudinally over the chord of the cross section of the shell of the apparatus, while the spaces resulting between two successive plates are in their turn further divided by diaphragms 51 which are interposed longitudinally between two plates and are perpendicular to the chord of said cross section. Obviously said diaphragm formation which constitutes a unitary conception for the mode of construction as shown in Figs. 1 and 3 may be substituted by sets of pipes as equivalents, and are to be equally understood as being flat plates in the claims when such plates are specified.

Fig. 14 is a sectional view of an undulated type of laminar conduits.

Variations may, of course, be resorted to and parts used without others within the scope of the appended claims.

Having now fully described my invention, I claim:

1. In an apparatus for the continuous countercurrent contacting of at least two liquid phases substantially immiscible and differing in specific gravity, as well as for the continuous countercurrent contacting of at least one liquid phase with at least one substantially insoluble solid phase differing in specific gravity, while contacting the phase by superposition thereof in layers, including an alternate succession of means forming quiescence and turbulence zones with a rotatable shaft carrying stirring arms and extending through said whole succession of zones, the combination of quiescence chambers arranged in a self-contained inclined shell and formed by a plurality of elongated, clear, straight conduits having a constant equal small sectional area consisting of pipes equally inclined with the shell, extending between two stirring arms located in chambers whose dimensions are restricted to those strictly necessary for the accommodation of said stirring arms, the degree of inclination of said shell and pipes being a sufficient departure from the vertical to allow of said superposition of the phases, one conduit chamber arranged at each end of said alternate succession of chambers, outlet ports for the contacted phases arranged after said terminal conduit chambers, and entrance ports for the phases to be contacted arranged on the chambers provided with stirring arms.

2. In an apparatus for the continuous countercurrent contacting of at least two liquid phases substantially immiscible and differing in specific gravity, as well as for the continuous countercurrent contacting of at least one liquid phase with at least one substantially insoluble solid phase differing in specific gravity, constituted by an alternate succession of means forming quiescence and turbulence zones with a rotatable shaft carrying stirring arms and extending through said whole succession of zones, the combination of quiescence chambers arranged in a self-contained shell and formed by a plurality of elongated, clear, straight conduits having a small cross-sectional area constituted by cylindrical shaped surface portions equally inclined with the shell and concentric to each other, said conduits being fixed on the rotatable shaft extending through the apparatus and arranged between two stirring arms located in chambers whose dimensions are restricted to those strictly necessary for the accommodation of said stirring arms, one conduit chamber arranged at each end of said alternate succession of chambers, outlet ports for the contacted phases arranged after said terminal conduit chambers, and entrance ports for the phases to be contacted arranged on the chambers provided with stirring arms.

3. In an apparatus for the continuous countercurrent contacting of at least two liquid phases substantially immiscible and differing in specific gravity, as well as for the continuous countercurrent contacting of at least one liquid phase with at least one substantially insoluble solid phase differing in specific gravity, constituted by an alternate succession of means forming quiescence and turbulence zones with a rotatable shaft carrying stirring arms and extending through said whole succession of zones, the combination of quiescence chambers arranged in a self-contained shell and formed by a plurality of elongated clear and straight conduits having a small sectional area constituted by cylindrical shaped surface members equally inclined with the shell, and concentric to each other and to the apparatus, and fixed on the rotatable shaft extending through the apparatus also while the edges of at least one of the two extremities of the several cylindrical shaped surface members lie on a curved revolution surface coaxial with the rotating shaft, said conduits being arranged between two stirring arms containing chambers whose dimensions are restricted to those strictly necessary for the accommodation of said stirring arms one conduit chamber arranged at each end of said alternate succession of chambers, outlet ports for the contacted phases arranged after said terminal conduit chambers, and entrance ports for the phases to be contacted arranged on the chambers provided with stirring arms.

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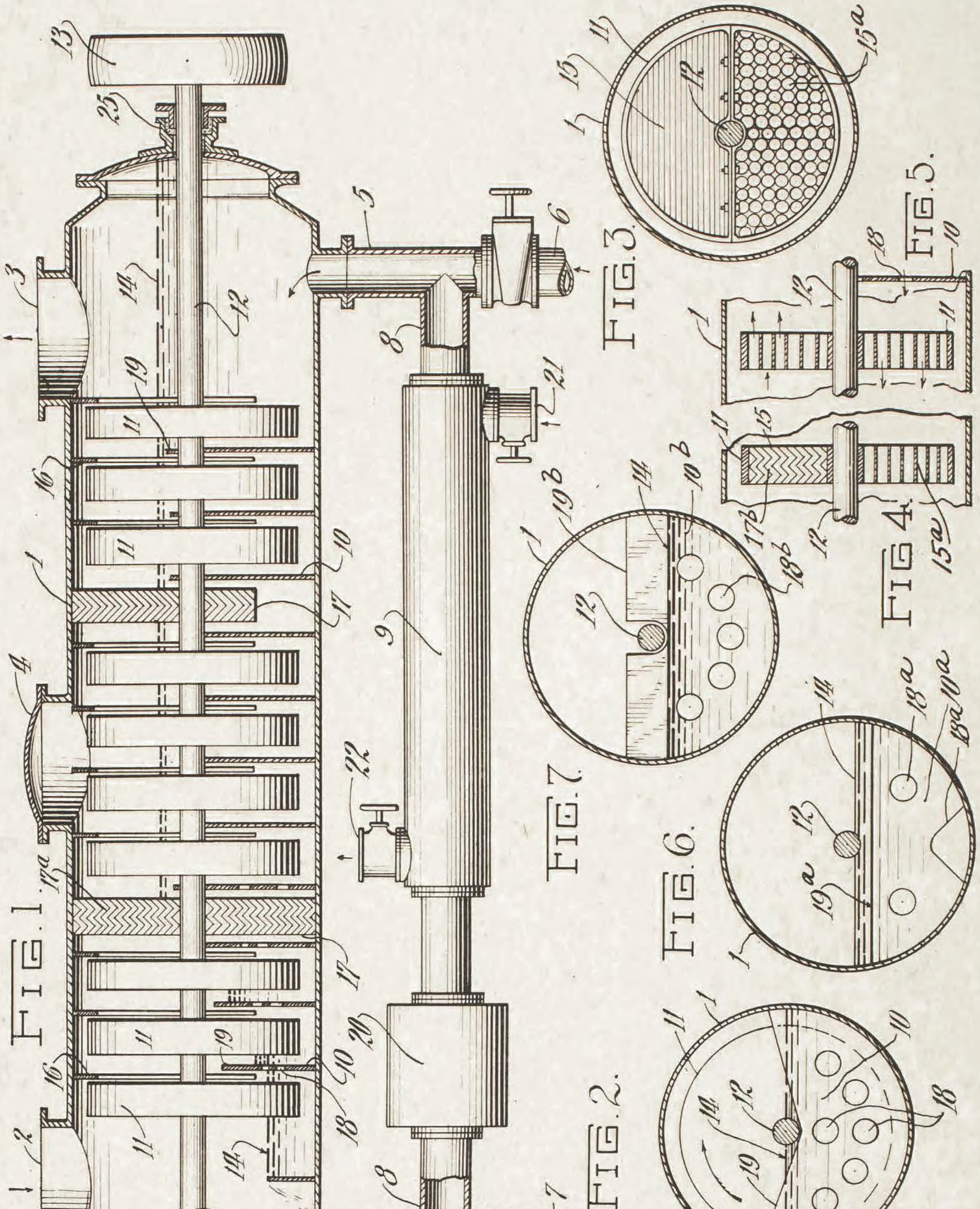
APPARATUS FOR TREATING HYDROCARBON AND OTHER GASES AND OILS

Filed April 25, 1927 2 Sheets-Sheet 1



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APPARATUS FOR TREATING HYDROCARBON AND OTHER GASES AND OILS

Filed April 25, 1927 2 Sheets-Sheet 2

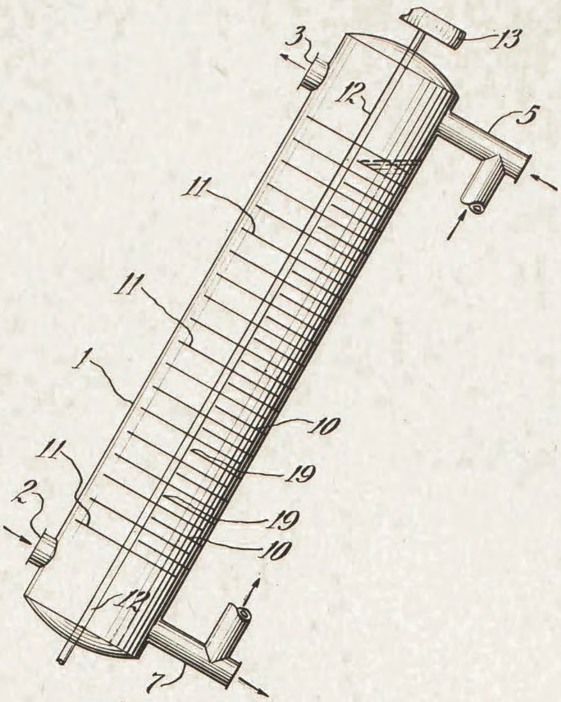

FIG. 9.

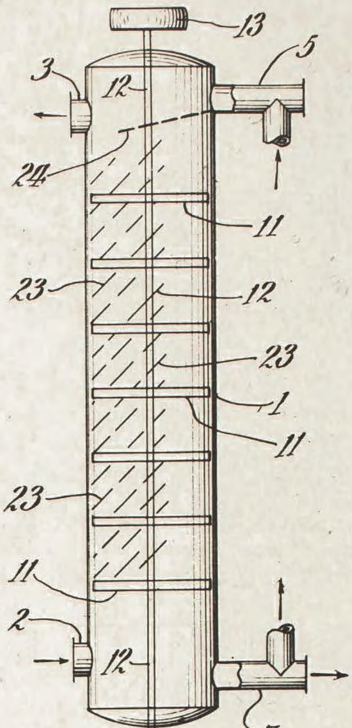

FIG. 10.

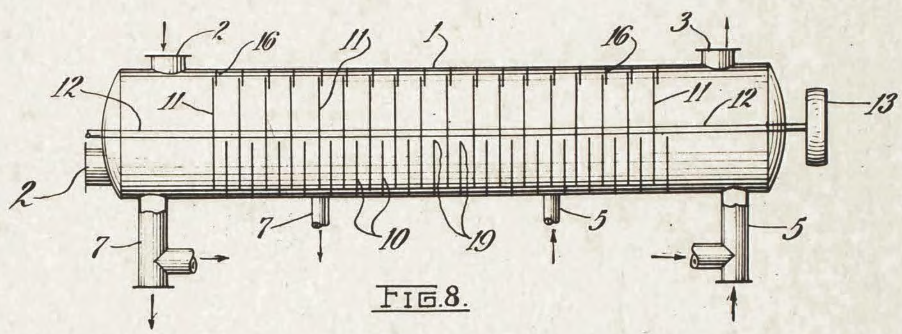

FIG. 8.

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APPARATUS FOR TREATING HYDROCARBON AND OTHER GASES AND OILS

Application filed April 25, 1927 Serial No. 186,459.

My process which is new and distinctive provides for the treatment of the products of the distillation or cracking, or both, of hydrocarbons and the incidental treatment of cooling oil and condensate, in an elongated chamber placed either horizontally or perpendicularly, or at any angle from the horizontal to the perpendicular, as may be preferred, which chamber is so constructed or arranged that the cooling liquid or medium, which may be crude petroleum oil, shall occupy one part longitudinally of the elongated chamber and the vapors or gases resulting from distillation or cracking, or both, shall occupy the other part longitudinally of the chamber, and while they may be in surface contact shall not intermingle except as herein set forth. In practice I admit the vapors or gas to the chamber at or near one end and admit the cooling liquid at or near the other end and pass them through practically the entire length of the chamber in counter current, or I may, if desired, admit both vapor or gas and cooling liquid separately at the same end of the chamber and pass them through it independently and concurrently.

By passing the vapor or gas and cooling liquid through the chamber in this manner, I may maintain such pressure as is desired, and regulate temperature in the chamber, thus dephlegmating under regulated pressure and temperature, as has not heretofore been done, and doing it more adequately, efficiently and speedily.

To aid in treating the vapors and gases, and at the same time remove moisture or mist from the vapor or gas being treated, I provide baffles to impede and distort the flow of such vapor or gas, and in any practical manner, but usually and preferably by means of revolving discs partly submerged in the cooling liquid, I agitate the vapor or gas and sprinkle, spray or dash particles of the cooling liquid against and into the gas, and transfer heat from the vapor or gas to the cooling liquid. In this manner I not only speedily and efficiently cool the vapor or gas and heat the liquid used as a cooling medium, both of which are purposes of my invention, but I also extract moisture from the vapor or gas, aid in condensing higher boiling point products and intimately intermingle said moisture and higher boiling point products with the cooling medium, and where it is a crude or other heavy petroleum oil, cause the absorption in it, either in whole or in part, of said moisture and higher boiling point products.

When sulphur or objectionable color or odors are present in the gas or vapor, I add to the cooling liquid, then usually a heavy or crude petroleum oil, any suitable treating agent, such as lime, caustic soda, soda ash, water, fuller's earth, or bentonite, or a combination of one or more of these, and then the treatment described, in addition to the effects already mentioned, clarifies the products and eliminates the objectionable sulphur, color and odor, either wholly or to a degree sufficient for commercial purposes, and heavy or crude oil when used as a cooling medium, is made into a product well adapted for transformation by simple and well known processes into a very efficient lubricating oil, or used as charging stock in cracking operation with or without the intervening removal of entrained solids.

In this manner, I may remove from or change in crude or other oils that portion thereof that unduly deposits carbon, in cracking, on the apparatus. My process is continuous. Gas or vapor and cooling medium are renewed or added to as often as desired or continuously and the treatment agent when used may be added or withdrawn whenever and as often as desired.

Other characteristics and further advantages of my process appear in the description of an apparatus I have invented particularly adapted to it, and in the several claims which follow.

In the drawings:

Figure 1 is a longitudinal sectional view of the apparatus showing the rotating discs in elevation;

Fig. 2 is a cross sectional view showing one form of a weir or dam in elevation;

Fig. 3 is a cross sectional view of the apparatus showing one form of disc in elevation;

Fig. 4 is a sectional detail of the disc of Fig. 3;

Fig. 5 is a sectional detail of a modified form of disc;

Figs. 6 and 7 are cross sectional views of the apparatus showing weirs of modified construction;

Fig. 8 is a diagrammatic view of the apparatus of Fig. 1; and

Figs. 9 and 10 are diagrammatic views showing modifications of said apparatus.

My apparatus consists of a chamber through which by suitable openings a liquid and gas enter at different temperatures and move counter current to each other while passing progressively through openings in a plurality of revolving metallic discs arranged concentrically on a revolving shaft whereby heat from the liquid is transferred to the discs and from the discs to the gas—or heat is transferred from the gas to the discs and from the discs to the liquid; or a liquid may be passed concurrently with a gas through the apparatus.

The liquid may contain lime, caustic soda, soda ash, fuller's earth, hydrated lime, or bentonite herein called treating agents, to alter the character of the liquid or vapor in the dephlegmator, for instance, by absorption of sulphur or coloring matter. This liquid is continually lifted as a film wetting the discs and may be used for altering the character of the gas by exposure thereto and by renewal for treatment by revolving the discs.

Figure 1 shows one arrangement of my apparatus and its application to oil stills as a separator of liquids heavier than gasoline out of vapors from a cracking still while operating under, for instance, 600 pounds pressure. However, it may be operated at lower or normal pressure, or higher pressure. A cylindrical chamber of steel is employed with an entrance port for hot vapors at 2, and an exit port for the vapors not condensed or absorbed at 3. A means of entrance for inspection and repair may be provided in the form of a port 4. Liquid oil produced in the apparatus by condensation or brought to it by a pipe 6, may be introduced through an intake 5, and withdrawn through an outlet 7, or returned through a pipe line 8 by a pump 20, being cooled during recirculation by water or other means entering the water jacket 9 at 21 leaving at 22.

Weirs represented in Figs. 2, 6 and 7, respectively, by 10 10^a and 10^b of whichever type may be preferred may be interposed along the lower side of the chamber, if desired, to insure pools of liquid into which perforated rotating discs 11 dip and which also act as protectors to prevent undue convection currents in the liquid, and gas lift effect, from rapidly overpassing gas. The chamber 1 may be horizontal as in Fig. 8, or vertical as in Fig. 10, or at an angle between, as in Fig. 9, but any angle sufficient to permit a flow of liquid from one end to the other in a suitable manner is satisfactory. Horizontal or nearly horizontal operation is very satisfactory. In the arrangement of Fig. 10, angular baffles 23 with openings are provided for the return downward on the baffle side of oil and for the passage upward on the opposite side of gas. A means 24 is provided for diverting incoming cooling oil.

12 is a shaft with suitable means of variable rotation provided by passing through stuffing boxes 25 and driven by means of a pulley 13. The discs 11 are concentrically fastened to the shaft and revolve between the weirs 10 dipping through the surface of liquid 14. The passage of gas through the passages in the discs 11 may be furthered by oppositely disposed baffles 16 which retard the passage. The perforations of the discs 11 may be of such character, as indicated in Fig. 5, that a large amount of surface in proportion to weight is presented for heating and cooling; or the perforations may be so formed or arranged tortuously as to give free passage to gas and to catch mists and entrained particles.

For the further purpose of removing mists I also may interpose stationary discs 17 or parts of discs with zigzag or tortuous or sharply diverted passages, if desired, between the revolving perforated discs 11. The stationary discs 17 may be provided with strips 17^a of corrugated metal arranged in zigzag or other tortuous relation so as to impede the flow therethrough. The same result may be attained by grouping short opened-ended tubes or the like in parallel relation to the shaft 12. Various arrangements of the rotating discs are shown in Figs. 3, 4 and 5 in which 15 indicates corrugated metal strips forming zigzag passages as at the top of Figs. 3 and 4, and 15^a represents short parallel tube sections as at the bottom of Figs. 3 and 4 and throughout the entire extent of the disc of Fig. 5, but any other arrangement affording passage to gas presenting a large metallic surface is suitable.

By thus constructing my apparatus I can use it for dephlegmator or bubble tower on oil cracking or other apparatus. I can take advantage of structural metals, such as high chromium or other steels resistant to corrosion, that are not now economically available for less efficient bubble towers and dephlegmators, which require more metal for construction in proportion to effectiveness and capacity.

I normally rotate the shaft 12 at a rate below that at which the perforated discs 11 will throw oil upwards—however, if desired, I can take advantage of the spraying effect of higher rates of revolution of shaft 12 and the heat transfer effect of liquid thrown through gas. Operating at lower rates of revolution, I find I am able to cool and handle greater volumes of gas than could be handled at higher speeds. Since the spray formed by the rapid rotation of the discs 11 would be carried concurrently with the gas, I have provided tortuous passages through stationary eliminators at intervals as represented by 17 to prevent the removal, as a mist or spray, of the liquid from the chamber 1. In Fig. 10, 24 is a deflector to insure liquid delivery to one side of the vertical dephlegmator from which it is separated from the ascending gas by deflecting perforated plates 23. Figs. 2, 6, and 7 show the baffles or weirs 10, 10^a and 10^b, respectively wholly or partly immersed in liquid whose surface is 14. The tops of the weirs or baffles are represented respectively at 19, 19^a and 19^b and the optional holes through the same which may be of various shapes and sizes are respectively 18, 18^a and 18^b, although the weirs may be imperforate if desired.

In operation the rotation of the shaft with the perforated discs carried thereby will cause a dashing up of the liquid hydrocarbon into the space through which the vapors are passing, thus effecting an intimate commingling of the fine liquid particles with the vapors which assists in an interchange of heat and also in the condensation of the more condensible vapors. At the same time the formation of the discs is such that as to afford a large surface exposure to the tortuously directed gases so that the exchange of heat is facilitated, and the separation of condensible gases promoted.

I claim:

1. In a dephlegmator, a chamber provided with an inlet for condensible vapors and gases, and an outlet for incondensible gases, an inlet and an outlet for liquid, discs in the chamber between said inlets and outlets provided with surfaces forming passages extending in angular relation to the line of flow of the gases and adapted to permit the gases to pass and be relieved of mist, said passages being configured to afford an extended surface exposure for the interchange of heat, and means for rotating the discs.

2. A dephlegmator having formed therein a section for the passage of vapors and gases and provided with mist eliminating stationary partitions interposed in said gas passageway and provided with passages configured to sharply divert the flow of the gas therethrough and thereby eliminate the mist therefrom, and having rotating discs located intermediate the stationary partitions, each of said discs being provided with passageways affording greater surface exposure than the lateral surface of the discs, means for rotating the discs, an inlet for vapors and gas, an outlet for incondensible gases, a liquid inlet, and a liquid outlet, the flow of liquid being opposite to the flow of the gas.

3. An apparatus for the treatment of hydrocarbon vapors including an elongated horizontally disposed chamber having an inlet at one end and an outlet at the other for the ingress and egress of vapors and gases, said chamber having a series of weirs arranged along the bottom to provide means for retaining a liquid therein but permitting the passage of vapors thereover, means for supplying a liquid to one end of the chamber and for receiving it from the other end, and perforate members adapted to revolve through said liquid so as to carry their wetted perforate surfaces into the path of said vapors to cause the gases to come into contact with the liquid.

4. An apparatus for the treatment of hydrocarbon vapors including an elongated horizontally disposed chamber having an inlet at one end and an outlet at the other for the ingress and egress of vapors and gases, said chamber having a series of weirs arranged along the bottom to provide means for retaining a liquid therein but permitting the passage of vapors thereover, means for supplying a liquid to one end of the chamber and for receiving it from the other end, perforate members adapted to rotate through said liquid so as to carry their wetted perforate surfaces into the path of said vapors to cause the gases to pass therethrough, the vapors passing through the chamber in the opposite direction from the liquid, and means for rotating said perforate members.

5. An apparatus for the treatment of hydrocarbon vapors including an elongated horizontally disposed chamber having an inlet at one end and an outlet at the other for the ingress and egress of vapors and gases, said chamber having a series of weirs arranged along the bottom to provide means for retaining a liquid therein but permitting the passage of vapors thereover, means for supplying a liquid to one end of the chamber and for receiving it from the other end, perforate members adapted to revolve through said liquid so as to carry their wetted perforate surfaces into the path of said vapors to cause the gases to pass therethrough, means in the path of said vapors for removing mist therefrom, and means for rotating said perforate members.

6. An apparatus for the treatment of hydrocarbon vapors including an elongated horizontally disposed chamber having an inlet at one end and an outlet at the other for the ingress and egress of vapors and gases, said chamber having a series of weirs arranged along the bottom to provide means for retaining a liquid therein but permitting the passage of vapors thereover, means for supplying a liquid to one end of the chamber and for receiving it from the other end, per-

forate members adapted to revolve through said liquid so as to carry their wetted perforate surfaces into the path of said vapors to cause the gases to pass therethrough, a series of corrugated vanes in the path of said vapors and between certain of said perforate members for removing mist therefrom, and means for rotating said perforate members.

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METHOD AND APPARATUS FOR SOLVENT EXTRACTION

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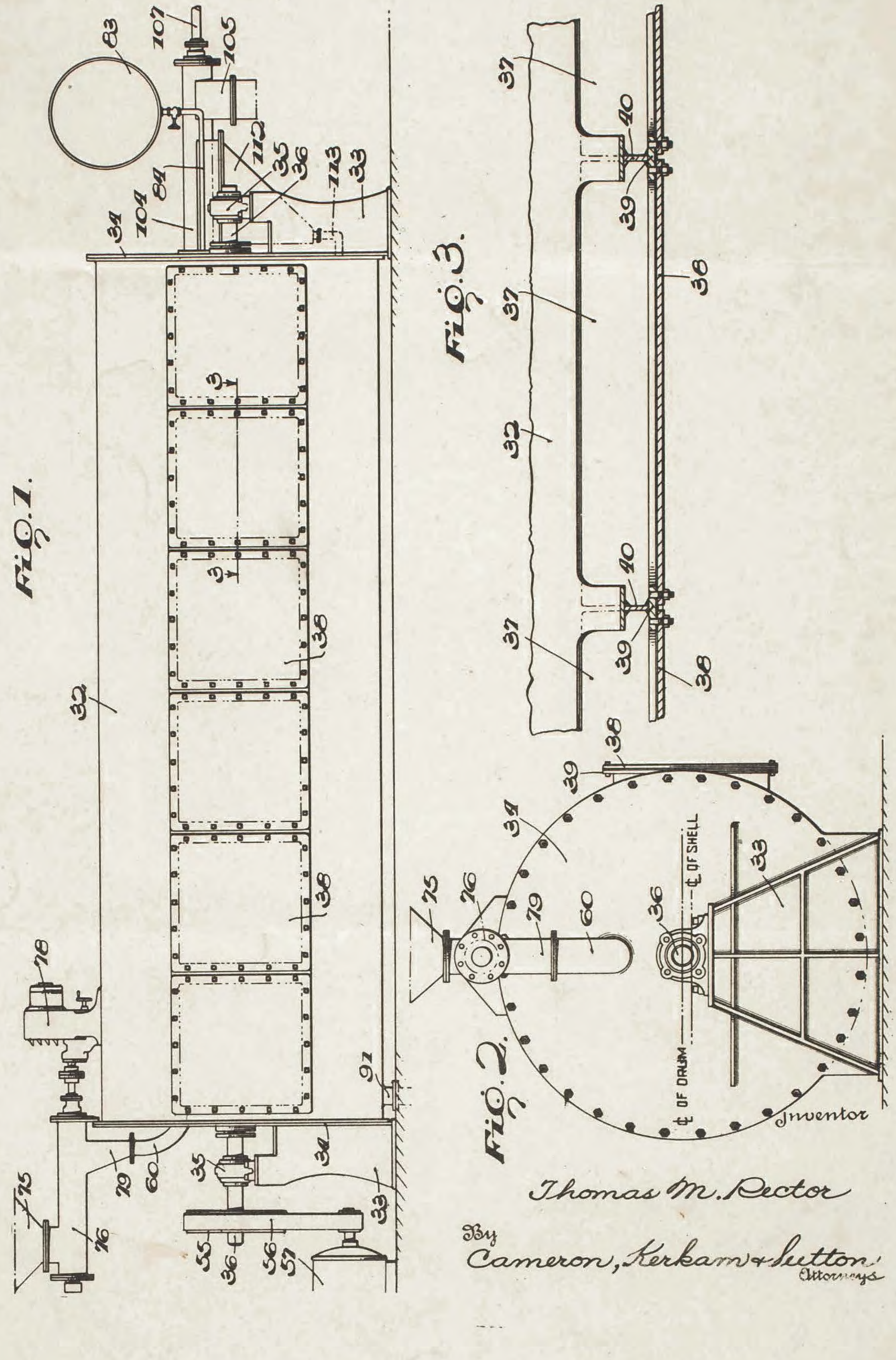

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METHOD AND APPARATUS FOR SOLVENT EXTRACTION

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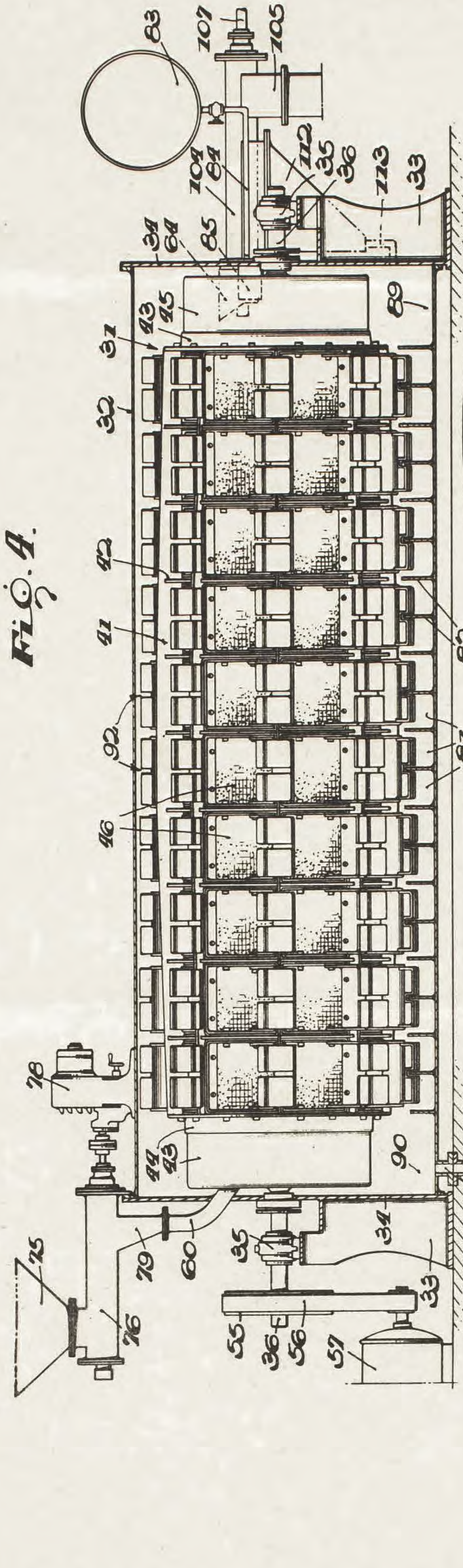

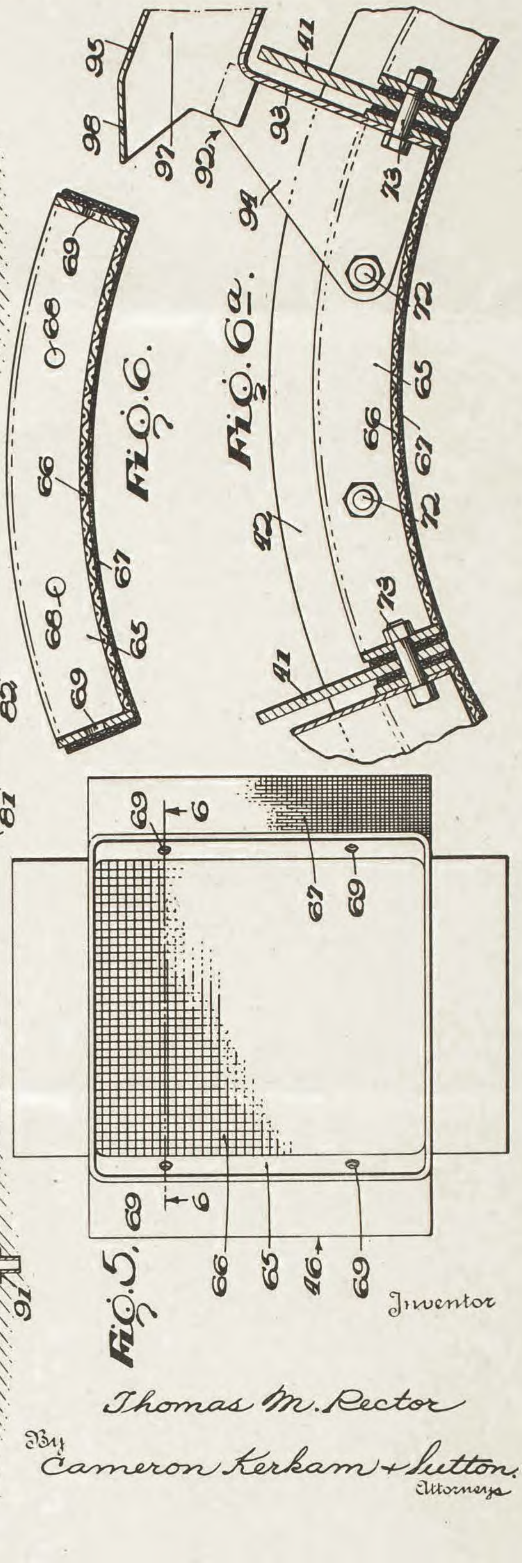

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METHOD AND APPARATUS FOR SOLVENT EXTRACTION

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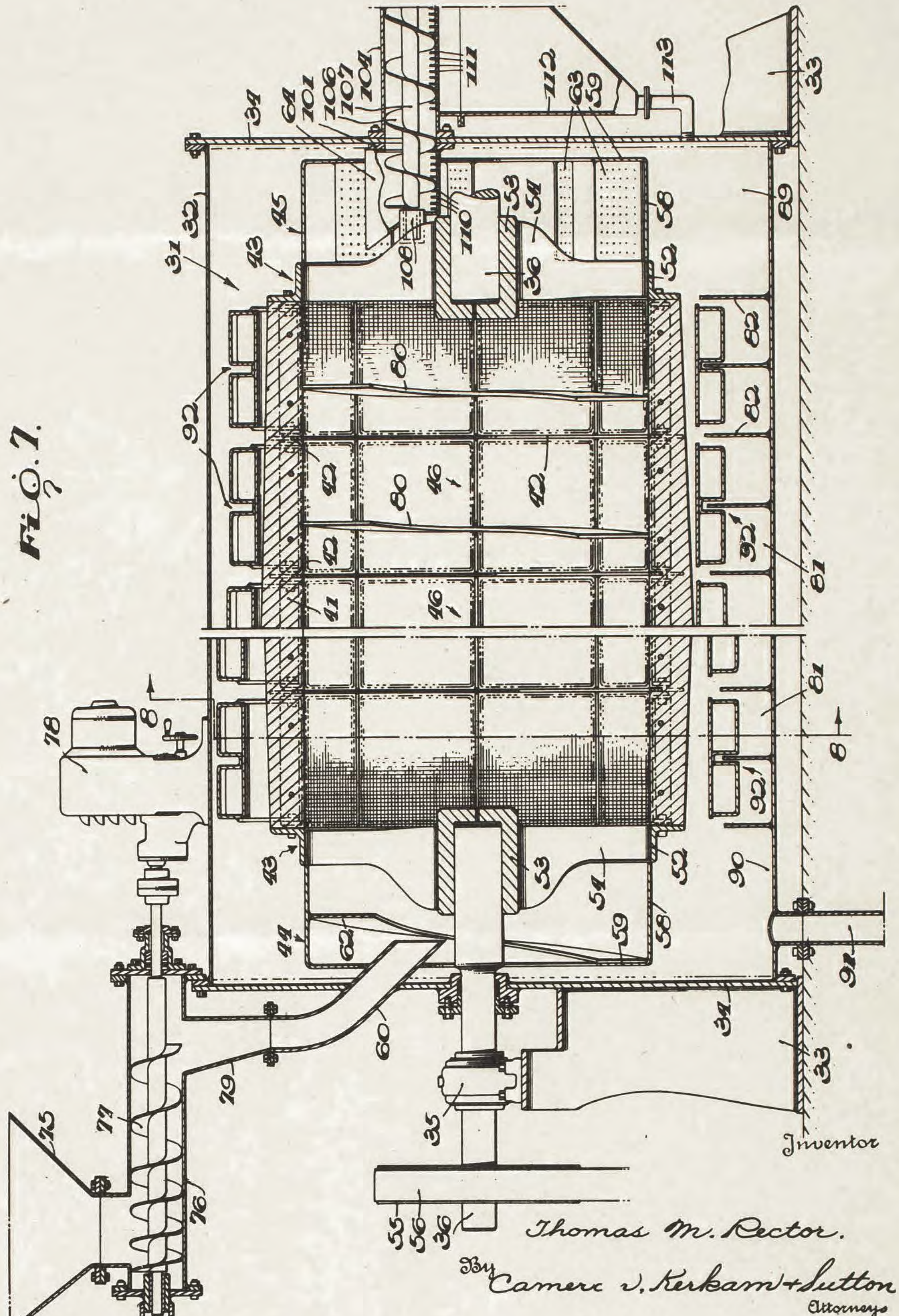

Fig. 7.

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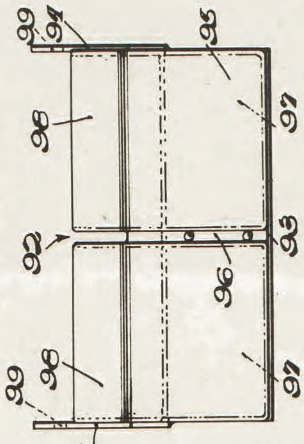

Fig. 11.

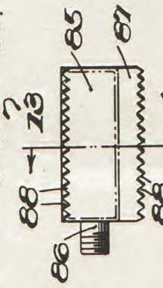

Fig. 12.

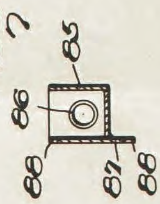

Fig. 13.

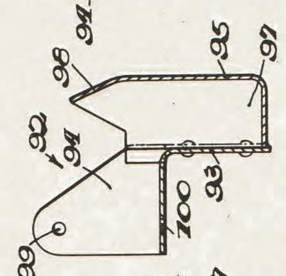

Fig. 9.

Fig. 10.

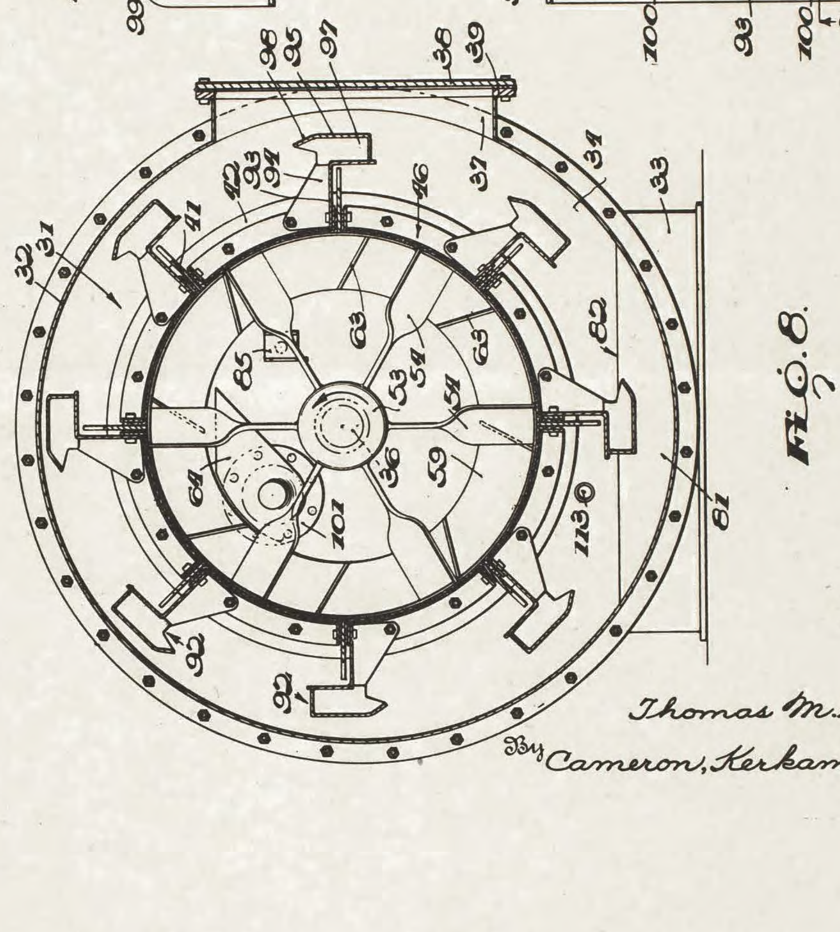

Fig. 8.

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FIG. 17.

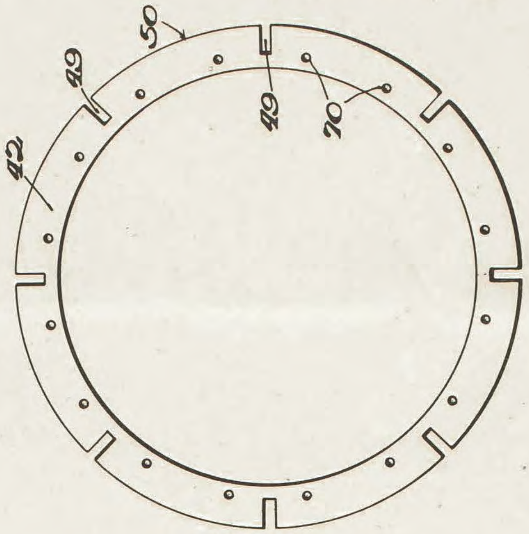


FIG. 15.

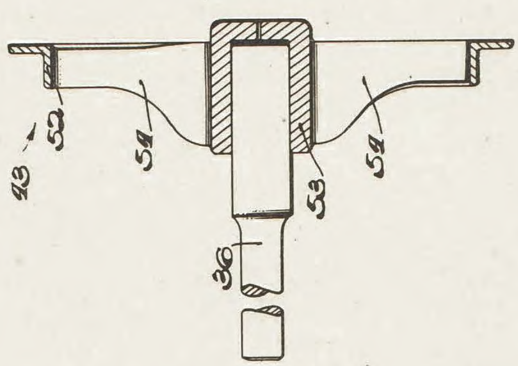


FIG. 14.

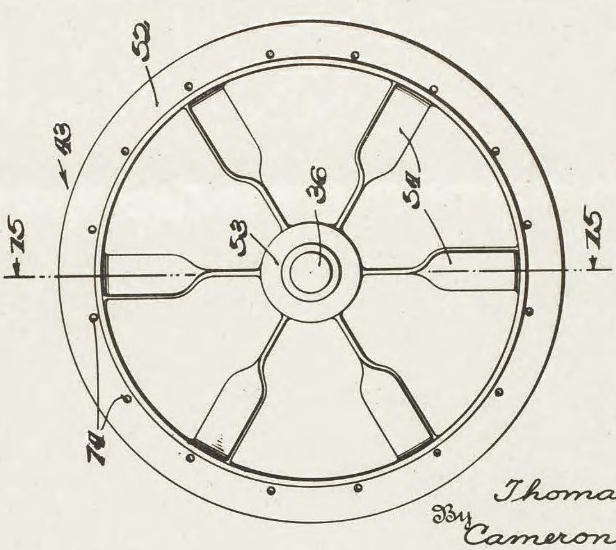
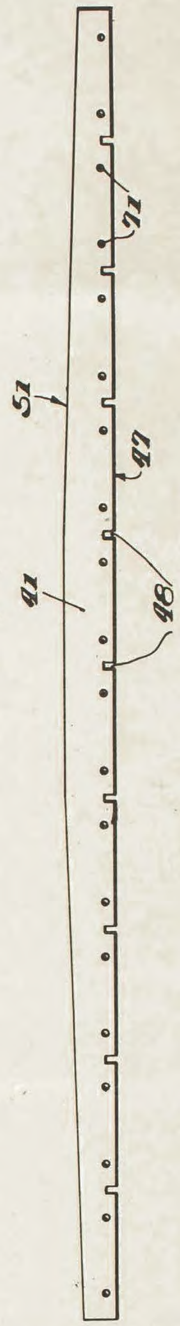


FIG. 16.



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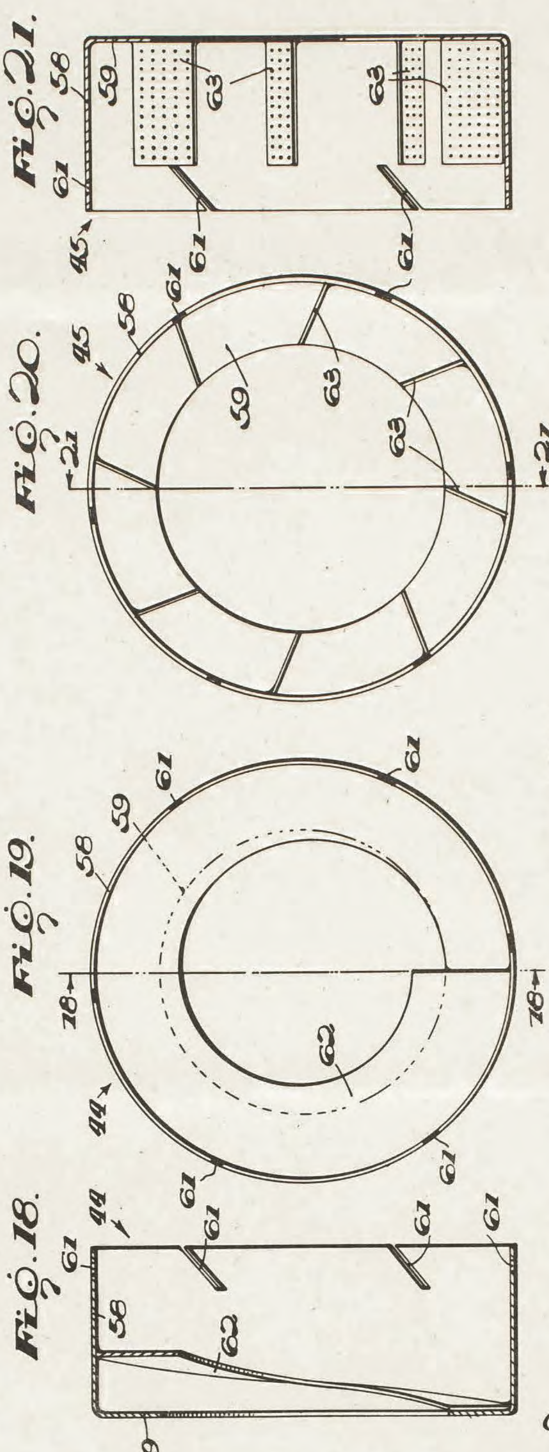

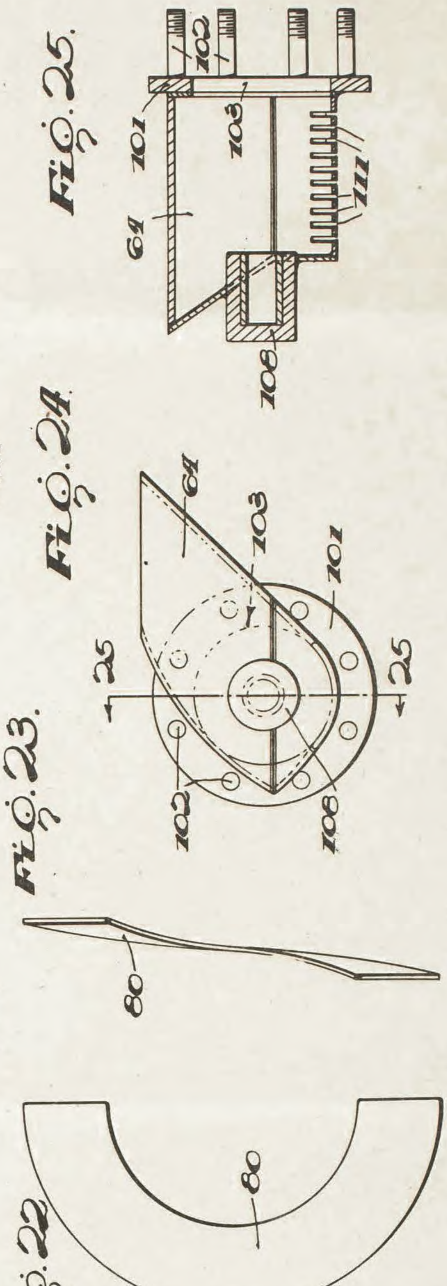

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR SOLVENT EXTRACTION

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Application June 12, 1940, Serial No. 340,205

9 Claims. (Cl. 23—270)

This invention relates generally to the art of extracting soluble matter from solid materials containing such matter, and has particular application to methods and apparatus for the solvent extraction of oils and fats from finely divided or flaked vegetable materials, such as corn germ, copra, palm kernels, soya beans, rape seeds, and the like.

For ease in expression, the more specific statements of the present disclosure will refer only to the extraction of oil from oil bearing vegetable material, although it is to be expressly understood that the invention is equally applicable to the extraction of various other substances, solid as well as liquid, from a wide variety of materials, including those of the mineral and animal kingdoms.

One of the immediate objects of the present invention is to provide a novel procedure and apparatus of greater efficiency than those heretofore known for extracting oil from vegetable materials which have been mechanical treated so as to free the oil from the natural cell structure.

Another object is to provide an extractor of the character described embodying the countercurrent principle, but so improved in structure and mode of operation as to be capable of more rapid and efficient extraction than prior devices intended for similar purposes.

A further object is to produce a continuously operative solvent extraction process and apparatus of novel characteristics wherein the solvent flows both countercurrently and transversely to the movement of the solid material while the latter is continuously agitated, thereby subjecting each particle of the material to frequent contact with, and relatively vigorous washing by, solvent of varying concentration.

Still another object is to provide an extraction device of the character described embodying a rotatable, screen type drum through which the extractable material is continuously moved and means for producing a continuous flow of solvent both countercurrently and transversely to the movement of said material through the drum, the transverse circulation of the solvent not only increasing the rapidity of the extraction but also preventing clogging of the drum screen.

These and other objects, including that of generally improving upon the structural and performance characteristics of the device heretofore available to the art for similar extraction procedures, will appear more fully upon a consideration of the detailed description of the embodiment of the invention which follows. Although only one particular form of machine embodying the invention is described and illustrated in the accompanying drawings, it is to be expressly understood that these drawings are for the purpose of illustration only and are not to be construed as defining the scope of the invention, reference being had for the latter purpose to the appended claims.

In the drawings, wherein like reference characters indicate like parts throughout the several views:

Fig. 1 is a side elevation of one form of extraction apparatus embodying the procedural and structural features of the present invention;

Fig. 2 is an end elevation of the extractor shown in Fig. 1, looking from the left in the latter figure but omitting the motor, belt and pulley of the drum rotating mechanism;

Fig. 3 is a fragmentary horizontal sectional view taken substantially on line 3—3 of Fig. 1, but on an enlarged scale, showing the manner in which the detachable cover plates are secured to the shell or casing of the extractor;

Fig. 4 is a side elevation of the extractor of Fig. 1 with the shell shown in section in order to illustrate the exterior of the rotatable extractor drum and the arrangement of the transverse partitions or weirs which divide the bottom portion of the shell into a plurality of solvent compartments;

Fig. 5 is a plan view of one of the removable screen units which make up the cylindrical wall of the extractor drum, showing the fine mesh working screen with its edge portions in the extended, unlapped positions which they occupy before the screen unit is inserted in its proper position in, and secured to, the framework of the drum;

Fig. 6 is a sectional view of one of the screen units taken substantially on line 6—6 of Fig. 5, but showing the working screen with its edge portions doubled and lapped upwardly around the sides of the screen frame;

Fig. 6*a* is a fragmentary, enlarged sectional view taken on a vertical plane perpendicular to the axis of the drum illustrating the manner in which the screen units and solvent transfer buckets are secured to the framework of the drum;

Fig. 7 is an enlarged, vertical sectional view taken approximately on the axis of the extractor of Fig. 1, but with the central portion of the extractor broken away, certain parts shown in full and others omitted in the interest of clarity;

Fig. 8 is a transverse vertical section taken substantially on line 8—8 of Fig. 7, looking toward the material discharge end of the extractor and, as in the case of the left-hand portion of Fig. 7, omitting for the sake of greater clarity the semicircular helical vanes within the drum which serve to feed the material axially through the drum;

Figs. 9, 10 and 11 are sectional, plan and side elevational views, respectively, of one of the solvent transfer bucket units which serve to deliver solvent from the compartments in the bottom of the shell to the upper surface of the rotatable drum, whence it passes into the drum through the perforations of the screen units. the section of Fig. 9 being taken substantially on line 9—9 of Fig. 10;

Figs. 12 and 13 are a side elevation and a transverse vertical section, respectively, of the solvent supply weir from which the fresh solvent is initially delivered to the interior of the drum, the section of Fig. 13 being taken substantially on line 13—13 of Fig. 12;

Figs. 14 and 15 are an end elevation and a vertical axial section, respectively, of one of the two end rings or wheels of the drum, including the associated stub shaft by which the drum is supported and rotated, the stub shaft and spokes of the wheel being shown in full in Fig. 15, rather than in section, said section being otherwise taken substantially on line 15—15 of Fig. 14;

Figs. 16 and 17 are elevational views of one of the longitudinal rib members and one of the circumferential hoop members, respectively, which make up the skeleton framework of the drum;

Figs. 18 and 19 are a vertical axial section and an end elevation, respectively, of the member forming the head of the drum at the end into which the solid material is initially fed, the section of Fig. 18 being taken substantially on line 18—18 of Fig. 19;

Figs. 20 and 21 are an end elevation and a vertical axial section, respectively, of the drum head which is secured to the material discharge end of the drum, the section of Fig. 21 being taken substantially on line 21—21 of Fig. 20;

Figs. 22 and 23 are side and end elevations, respectively, of one of the semicircular, helical material feeding vanes of the drum; and

Figs. 24 and 25 are an end elevation and a vertical axial section, respectively, of the material discharge trough into which the solid extracted material is delivered by the blades of the discharge head of the drum and from which said material is removed by the screw conveyor indicated in Fig. 7, the section of Fig. 25 being taken substantially on line 25—25 of Fig. 24.

The extraction apparatus illustrated in the drawings as one embodiment of the present invention primarily comprises an extractor drum having a foraminous peripheral wall rotatably mounted in a shell or casing the bottom of which is formed into a plurality of intercommunicating solvent compartments through which the solvent and dissolved matter gradually flow in a direction countercurrent to that in which the solid extractable material moves through the interior of the drum, the drum being provided with a plurality of bucket-like members secured to its periphery at spaced points both axially and circumferentially thereof which take solvent from the compartments at the bottom of the shell, elevate it, and then pour it over the exterior surface of the drum, whence it passes into the drum through the perforations of the foraminous wall, flows through the particles of solid material in a direction substantially transverse to the axial direction of movement thereof through the drum, and then drains back into the compartments through the perforations of the lower portion of the drum wall. Novel means are also provided for feeding the solid material into the drum, moving it through the drum with a combined axial and rolling or tumbling movement and removing it from the discharge end thereof, as well as for supplying fresh solvent to the extractor and causing a controlled countercurrent flow thereof through the compartments beneath the drum. With this general concept of the combined transverse and countercurrent flow extractor of the present invention in mind, reference may now be had to the drawings for a more detailed disclosure of the various novel features thereof.

As can be seen best from Figs. 1, 2, 4, 7 and 8, the drum of the extractor, indicated generally at 31, is an elongated, substantially cylindrical device of built-up construction (the elements of which will be described in detail hereinafter) which is housed and mounted for rotation about a horizontal axis within a generally cylindrical shell or casing 32, the latter being supported in any suitable manner as by standards 33 secured to or formed integrally with the plates 34 forming the end closures of the shell. The standards 33 also support suitable bearings 35 in which are journalled the stub shafts 36 of the drum 31, the positions of these bearings being such as to support the drum with its axis off-set vertically above that of the shell 32 in order that there may be adequate space in the bottom portion of the shell for the solvent compartments later to be described.

The shell 32 is so constructed as to be liquid tight, and may also be normally sealed against the escape of vapor by packing or welding around all of the openings in the end plates 34 through which extend the drum shafts, material feed and discharge conduits, etc. Access to the interior of the shell may be had, however, for purposes of repair, cleaning or the like, through a plurality of manholes 37 extending the entire length of the shell along one side thereof, each manhole being provided with a removable cover plate 38 adapted to be suitably secured to a flanged frame 39 which is in turn welded to webs 40 projecting outwardly from the shell 32 (see Fig. 3).

The drum itself is of novel composite construction, comprising a plurality of longitudinal rib members 41 and circumferential hoop members 42 suitably secured together, as by welding, to form a skeleton framework, a pair of spoked end rings or wheels 43 which carry the stub shafts 36 and may be welded to the ends of the rib members 41, a feeding drum head 44, a discharge drum head 45, and a plurality of arcuate screen units 46 which are detachably secured to the rib and hoop members 41 and 42 to form a perforated cylindrical wall for the drum.

Each of the longitudinal rib members 41 (Fig. 16), of which there are eight in the embodiment illustrated, extends the entire length of the drum between the end rings 43, and is provided in its bottom or radially inner edge 47 with a plurality of equally spaced notches 48 which are adapted to cooperate with similar notches 49 extending radially inwardly from the outer edges 50 of the hoop members 42 (Fig. 17), of which there are nine in the embodiment disclosed, when the rib and hoop members are assembled to form the skeleton of the drum. The notch joints thus formed facilitate maintenance of the rib and hoop members in their proper relative positions while they are being welded together to form the drum framework. The upper or radially outer edge 51 of each of the rib members is preferably divergently inclined from both ends toward the middle, as shown, in order to increase the radial depth of the ribs intermediate the ends thereof and thereby strengthen the drum framework against sagging.

To each end of the framework formed by the rib and hoop members 41 and 42 is secured an end ring or wheel 43 (Figs. 14 and 15) consisting of a rim 52 of L-shaped cross section, a hub 53 and a plurality of twisted spokes 54 interconnecting the rim and hub, and preferably welded thereto. Fixed in the hub 53 of each of the wheels 43, as by a shrinkage fit, is the inner end of one of the stub shafts 36 by which the drum is journalled for rotation in the bearings 35. As is indicated in Fig. 14, the radially inner portion of each of the spokes 54 adjacent the hub 53 is coplanar with the axis of the drum, while the outer portion of each spoke is twisted out of the axial plane at a suitable angle so as to assist in moving the solid material being treated axially through the drum. The two wheels 43 are identical in construction except that, because they are faced in opposite directions, their spokes are likewise twisted oppositely. The stub shaft 36 fixed to the wheel at the feeding end of the drum is also preferably longer than that at the discharge end in order to provide for the connection thereto of a suitable means by which the drum may be rotated. For example, in the construction illustrated, this stub shaft carries a pulley 55 which is driven by a belt 56 from a motor 57, it being understood that the drive thus provided is suitably controllable in order to rotate the drum at any desired speed.

The element 44 (Figs. 18 and 19) which forms the head of the drum at the material feeding end thereof consists of an imperforate cylindrical wall 58 of slightly smaller diameter than the rim 52 of the adjacent end wheel 43, and a lip or flange 59 which extends radially inwardly from the left-hand or outer edge of cylindrical wall 58, the opening defined by the inner edge of said lip being of sufficiently large diameter to admit the discharge end of a fixed delivery chute 60 forming a part of the mechanism, later to be described, by which the solid material to be extracted is fed into the drum. The right-hand or inner edge portion of cylindrical wall 58 is provided with a plurality of diagonally extending slots 61 equal in number to, and of the same angularity as the twisted portions of, the spokes 54 of the adjacent end wheel 43, this construction enabling assembly of the drum head 44 with the rest of the drum by simply telescoping its right-hand or inner edge portion inside of the rim 52 of end wheel 43, the spokes of the wheel seating in the slots 61 and thereby holding the head against rotation relatively to the drum framework. If desired, the head may then be permanently secured to the end wheel, as by welding.

In order to positively feed the material delivered to the drum head 44 by the chute 60 into the main body of the drum, said head is also provided with a helical vane 62 which, as shown best in Fig. 19, may be of a gradually increasing radial height from the outer end thereof, which is adjacent to and of the same height as the lip 59 of the drum head, to its inner end which lies in axial alignment with its outer end and in the same transverse plane as the closed ends of the slots 61. That is, in the illustrated embodiment, the radially inner edge of the vane 62 follows a path which is both helical and spiral, the radial height of said vane at its inner end being substantially the same as that of the hereinafter described semicircular, helical feeding vanes within the main body of the drum.

The drum head 45 (Figs. 20 and 21) which is located at the discharge end of the drum is similar in construction to the feeding head 44 in so far as it includes an imperforate cylindrical wall 58, an inwardly turned lip or flange 59 and diagonal slots 61 for engagement with the spokes 54 of the end wheel 43, although, of course, it is faced oppositely to said feeding head 44. Interiorly, however, the two heads differ, the discharge head 45 being provided with a plurality of flat, perforated lifting blades 63 which are secured to the cylindrical wall 58 and radial lip 59 as by welding, each of these blades lying at an angle to the radial plane through its line of contact with the cylindrical wall 58, but with its inner longitudinal edge parallel to the drum axis and at the same distance therefrom as the inner edge of lip 59. The function of these blades 63 is to lift the extracted solid material from the bottom of the discharge head 45, where it collects after passage through the main body of the drum, and to deliver said material into a fixed discharge trough 64 which extends into the opening defined by the inner edge of the lip 59 of the drum head and forms a part of the mechanism, later to be described, which removes the exhausted solid material from the apparatus after extraction. The perforations in the blades 63, which may be on the order of ⅛" in diameter, are adapted to permit drainage of solvent and dissolved matter from the solid material being elevated by the blades downwardly into the bottom portion of the drum head, whence it may flow into the solvent compartments in the bottom of the shell 32 in a manner to be set forth hereinafter.

Coming now to the removable screen units 46 constituting the cylindrical wall of the drum, eighty of which are required to surface the drum of the disclosed embodiment, it will be seen from Figs. 5, 6 and 6a that each unit consists of a quadrilateral frame 65 having two arcuate sides and two which are straight-edged, a section of relatively coarse mesh supporting screen 66 spot welded along its edges to the frame, and a section of fine mesh working screen 67 which has no permanent connection to the frame 65, but is simply placed under the supporting screen 66 with its edge portions doubled and lapped around the outside of the screen frame. Each of the arcuate sides of the frame 65 is provided with a pair of bolt holes 68, while each of the straight sides has similar holes 69, said bolt holes being so located and spaced as to line up with corresponding holes 70 and 71 formed in the circumferential hoop members 42 and longitudinal rib members 41, respectively (see Figs. 16 and 17). With this construction, after the section of working screen 67 has been folded about the frame 65 in the manner indicated in Fig. 6, the whole unit may be inserted into one of the eighty spaces in the drum framework defined by the rib and hoop members, and then secured in place to the hoop and rib members, respectively, by bolts 72 and 73, which bolts also pass through the doubled and lapped edge portions of the fine mesh working screen 67, as indicated in Fig. 6a. The rims 52 of the end wheels 43 are also provided with bolt holes 74, corresponding to those in the circumferential hoop members 42, in order to receive half of the bolts 72 which pass through the arcuate sides of the screen units in the two end sections of the drum.

Although the cylindrical surface 66 of each screen unit which serves merely to support the fine mesh working screen 67 may be formed in any suitable manner, it has been found that a coarse screen of approximately ½" mesh, spot welded to the frame 65, is quite satisfactory. While the specific character of the working screen 67 may also vary dependent upon the size of the particles of solid matter being treated, a screen of approximately 100 mesh is considered suitable when the apparatus is to be used for the extraction of oil from finely divided or flaked vegetable matter, such as corn germ. A convenient way of making each of the necessary sections of working screen is to first cut a rectangular piece of dimensions exceeding those of the bottom of the screen frame by approximately twice the height of the frame sides, then cut out the corners to produce the cruciform shown in Fig. 5, and finally double over the outwardly extending edge portions of the cruciform and fold them up against the sides of the screen frame, as indicated in Fig. 6.

The mechanism by which the solid material to be extracted is fed into the drum may be of any suitable construction, and may be varied when handling materials of specifically different character. In the embodiment illustrated, the means provided are particularly adapted to handle vegetable material in finely divided or flaked state and comprise a hopper 75 delivering into one end of a horizontal pipe 76 in which is mounted a helicoidal screw conveyor 77 driven by a variable speed motor 78 mounted on top of the extractor shell 32. The pipe 76 is also provided with a downwardly extending spout 79 into which the material is delivered by the conveyor 77 and which connects to the upper end of the previously mentioned chute 60, the lower end of which extends through the end plate 34 of the shell and into the feeding head 44 of the rotating drum 31. The material thus delivered from the chute 60 into the drum head 44 is caused to move into the main body of the drum by the feeding action of the helical vane 62 and the twisted portions of the spokes 54 of the end wheel 43.

Once inside the drum, the material is continuously moved therethrough in a generally axial direction, and at the same time rolled or tumbled, by any suitable means such as an interrupted type helical conveyor of the construction indicated in the right-hand portion of Fig. 7. This conveyor, of which only a portion is shown in the latter figure, comprises a plurality of semicircular helical vane members 80, each of the construction illustrated in Figs. 22 and 23, secured to the interior of the drum at axially spaced points therealong and arranged in staggered relationship in two opposed rows with the leading edge of each vane in substantially the same radial plane with, but axially spaced from, the trailing edges of the immediately adjacent vanes. Two such vane members 80 are located in each of the ten sections of the drum defined by the circumferential hoop members 42 and end wheels 43, and are preferably welded to the inner edges of the longitudinal rib members 41. Inasmuch as it is desirable to maintain the drum less than half full, so as to insure a vigorous rolling or tumbling action of the material as it moves through the drum, the radial height of the vanes 80 may be substantially less than the radius of the drum, as is indicated in Fig. 7.

In order to produce the combined countercurrent and transverse flow of solvent relatively to the movement of the solid material which is one of the features of the present invention, novel means have been provided for establishing a plurality of solvent compartments within the shell adapted to contain solvent of varying concentration, and for delivering solvent from said compartments to the interior of the drum in such a manner that it flows substantially transversely through the material therein and then drains back into said compartments through the screened cylindrical surface of the drum, the compartments being so constructed and arranged that there is a continuous, gradual flow of solvent and dissolved matter in a direction opposite to that in which the material is moved through the drum. Novel means have also been provided for originally supplying the fresh solvent to the extractor, and for returning thereto solvent which may be carried out of the drum in the solid material leaving the discharge end of the latter.

As is shown best in Figs. 4, 7 and 8, the bottom portion of the extractor shell 32 is divided into a plurality of solvent compartments 81 by means of transversely extending, segmental shaped partitions or weirs 82 which may be welded to the shell, the weirs varying uniformly in height from one end of the shell to the other, the tallest weir being positioned in substantially the same vertical plane as rim 52 of the end ring or wheel 43 at the material discharge end of the drum. The weirs 82, of which there are twenty-one in the embodiment illustrated, are uniformly spaced along the length of the drum 31, alternate weirs lying in the same vertical planes with the circumferential hoop members 42 of the drum framework. The difference in height between adjacent weirs is so selected that the overflow from one compartment 81 to another will be such as to produce the desired rate of countercurrent flow of the solvent through the extractor.

If desired, the top edges of the weirs 82 may be provided with rectangular or triangular cutouts at one or more points therealong through which the overflow may be effected, instead of using the entire lengths of said edges for this purpose. Alternatively, the weirs might be made of uniform height throughout the length of the shell and provided with communicating orifices of suitable size and shape to produce the desired gradual flow of solvent from compartment to compartment.

The fresh solvent may be originally introduced into the apparatus from any suitable source 83 through a valved pipe 84 and a solvent supply weir 85 of the novel construction illustrated in Figs. 12 and 13. This supply weir is essentially a channel shaped receptacle or container having an inlet nipple 86 which is adapted to pass through the end plate 34 of the extractor shell and to be suitably coupled to the pipe 84 so as to support the weir in an inwardly extending, horizontal position within the shell, off-set from both the horizontal and the vertical axial planes of the drum as indicated in Figs. 4 and 8. The vertical side wall of the weir which is adapted to serve as the overflow side is provided with a downwardly extending continuation 87, and both the top and the bottom edges of said wall are serrated as indicated at 88 in order to insure a substantially uniform overflow of solvent along the entire length of said wall.

With this construction, fresh solvent from the source 83 may be permitted to flow at a controllable rate through the pipe 84 into the supply weir 85, and thence to overflow the serrated wall, dripping off the points of the bottom edge thereof into the discharge head 45 of the drum. The fresh solvent thus washes down through the solid material which is being elevated by the perforated lifting blades 63 and accumulates in the bottom of the drum head 45, whence it overflows into the adjoining screened section of the drum and then drains through the screen into the first one or two solvent compartments 81 therebeneath.

Although the fresh solvent might, if desired, be introduced directly into the space or compartment indicated at 89 between the first transverse weir 82 and the end plate 34 of the shell, the novel arrangement illustrated is of advantage in that it increases the efficiency of the extraction by removing from the solid material which has already reached the discharge drum head 45 an appreciable quantity of soluble matter which, while already extracted from the solid material, would otherwise be carried out of the apparatus with said material because of the lack of sufficient liquid solvent to wash the extracted matter back into the screened portion of the drum. When the solvent is introduced in the manner illustrated so as to wash through the solid material which is in the course of being discharged, the solvent and dissolved matter (miscella) which is being carried along with the mass of solid material will be washed out by the fresh solvent so that substantially no extracted soluble matter will leave the drum with the solids.

The solvent which overflows from the last or left-hand compartment 81 into the space 90 between the last transverse weir 82 and the end plate 34 of the shell is discharged from the extractor through a suitable outlet 91. This solvent, which normally contains a small amount of solid material as well as the desired, predetermined percentage of soluble matter, may first be passed through a suitable filter or other device for removing the solids, and then to a suitable recovery plant where the soluble matter and solvent may be separated and collected in known manner.

The means by which the solvent is transferred from the solvent compartments 81 at the bottom of the shell 32 to the interior of the drum 31 is best illustrated in Figs. 7–11. As there shown, there are secured to the exterior of the drum a plurality of solvent bucket units 92, one for each of the screen units 46, which are so constructed and arranged that, as the drum is rotated, they dip into the solvent contained in the compartments 81, elevate that solvent through approximately a quarter revolution of the drum and then pour the solvent onto the screened periphery of the drum, whereupon it flows through the screen and downwardly through the solid material within the drum, which is simultaneously being rolled or tumbled and gradually moved axially of the drum, picking up soluble matter as it flows, and finally drains back into the compartments 81 through the lower portion of the screened drum wall. Although the specific construction of the bucket units 92 may be varied as desired, that illustrated in the drawings has been found capable of delivering the solvent into the drum in a more desirable manner than other constructions which have been tried, and susceptible of both economical manufacture and ready connection to and disconnection from the drum.

As shown, each unit consists of an L-shaped base plate 93, a pair of side or wing plates 94 of generally triangular shape welded to the edges of the radially extending portion of the base plate at right angles to the latter, and a bucket forming element 95 of relatively complex shape which is welded both to the tangentially extending portion of the base plate 93 and to the side plates 94. The outer wall portion of each bucket forming element 95 is inwardly depressed as indicated at 96 so that, as the drum rotates, channels are available for reception of the alternate solvent compartment partitions or weirs 82 which lie intermediate the radial planes of the circumferential hoop members 42 (see Fig. 7). By riveting the depressed portion of the wall of the bucket forming element 95 to the base plate 93 in the manner indicated, each bucket unit is divided into two solvent containing spaces 97. To assist in retaining the desired amount of solvent in the spaces 97 when the bucket units are passed through the solvent compartments by rotation of the drum, the upper or free edges of the outer wall portion of the bucket forming element 95 may be hooded inwardly as indicated at 98. It will also be noted that the end wall portions of the bucket forming element 95 are longer than the tangentially extending portion of base plate 93 and underlap the side plates 94 in the manner shown best in Fig. 9. With this latter construction, it will be seen that, as each bucket unit is elevated beyond the horizontal position shown in Fig. 9, the solvent therein will flow out of the spaces 97 over the radially extending portion of base plate 93 in a stream which is confined and directionally controlled by the end wall portions of the element 95 and the side plates 94.

In order to provide for ready detachable mounting of the bucket units 92 on the drum, the axial dimension of each unit (that is, the distance between the two side plates 94) is made slightly less than the distance between the arcuate sides of the frame 65 of one of the screen units 46, and the side plates 94 and base plate 93 are provided with bolt holes 99 and 100, respectively, which are adapted to line up with the screen frame bolt holes 68 and 69, and to receive the bolts 72 and 73 by which the screen units are secured to the drum framework (see Fig. 6a).

All of the bucket units 92 are of identical construction except as respects the radial dimensions of the base plates 93 and side plates 94. Because of the fact that the solvent compartment weirs 82 decrease uniformly in height from one end of the drum to the other, it is obvious that the distance between the liquid level of the solvent in the compartments 81 and the axis of the drum will increase proportionately as the material feeding end of the latter is approached. Consequently, in order that the bucket units associated with the different sections of the drum may all receive the proper amount of solvent in passing through the compartments 81, it is desirable that the radial dimensions of the base and side plates of these units be suitably varied to compensate for the difference in solvent level in the various compartments. Although, with compartment weirs of uniformly varying height such as those illustrated, the bucket units in each section of the drum should theoretically be of a different radial dimension than those of the adjacent sections, satisfactory results and more economical manufacture may be obtained by using units of the same dimension in each pair of sections along the length of the drum, thereby requiring only five different sizes of base and side plates, instead of ten.

After the solid material being treated has been moved through the drum and simultaneously subjected to a vigorous agitation and washing with transversely flowing solvent in the manner previously described, it reaches the discharge head 45 of the drum and is there delivered by the lifting blades 63 into the previously mentioned discharge trough 64 which constitutes one element of the means by which the extracted material is removed from the apparatus. This trough, which is of the irregular shape illustrated in Figs. 24 and 25, is provided with a supporting flange 101 carrying a plurality of stud bolts 102 by which the trough is adapted to be fixed to the end plate 34 of the shell 32 in proper position to project inwardly through the central opening defined by the inwardly turned lip 59 of the drum discharge head 45. As is shown best in Fig. 8, the position of the flange 101 is off-set from the vertical axial plane of the drum, but the body portion of the trough is formed with a corresponding eccentricity in the opposite direction so as to bring the open mouth of the trough into proper position to receive the solid material as it slides off the lifting blades 63.

The stud bolts 102 also serve to secure to the outer surface of end plate 34, in coaxial alignment with the opening 103 in supporting flange 101, a discharge pipe 104 provided adjacent its outer end with a downwardly directed conduit 105 through which the extracted solid material may be delivered from the extractor to any desired destination, as, for example, to a solvent recovery device. In order to move the extracted material from the trough 64 through the pipe 104 to the conduit 105, a screw conveyor 106 is rotatably mounted in the trough and pipe, the inner end of the conveyor shaft 107 taking bearing in a suitable boss 108 carried by the body of the trough 64, while its outer end passes through a combined radial and thrust bearing 109 carried by the pipe 104 and thence to any suitable driving member (not shown), such as a variable speed motor like that indicated at 78 which drives the conveyor 77 at the feeding end of the extractor.

Inasmuch as the solid material which is delivered into the discharge trough 64 may still contain some solvent and dissolved soluble matter, it is desirable that this liquid be given an opportunity to drain back into the extractor before the solids are finally discharged from the apparatus. To this end, the bottom of the body portion of the trough 64 is provided with a plurality of milled slots 110 through which liquid may drain into the discharge drum head 45 or the space 89 in the bottom of the shell 32. For the same purpose, a substantial section of discharge pipe 104 is provided with similar slots 111 and a catch tank 112 into which said slots open. Any liquid draining into the catch tank 112 is returned to the end compartment 89 of the shell 32 through a suitable conduit 113.

While it may be feasible in many instances to omit the special solids discharge mechanism disclosed and to simply drop the solids from the lifting blades 63 of the discharge head 45 into a steep angle, gravity discharge chute and later recover whatever solvent may remain in the solids by a pressing or distilling operation, the use of the particular construction illustrated increases the magnitude of the solvent flow through the extractor and, as a consequence, the extraction efficiency also, particularly when the apparatus is used for extracting oils and fats from finely divided or flaked vegetable materials.

Although it is believed that the method aspects of the present invention will be obvious from the foregoing description of a preferred form of apparatus for carrying out the method, the procedure may be summarized as follows, applying it, by way of example, to the extraction of oil from corn germ.

The corn germ is first reduced to finely divided condition, as by flaking, crushing, grinding or other suitable mechanical operation, so as to free the oil from the natural cell structure of the corn. The finely divided corn is then placed in the hopper 75, whence it is fed by the helicoidal conveyor 77 through the pipe 76 and into the delivery spout 79 and chute 60 which deliver it to the interior of the feeding head 44 of the drum 31. As the drum is continuously rotated by the motor 57, the particles of corn are gradually moved through the drum by the semicircular helical vanes 80 with a combined axial and rolling or tumbling movement. At the same time, solvent, originally supplied in fresh state from the source 83 to the interior of the discharge head 45 of the drum by the solvent supply weir 85, is being continuously taken from the compartments 81 in the bottom of the extractor shell 32 by the bucket units 92, elevated therein and then dumped over the upper portion of the screened circumferential wall of the drum, whereupon it flows through the fine mesh working screen 67 (backwashing the screen as it passes therethrough), into the drum and through the mass of finely divided particles of corn until it reaches the bottom portion of the drum and drains back through the screened wall thereof into the compartments 81.

Due to the stepped arrangement of the transverse partitions or weirs 82 forming the solvent compartments 81, there is a gradual flow of solvent and dissolved oil from one compartment to the next in a direction countercurrent to that in which the corn moves through the drum, the result being that the oil concentration of the solution in the various compartments varies substantially uniformly from one end of the extractor to the other, being a minimum in the extreme right-hand compartment adjacent the discharge end of the drum and a maximum in the left-hand compartment and space 90 whence the concentrated solution is discharged to the oil and solvent separating and recovery system through the outlet 91. In this manner, the concentration of the solvent which is flowed through the corn at the various points along the length of the drum is varied in approximately direct relation to the oil content of the corn through which it flows.

For optimum results, the speed of operation of the feeding conveyor 77 is so regulated relatively to the speed of rotation of the drum 31 that the latter is maintained less than half full of corn, a 40% fill being preferred when handling this particular material. The flow of fresh solvent from the source 83 is also controlled in any suitable manner relatively to the feed of the corn so as to extract the desired proportion of oil from the corn during the interval of time which it takes for the passage of the corn through the drum.

When the corn reaches the discharge end of the drum, it moves into the discharge head 45 through the spaces between the spokes 54 of the end wheel 43, where it is subjected to a shower of fresh solvent dripping off the serrated bottom edge of the overflow wall of the solvent supply weir 85. The corn is then elevated by the lifting blades 63 and delivered thereby into the discharge trough 64, the perforations in said blades and the milled slots 110 in the bottom of said trough permitting drainage of solvent and dissolved oil back into the bottom of the discharge head 45, whence it may escape into the screened section at the end of the drum and thence drain into the solvent compartments 81 therebeneath. The extracted corn is moved outwardly from the trough 64 through the pipe 104 and into the discharge conduit 105 by the screw conveyor 106, the milled slots 111 in the bottom of the pipe permitting further drainage of liquid into the catch tank 112 from which it is returned to the space 89 at the end of the shell through the conduit 113. The relatively dry, extracted corn which is thus delivered into the discharge conduit 105 may be treated for further recovery of solvent, if desired, and then disposed of in any suitable manner.

There are thus provided by the present invention both an improved method and a novel apparatus for extracting soluble matter from solid materials containing the same which are capable of more rapid and efficient extraction than the procedures and mechanisms heretofore known. By combining the countercurrent principle of solvent extraction with a relatively vigorous agitation of the material and a transverse flow of the solvent relatively to the movement of said material through the treating zone in the manner disclosed, it has been found that substantially complete extraction of any given material can be accomplished in from 10% to 25% of the time required when using ordinary counterflow methods and apparatus. Consequently, an installation embodying the present invention is capable of extracting the same amount of raw material per unit of time as could be handled by a machine of from four to ten times its size constructed and operated according to the teachings of the prior art.

In extracting oil from the insides of fibrous particles such as finely divided vegetable matter, the rolling or tumbling movement imparted to the particles according to the present invention produces a sponge-like squeezing action, while the substantially continuous transverse flow of solvent insures that there is always solvent available for picking up any oil that may come to the exposed surfaces of the particles, dissolving it and carrying it away out of the drum. The constant backwashing of the screen by the solvent as the latter is poured from the buckets onto the exterior of the drum is also of substantial advantage because it prevents the screen from becoming clogged with the finely divided material being extracted, and thereby avoids the lost time that would occur were it necessary to periodically take the machine out of service for the purpose of cleaning the screen.

Structurally, the apparatus of the present invention is not only novel, but also particularly well adapted for continuous operation with a minimum of attention by the operating force. It is also of such construction as to facilitate manufacture, since the principal elements of the drum, shell and material feeding and discharge means are separately formed and assembled in such a way as to be readily removable and replaceable without dismantling of the machine.

These and other advantages of the procedure and apparatus herein disclosed characterize the present invention as a marked improvement over the extraction methods and devices of the prior art. In this connection, although only one specific mechanism for carrying out the invention has been illustrated in the accompanying drawings, it should be obvious that the invention is not limited to the particular structure shown, but is capable of a variety of mechanical embodiments. For example, instead of using the bucket and compartment arrangement disclosed, various other expedients could be readily devised for delivering solvent into the drum at various points along the length thereof and causing said solvent to flow through the material in the drum in a generally radial direction. Similarly, the movement of the particles of solid material through the drum could be produced in ways other than by the use of a helical conveyor like that illustrated; in some instances, the mere pressure of the feed of the material into the drum would be sufficient. The gradual countercurrent flow of the solvent might also be effected by other means than the stepped compartment partitions or weirs shown, as by the provision of cut-outs or flow orifices in said partitions of suitable size or shape, as heretofore mentioned. Furthermore, certain of the elements of the apparatus are obviously useful independently of the others and in combination with various other devices adapted for similar purposes.

Inasmuch as numerous other changes, which will now suggest themselves to those skilled in the art, may also be made in the procedural steps of the method, and in the form, details of construction and arrangement of the parts of the apparatus, without departing from the spirit of the invention, the limits of the invention are to be measured only by the appended claims.

What is claimed is:

1. In a method of extracting soluble matter from particles of solid material, the steps of moving said material in one direction through a solvent treating zone, flowing a body of solvent in the opposite direction below and out of contact with said zone, lifting portions of said solvent body above said zone at a plurality of points along its length, and percolating the lifted portions of solvent down through said material, said percolating solvent draining from the material in said zone back into the body of solvent below.

2. In a method of extracting soluble matter from particles of solid material, the steps of moving a continuous mass of said material in one direction through a solvent treating zone, flowing a body of solvent in the opposite direction below and out of contact with said zone, lifting portions of said solvent body above said zone at a plurality of points along its length, and percolating the lifted portions of solvent down through said material, said percolating solvent draining from the material in said zone back into the body of solvent below.

3. In a method of extracting soluble matter from particles of solid material, the steps of moving a continuous mass of said material in one direction through a solvent treating zone, while simultaneously rolling or tumbling said material, flowing a body of solvent in the opposite direction below and out of contact with said zone, lifting portions of said solvent body above said zone at a plurality of points along its length, and percolating the lifted portions of solvent down through said material, said percolating solvent draining

from the material in said zone back into the body of solvent below.

4. In a method of extracting soluble matter from particles of solid material, the steps of moving said material in one direction through a solvent treating zone, flowing solvent in the opposite direction below and out of contact with said zone through a plurality of substantially separate but communicating stages, lifting portions of said solvent above said zone from each of said stages, and percolating said lifted solvent down through said material, said percolating solvent draining from the material in said zone back into the stage from which it was lifted.

5. In a method of extracting soluble matter from particles of solid material, the steps of moving said material in one direction through a solvent treating zone, while simultaneously rolling or tumbling said material, flowing solvent in the opposite direction below and out of contact with said zone through a plurality of substantially separate but communicating stages, lifting portions of said solvent above said zone from each of said stages, and percolating said lifted solvent down through said material, said percolating solvent draining from the material in said zone back into the stage from which it was lifted.

6. In a method of extracting soluble matter from particles of solid material, the steps of moving said material in one direction through a solvent treating zone, while simultaneously rolling or tumbling said material, flowing solvent in the opposite direction below and out of contact with said zone by overflow to stages of successively decreasing level, lifting portions of said solvent above said zone from each of said stages, and percolating said lifted solvent down through said material, said percolating solvent draining from the material in said zone back into the stage from which it was lifted.

7. Apparatus for extracting soluble matter from particles of solid material comprising a rotatable, cylindrical drum having a perforated wall, means for feeding said material through said drum in one direction, a plurality of solvent compartments having solvent levels below and out of contact with said drum, means for feeding solvent from one compartment to another in succession in the opposite direction, and means carried by said drum for lifting solvent from said compartments and emptying it on the top of the drum to percolate through said material therein and drain from the bottom of the drum back into said compartments.

8. Apparatus for extracting soluble matter from particles of solid material comprising a rotatable, cylindrical drum having a perforated wall, means for feeding said material through said drum in one direction, a plurality of solvent compartments having solvent levels below and out of contact with said drum and successively decreasing in height in the opposite direction, means for feeding solvent to a high compartment whereby it overflows from one compartment to another in said opposite direction, and means carried by said drum for lifting solvent from said compartments and emptying it on the top of the drum to percolate through the material therein and drain from the bottom of the drum back into said compartments.

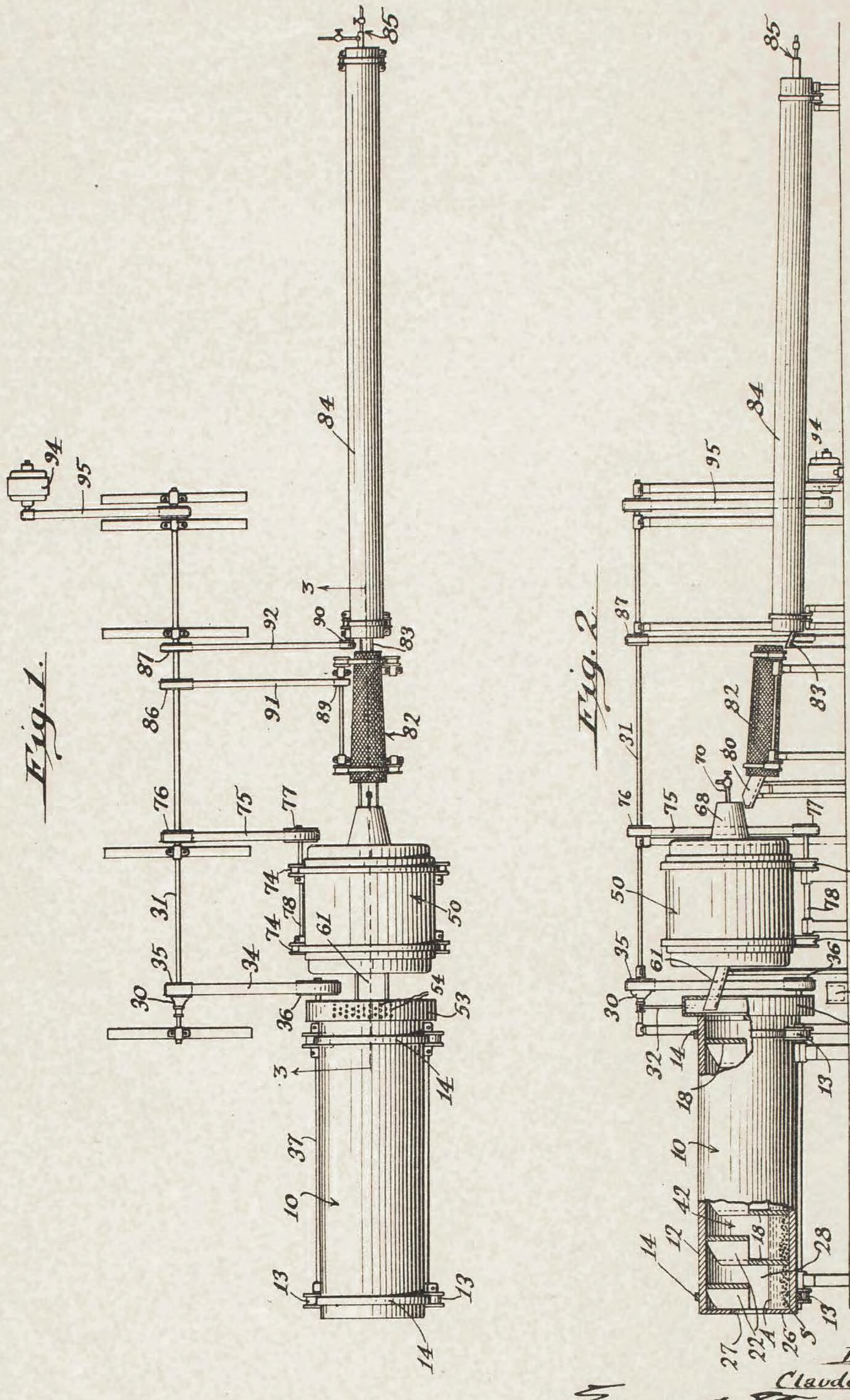
9. Apparatus for extracting soluble matter from particles of solid material comprising a rotatable, cylindrical drum having a perforated wall, feeding elements within said drum for feeding said material therethrough in one direction, a plurality of solvent compartments having solvent levels below and out of contact with said drum, means for feeding solvent from one compartment to another in succession in the opposite direction, and means for lifting solvent from each compartment and emptying it on top of the drum to percolate through the material therein and drain back into said compartments.

THOMAS M. RECTOR.

Nov. 10, 1931. C. E. BOWERS **1,831,091**

METAL RECOVERING APPARATUS

Filed Aug. 23, 1929 3 Sheets-Sheet 1



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METAL RECOVERING APPARATUS

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Fig. 3.

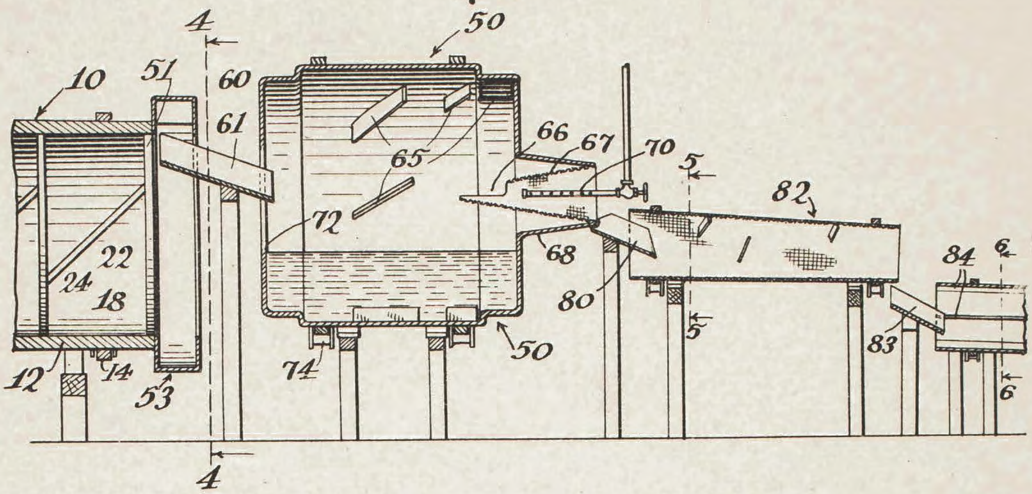


Fig. 4.

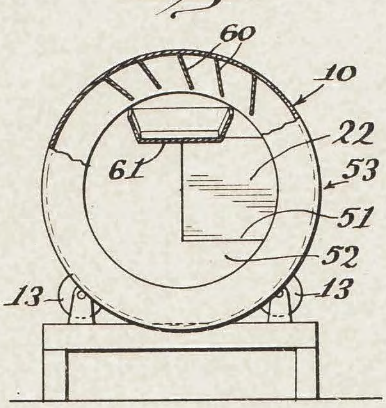


Fig. 5.

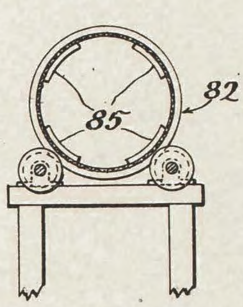
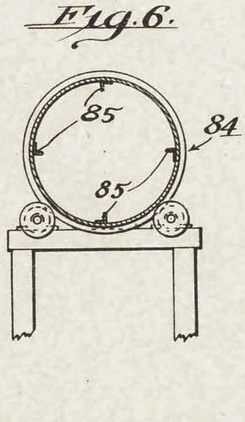


Fig. 6.



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METAL RECOVERING APPARATUS

Filed Aug. 23, 1929 3 Sheets-Sheet 3

Fig. 7.

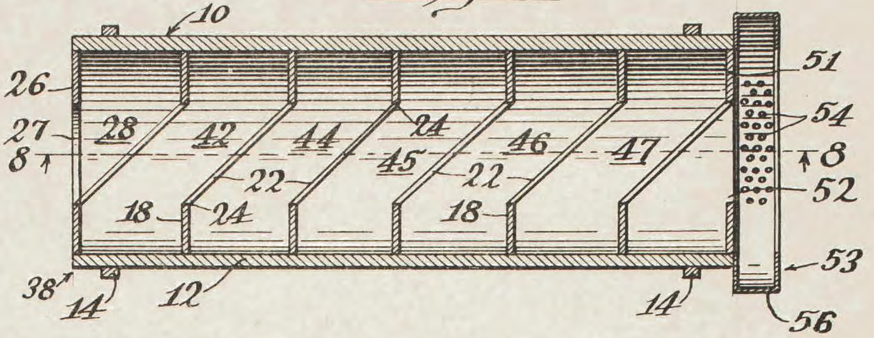


Fig. 8.

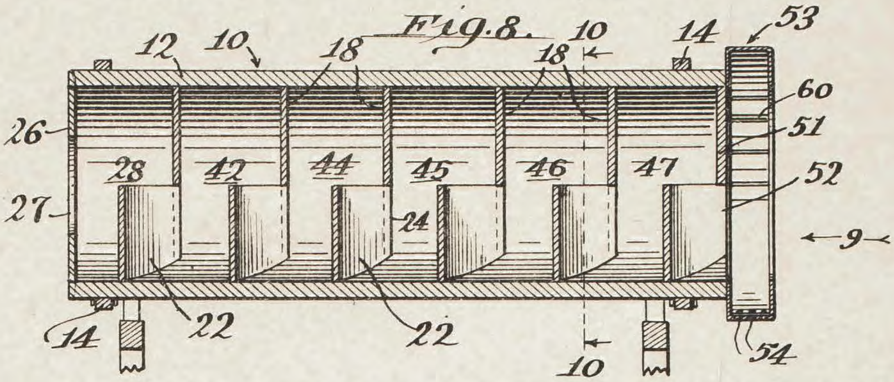


Fig. 9.

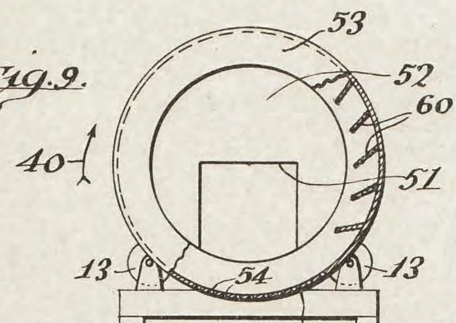


Fig. 10.

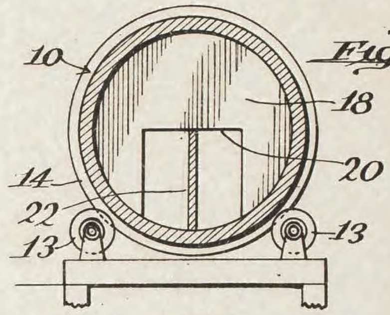


Fig. 11.

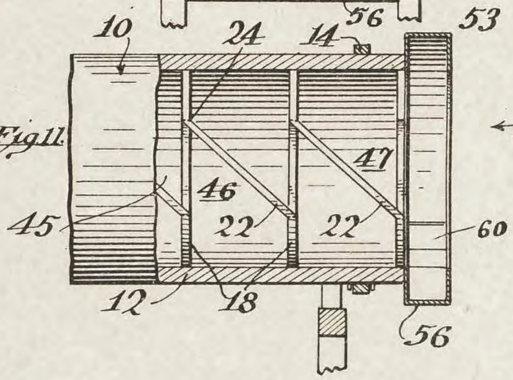
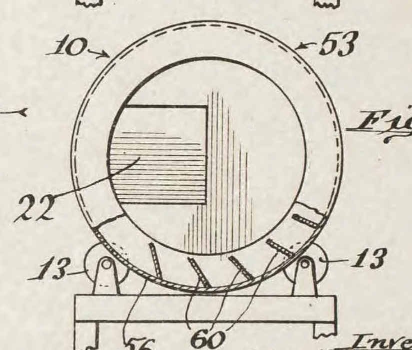


Fig. 12.



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Attorneys

UNITED STATES PATENT OFFICE

CLAUDE E. BOWERS, OF LOS ANGELES, CALIFORNIA

METAL RECOVERING APPARATUS

Application filed August 23, 1929. Serial No. 387,962.

Metallic values estimated at thousands of tons are lost annually in galvanized iron scrap resulting from the punching or shearing operations during the manufacture of articles made from galvanized sheet iron as such scrap has no commercial value due to the coating of zinc thereon which renders it unfit for re-melting.

The chief object of this invention is to provide an apparatus for recovering the basic metallic values from plated scrap metal.

Another object of this invention is to provide an apparatus wherein galvanized iron scrap is first subjected to an acid solution bath to remove the zinc coating thereon, then cleansed with water to remove the acid therefrom, and finally dried by heat treatment.

Briefly stated the invention resides in an apparatus consisting of a rotatable drum having a plurality of compartments adapted to receive intermittent charges of a given amount of galvanized iron scrap and sulfuric acid solution in required proportions wherein the action of the acid upon the scrap removes the zinc coating thereon by pickling, the charge of scrap and acid solution being transferred from one compartment to another during each revolution of the drum, which is rotated one revolution at a time at predetermined intervals in order that the acid may have sufficient contact with the scrap to remove the coating thereon before it is discharged therefrom.

The scrap and solution are discharged from the drum and separated, the acid going to waste or to an apparatus adapted to recover the zinc values therein. The scrap is discharged from the drum into a rotating barrel wherein it is cleansed with water to remove the acid therefrom, and is discharged from the washing barrel into a revolving screen or trommel wherein the scrap is partly dried. As the scrap is discharged from the barrel into the screen it is continually sprayed with fresh water which also enters and overflows from the barrel, the fresh water entering the barrel reducing the acid content of the solution caused by any acid remaining on the surface of the scrap. The scrap is then discharged from the screen into a tubular rotating drier wherein any remaining moisture thereon is evaporated by a hot air blast as the scrap passes through the drier from one end to the other from which the finished product is finally discharged.

Referring to the drawings which illustrate a practical embodiment of the invention wherein:

Fig. 1 is a top plan view of the apparatus employed in carrying out the method stated;

Fig. 2 is a side elevation of the apparatus, parts being broken away and shown in section;

Fig. 3 is an enlarged vertical section taken on line 2—2 of Fig. 1;

Fig. 4 is a sectional view taken on line 4—4 of Fig. 3 in the direction indicated by the arrows;

Fig. 5 is a section taken through the drying screen on line 5—5 of Fig. 3;

Fig. 6 is a transverse sectional view of the tubular drier taken on line 6—6 of Fig. 3;

Fig. 7 is a horizontal sectional view taken through the drum;

Fig. 8 is a sectional view taken on line 8—8 of Fig. 7;

Fig. 9 is a view looking toward the discharge end of the drum as indicated by the arrow 9 of Fig. 8;

Fig. 10 is a transverse section through the drum taken on line 10—10 of Fig. 8;

Fig. 11 is a fragmentary side elevation partly in section of the drum showing the interior construction as it appears after one quarter revolution from the position shown in Figs. 7 and 10;

Fig. 12 is a fragmentary side elevation of the discharge end of the drum as indicated by arrow 12 of Fig. 11 parts being broken away and shown in section.

Referring by numerals to the accompanying drawings, the drum is designated at 10 and consists of a cylinder 12 rotatably carried by rollers 13 engaging bands 14 encircling the drum at each end thereof as indicated at 15. The cylinder 12 is constructed of wood or other acid-proof material and is provided with a plurality of disk shaped partition plates 18, each of which have a substantially square shaped opening 20 therein as best shown in Fig. 10. A plurality of diagonally disposed scrap transfer plates 22 are positioned between the partitions, each end of which join the partitions adjacent the openings 20 as indicated at 24 in Figs. 1 and 11, and serve to transfer the scrap from one compartment to the next during rotation of the drum.

The forward end of the drum is provided with a closure plate 26 having a circular opening 27 therein through which a charge made up of a quantity of scrap —S— and sulfuric acid solution —A— is introduced into the first compartment of the drum as designated at 28. When feeding a charge of scrap into the drum, the drum remains stationary with the diagonal transfer plates in the position shown in Fig. 2, and when in this position the scrap or solution cannot run from one compartment to another due to the openings in the partition being above the level of the solution in the drum.

The charge remains in the first compartment until the drum is given another revolution which is accomplished by shifting a clutch 30 on a line shaft 31 by a lever 32 which transmits power from the shaft to the drum by a belt 34 passing over a pulley 35 on the line shaft 31 and a pulley 36 on the shaft 37 upon which a pair of the rollers 13 are mounted.

The drum is rotated to the left when facing the forward end 38 of the drum or in the direction indicated by the arrow 40 when facing the rear or discharge end as shown in Fig. 9. Normally the clutch is disengaged and the drum remains stationary for a predetermined interval after a charge is introduced into the first compartment, the drum is then given a single revolution by shifting the clutch 30.

During rotation of the drum the solution will pass from the first compartment 28 into the next or second compartment 42 when the transfer plates reach the position shown in Figs. 7 and 8, (but cannot enter the third compartment 44 due to the position of the transfer plate at this time), and during the remainder of the revolution the scrap resting on the bottom of the drum in the first compartment will collect on the transfer plate which, due to its inclined position, will discharge the scrap therein into the second compartment when the plates reach the position shown in Figs. 11 and 12. Another charge is then fed into the first compartment and the above operations repeated the action of which carries the charge introduced into the first compartment 28 through each of the succeeding compartments designated at 44, 45, 46, and 47 at each revolution of the drum.

From the foregoing it will be seen that by introducing a charge at each revolution of the drum all of the compartments will eventually be filled, and that a charge placed in the first compartment will pass through each of the succeeding compartments during which time the acid will remove the metal coating from the scrap, the intervals between each revolution of the drum being governed by the number of compartments employed, for example it requires about thirty minutes contact with a twelve percent (12%) acid solution to remove the zinc from one hundred fifty (150) pounds scrap, hence with a drum having six compartments a lapse of six minutes is allowed between each rotation of the drum.

Thus it will be seen that by providing a drum with a greater number of compartments the period between revolutions may be reduced, for instance with a drum having twelve compartments the interval between revolutions may be reduced to one half.

Each charge of treated scrap is discharged from the drum into a rotating washing barrel designated at 50, however before the charge enters the washing barrel the solution is separated from the scrap in the following manner:

When the transfer plates reach the position shown in Figs. 7 and 8 the solution in the last compartment 47 will flow through the opening 51 in the end plate 52, into an annular trough 53 secured to the end of the drum, at which time the solution will drain through a plurality of openings 54 formed in the side wall 56 of the trough into a launder 58 which carries the solution to waste or to a treatment plant adapted to recover the zinc values in the solution.

As the drum continues to rotate the scrap will collect on the transfer plate in the last compartment which will discharge it into the trough between a plurality of baffle plates 60 which serve to carry the scrap upwardly, and when the baffle plates reach the position shown in Figs. 3 and 4 the scrap will drop into a chute 61 which carries it into the barrel.

The washing barrel 50 is of cylindrical shape and is partially filled with water and is provided with a plurality of baffle plates 65 which agitates the scrap as the barrel rotates, a portion of the scrap being continually discharged into an opening 66 formed in a conical screen 67 mounted in an extension 67 projecting from the end wall of the barrel.

The screen serves to separate or drain the water from the scrap which is continuously sprayed with fresh water issuing from a perforated pipe 70 extending into the screen, the fresh water passing through the screen and overflowing from the opposite end of the drum through an opening 72, thereby preventing the water in the barrel from becoming charged to any appreciable extent with acid as it is removed from the scrap.

Rotation of the washing barrel is accomplished by rollers 74 which engage a circular track on each end thereof, the rollers being driven by a belt 75 passing over pulleys 76 and 77 respectively on the line shaft 31 and on a shaft 78 to which the rollers are secured.

The washed scrap is discharged from the screen through chute 80 into a revolving screen or trommel 82 which serves to eliminate water remaining on the scrap as it passes therethrough, and is discharged from the screen through a chute 83 into a tubular rotating drier 84 which serves to remove any moisture remaining on the scrap.

The drier is of considerable length and is provided with a plurality of baffle plates 85 which extend throughout the length thereof, the scrap being dried as it passes through the drier by a hot air blast induced by a burner 85.

Rotation of the screen 82 and drier 84 is accomplished by pulleys 86 and 87 on the line shaft 31 and pulleys 89 and 90 on shafts having rollers engaging tracks on the screen and drier respectively, power being transmitted from the shaft 31 to the pulley by belts 91 and 92. The line shaft may be rotated by a motor 94 through a belt 95 passing over pulleys on shaft and motor.

From the construction it will be seen that charges of scrap fed into the drum 10 will pass successively through the drum, washing barrel 50, screen 82, and finally through the drier during which time all of the zinc coating thereon will have been removed from the scrap.

Although the apparatus above described is particularly adapted to remove coating from scrap resulting from punching of galvanized sheet iron in which an acid solution is employed to remove the zinc coating on the metal base, it will be readily understood that the apparatus may be employed in removing other coatings from materials of different character by employing a suitable solvent.

I claim:

1. An apparatus for removing coatings from scrap metal comprising a drum rotatably mounted, a plurality of partition plates in said drum having openings therein forming a plurality of compartments, a diagonally disposed plate in each compartment joining said partition plates, a closure plate having an opening therein through which a charge of scrap and a solvent is introduced into the first compartment of said drum, said drum adapted to be rotated one revolution at a time at predetermined intervals, a charge being introduced into the first compartment of said drum at the completion of each revolution, said diagonally disposed plates adapted to transfer the scrap from one compartment to the next through the openings in the partition plates during each revolution of said drum, whereby a charge introduced in the first compartment will pass successively through each compartment and be discharged from the last compartment, an annular trough secured to the discharge end of said drum adapted to receive charges of scrap discharged from the last compartment of said drum, said annular trough having a perforated portion through which the solvent is drained from the scrap, and a plurality of baffle plates in said annular trough adapted to elevate the scrap to a position for discharging it from the drum at each revolution.

2. An apparatus for removing coatings from scrap metal comprising a drum rotatably mounted, a plurality of partition plates in said drum having openings therein forming a plurality of compartments, baffle plates in each compartment joining the said partition plates, a closure plate having an opening therein through which a charge of scrap and a solvent is introduced into the first compartment of said drum, said drum adapted to be rotated at predetermined intervals, a charge of scrap being introduced into the first compartment of said drum at the completion of each revolution, said baffle plates adapted to transfer the scrap from one compartment to the next through the openings in the partition plates during each revolution of the drum, whereby a charge introduced into the first compartment will pass successively through each compartment and be discharged from the last compartment, an annular trough secured to the discharge end of said drum adapted to receive charges of scrap discharged from the last compartment of said drum, said annular trough having a perforated portion through which the solvent is drained from the scrap, and means in said annular trough adapted to elevate scrap to a position for discharging it from the drum at each revolution.

3. An apparatus for removing coatings from scrap metal comprising a drum rotatably mounted, a plurality of partition plates in said drum having openings therein forming a plurality of compartments, scrap transfer plates in each compartment joining the said partition plates, a closure plate having an opening therein through which a charge of scrap and a solvent is introduced into the first compartment of said drum, said drum adapted to be rotated at predetermined intervals, a charge of scrap being introduced into the first compartment of said drum at the completion of each revolution, said transfer plates adapted to transfer the scrap from one compartment to the next through the openings in the partition plates during each revolution of the drum, whereby a charge introduced into the first compartment will pass successively through each compartment and be discharged from the last compartment, and means at the discharge end of said drum adapted to elevate

scrap to a position for discharging it from said drum at each revolution.

4. An apparatus for removing coatings from scrap metal comprising a drum rotatably mounted, a plurality of partition plates in said drum having openings therein forming a plurality of compartments, means in each of said compartments for transferring the scrap from one compartment to the next through the openings in the partition plates during each revolution of the drum, a closure plate having an opening therein through which a charge of scrap and a solvent is introduced into the first compartment of said drum, said drum adapted to be rotated at predetermined intervals, a charge of scrap being introduced into the first compartment of said drum at the completion of each revolution, and means at the discharge end of said drum adapted to elevate scrap to a position for discharging it from said drum at each revolution.

5. An apparatus for removing coatings from scrap metal comprising a drum rotatably mounted, a plurality of partition plates in said drum having openings therein forming a plurality of compartments, means in each of said compartments for transferring the scrap from one compartment to the next through the openings in the partition plates during each revolution of the drum, a closure plate having an opening therein through which a charge of scrap and a solvent is introduced into the first compartment of said drum, said drum adapted to be rotated at predetermined intervals, a charge of scrap being introduced into the first compartment of said drum at intervals during its revolution, and means at the discharge end of said drum for draining the surplus solvent from the scrap and elevating the same to a discharge position during a revolution of the drum.

In testimony whereof I affix my signature.

CLAUDE E. BOWERS.

O. J. SHINER, DEC'D.

M. E. SHINER, ADMINISTRATRIX.

APPARATUS FOR PURIFYING OIL.

APPLICATION FILED MAY 1, 1913.

1,203,419. Patented Oct. 31, 1916.

3 SHEETS—SHEET 1.

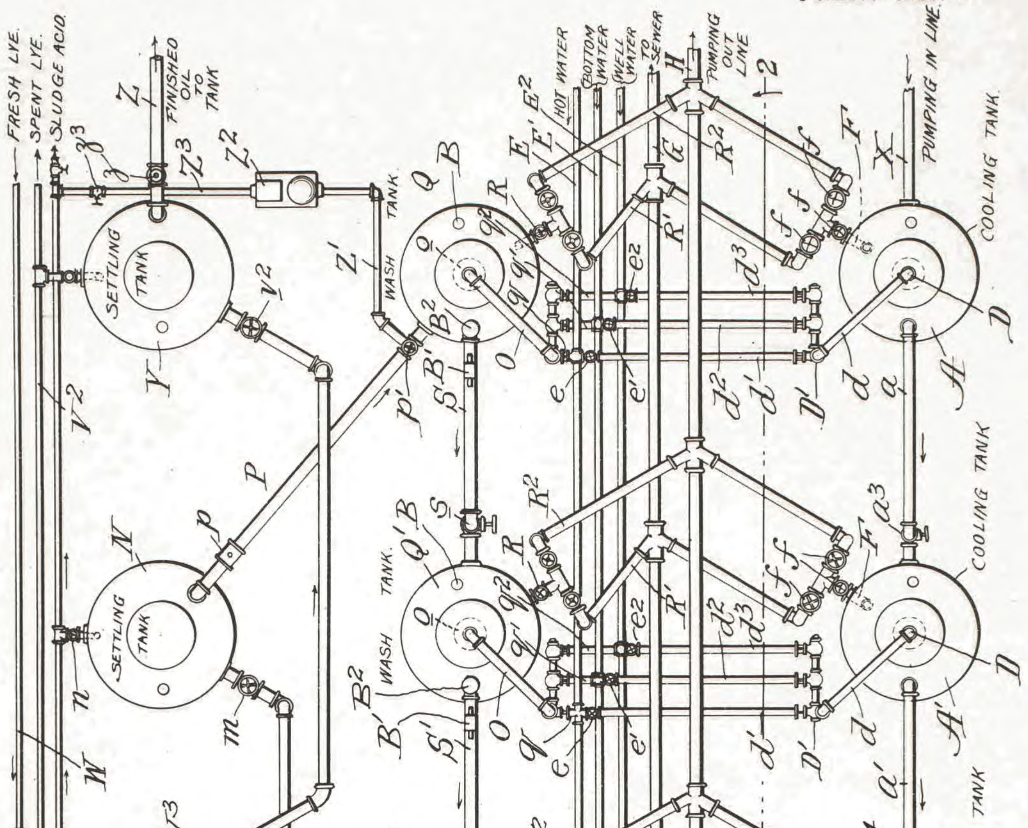

Fig. 1.

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Estate of Oliver J. Shiner.
By her Attorneys:
Baldwin & Wight

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M. E. SHINER, ADMINISTRATRIX.
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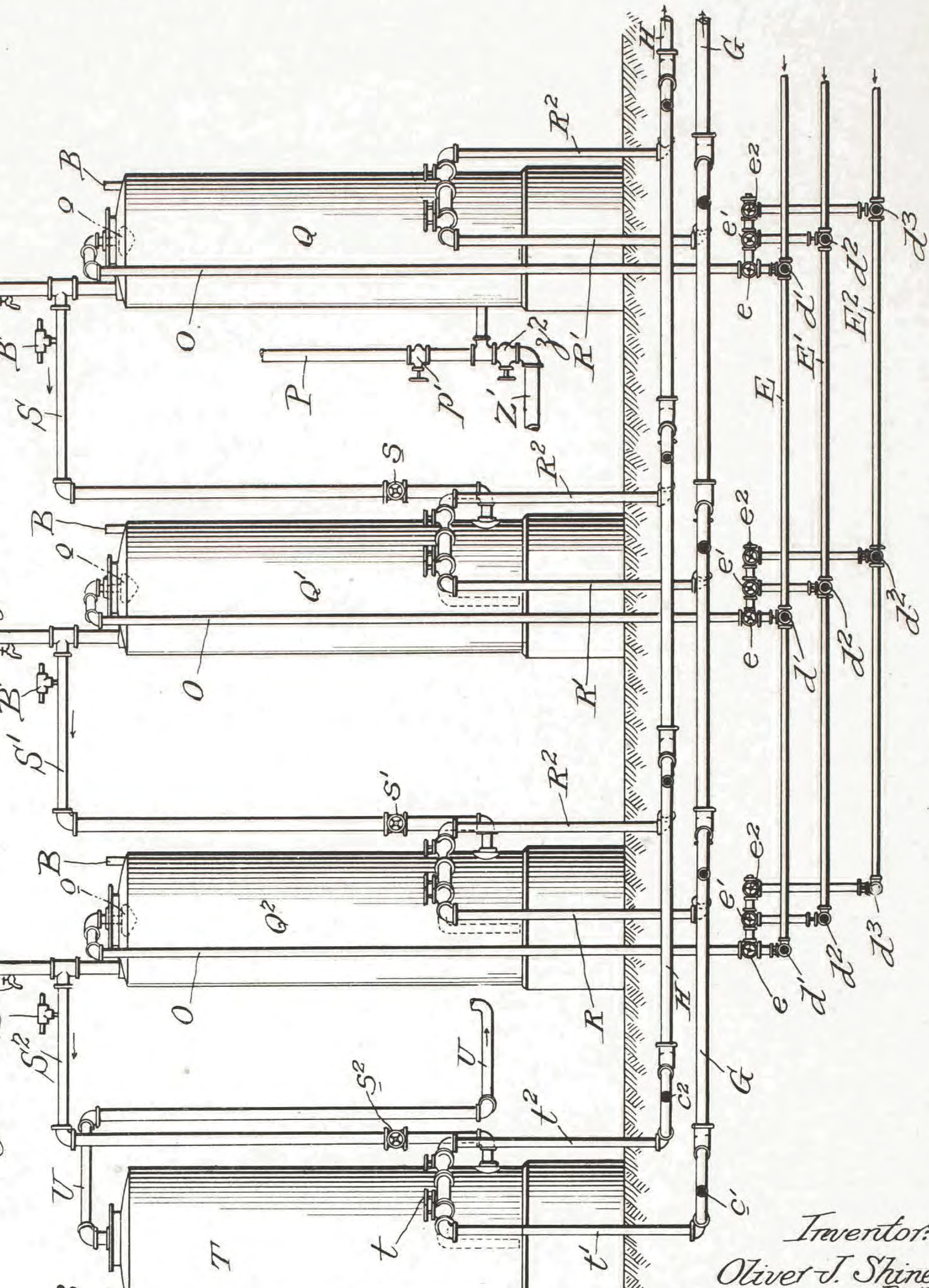
3 SHEETS—SHEET 2.

Fig. 2.



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By her Attorneys:
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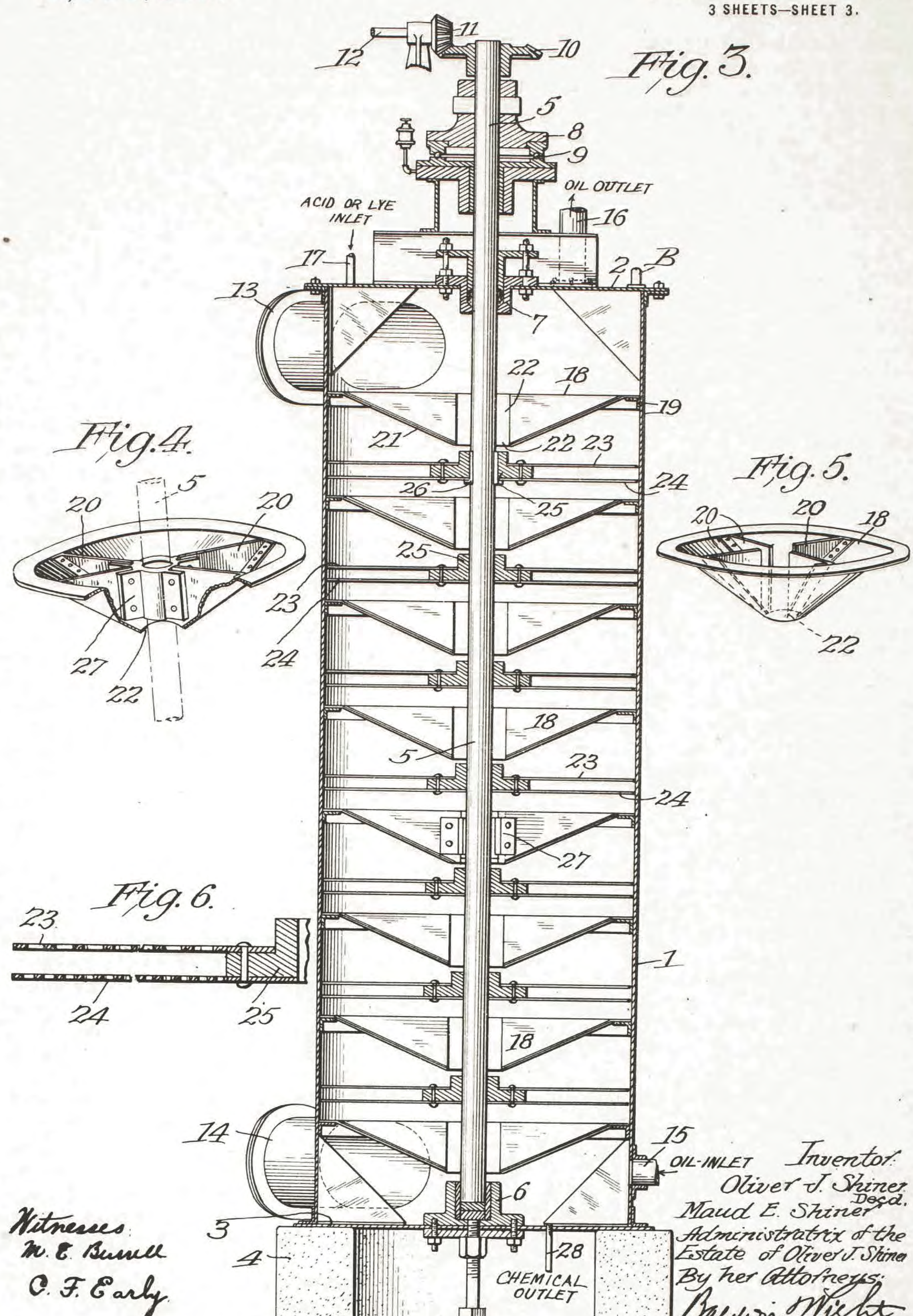
3 SHEETS—SHEET 3.



Witnesses
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C. F. Early

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Oliver J. Shiner Dec'd.
Maud E. Shiner
Administratrix of the Estate of Oliver J. Shiner
By her Attorneys.
Baldwin Wight

UNITED STATES PATENT OFFICE.

OLIVER J. SHINER, DECEASED, LATE OF BAYONNE, NEW JERSEY, BY MAUD E. SHINER, ADMINISTRATRIX, OF BAYONNE, NEW JERSEY, ASSIGNOR OF TWENTY-FIVE ONE-HUNDREDTHS TO THOMAS A. MURPHY, OF BAYONNE, NEW JERSEY, AND FORTY-NINE ONE-HUNDREDTHS TO LLOYD B. WIGHT, OF WASHINGTON, DISTRICT OF COLUMBIA, AND EDWARD C. DAVIDSON, OF ELIZABETH, NEW JERSEY; MARIE A. DAVIDSON, ADMINISTRATRIX OF SAID EDWARD C. DAVIDSON, DECEASED, ASSIGNOR TO MARIE A. DAVIDSON, INDIVIDUALLY, OF ELIZABETH, NEW JERSEY.

APPARATUS FOR PURIFYING OIL.

1,203,419. Specification of Letters Patent. **Patented Oct. 31, 1916.**

Application filed May 1, 1913. Serial No. 764,970.

To all whom it may concern:

Be it known that OLIVER J. SHINER, late a citizen of the United States, residing in Bayonne, in the county of Hudson and State of New Jersey, invented certain new and useful Improvements in Apparatus for Purifying Oil, of which the following is a specification.

This invention relates to apparatus of the kind shown in U. S. Patent No. 1,099,622, dated June 9, 1914 which shows and describes a process of and apparatus for purifying oil similar to that herein shown and described. Claims for the process and claims to some features of the apparatus are made in said patent. The claims of the application for the present patent are confined to certain details of the apparatus which will be hereinafter specified.

In the accompanying drawings illustrating the invention, Figure 1 is a diagram of the apparatus for purifying oils constructed in accordance with this invention. Fig. 2 shows a section on the line 2—2 of Fig. 1 and illustrates the washing tanks and some of their pipe connections. Fig. 3 shows a vertical central section through one of the mixers forming part of the apparatus. Figs. 4, 5, and 6 are detail views of parts of the mixer.

The apparatus employed preferably comprises twelve tanks,—three tanks in which the oil is cooled or heated to bring it to the required temperature, three tanks for washing purposes, four settling tanks, and two mixing tanks. The cooling or heating tanks A, A′, A^2 are arranged in series, as shown, oil being pumped into the bottom of tank A at X, filling this tank and flowing from the top of the tank through the pipe *a* to the bottom of tank A′ in which tank it rises, overflows through the pipe *a′* and enters the bottom of tank A^2 which tank it fills and overflows at the top through the pipe a^2 and enters the bottom of the settling tank C. The pipes *a*, *a′*, and a^2 are provided with valves a^3, a^4, a^5, and each tank is provided with a water-spraying device D which is connected by a pipe *d* with a manifold D′, which manifold is connected by pipes *d′*, d^2, d^3 with the hot water supply pipe E, the supply pipe E′ for bottom water and the supply pipe E^2 for well water. The bottom water referred to comes from the bottom of the tanks A, A′, A^2 and is stored in a suitable receptacle and afterward brought in by pipes, as indicated in Fig. 1, and may be used for modifying the temperature of the oil in said tanks. This bottom water is supplied at a temperature of about 62° F. Each of the pipes *d*, *d′*, d^2 is provided with suitable valves *e*, *e′*, e^2. By operating these valves the spraying device D may be supplied with hot water, bottom water or well water, or a mixture of these waters, as may be required for the purpose of obtaining the desired temperature in the oil. Each of the tanks A, A′, A^2 is in like manner connected with the pipes E, E′, E^2 and each of said tanks A, A′, A^2 is provided with a drain pipe F in the bottom for carrying off water and delivering it to a sewer pipe G. Said pipe F is also connected with a pumping-out line H. The drain pipe F is connected with said pipes G and H in the manner clearly indicated in the drawings, valves *f* being employed to control the flow of liquid to either the pipe G or the pipe H. Each of the tanks A, A′, A^2 is in like manner connected with the pipes G and H. The oil continuously flows from the pipe X to and through the several tanks A, A′, A^2 where it acquires the desired temperature and it then passes to the settling tank C where any water that may still cling to the oil descends or is held at the bottom while the oil rises and passes out at the top through a pipe I which leads to a mixing tank J, the details of construction of which are shown in Figs. 3, 4, 5, and 6, and will be hereinafter more fully described. The pipe I is provided with valves *i*, *i′*, as shown. The number and sizes of the cooling or heating tanks and the number and sizes of the settling tanks employed may vary at different seasons of the year or in the treatment of different oils, naphtha, etc. It will be understood that water of the proper temperature is supplied continuously through the spraying devices D and it comes in contact with the continuously flowing oil, the water being heavier descends and passes the constantly rising oil. In the summer time the temperature of the oil entering the cooling tanks is usually about 85° F. By treating the oil in the several cooling tanks with water at a temperature of say 60° F. the oil may have its temperature gradually reduced to about 60° F. The temperature of the oil varies at different times and under different conditions and the temperature of the water should be correspondingly varied in order to bring the oil to a temperature of about 60° F. before it is subjected to the acid treatment.

The cooling tanks A, A′, A^2 and the settling tank C are all closed air-tight and are joined by air-tight connections. The water admitted to the cooling tanks and which descends to the bottom thereof flows continuously to the sewer, the flow being regulated by suitable valves. The water settling in the tank C is drawn therefrom and passed to the sewer as often as required, gages being employed to show the water level. It will be understood that the pumping-out line H is for the purpose of emptying the tanks throughout the system of oil when repairs are necessary and for other like purposes, and normally this pumping-out line H is not in use, but is only employed occasionally.

Fresh acid preferably 66° Baumé from a suitable pump or other device for supplying acid under pressure is conveyed by a pipe K to the top of the mixer J and is mixed with oil in the manner hereinafter described. The acid passes downwardly through the oil and is drawn off as often as required through a pipe L provided with a valve *l* and it is conveyed as sludge-acid to any suitable receptacle. The oil which rises to the top of the mixer passes by means of a pipe M provided with a valve *m* to the bottom of a settling tank N where it is separated from any acid which may cling to it, said acid settling to the bottom and being drawn off when required through a valved pipe *n* and passed to the pipe L which conveys it to any suitable receptacle for sludge-acid. The oil which continually rises in the tank N passes out through the top thereof through a pipe P provided with a check valve *p* and it enters the lower portion of a washing tank Q which is supplied with either hot water, bottom water, well water, or a mixture thereof through the pipes *q*, *q′*, q^2, said supply being controlled by the valves *e*, *e′*, e^2. Each set of pipes *q*, *q′*, q^2 connects with a pipe O provided with a spraying device *o*. The first wash tank Q should be lead lined because the oil has commingled with it some weak acid which would attack an iron tank, and furthermore the oil is cooled or maintained at a relatively low temperature in the tank Q for a similar purpose, *i. e.*, so that the metal tank shall not be attacked by the weak acid in the said tank. There are two other wash tanks Q′, Q^2, which are supplied with water from the pipes E, E′, E^2 in a similar way and each of said tanks Q, Q′, Q^2 is provided with a discharge pipe R connected by pipes R′, R^2 with the pipe G which leads to the sewer or to the pipe H through which oil may be pumped when emptying the system. The water supplied to the tanks Q, Q′, Q^2 in the normal operation of the apparatus passes continuously through the pipe connections described to the sewer. The flow of the water may be regulated by the valves shown.

Suitable air inlet valves are applied to the tanks where required. In Fig. 2 such valves are shown at B and the other tanks in the system may be provided with such valves. The connecting pipes may, if necessary be equipped with air inlet valves as indicated at B′ in Fig. 2. Such valves are necessary when emptying the system through the pumping-out line H, but when oil is being pumped through the tanks. such valves are, of course, closed. The tanks where required may be provided with air chambers B^2 as indicated in Fig. 2. These, as shown in Fig. 2, are connected with the pipes S, S′ and S^2. The air in the tanks and pipes when the system is being filled with oil, for the most part, passes out at the delivery end of the system, but some air lingers and such air will be forced up into air chambers, such as indicated at B^2, and the air pressure may be relieved, if necessary, from time to time, by means of air-relief cocks *b*.

The oil after being washed in the tank Q passes out from the top thereof and flows by means of the pipe S having a valve *s* to the bottom of the tank Q′ in which it rises and passes out from the top through a pipe S′ having a valve *s′* and enters the bottom of the tank Q^2 where it rises and flows out from the top through a pipe S^2 having a valve s^2 and then enters the bottom of the settling tank T. It will be understood that the oil is washed as it flows through the tanks Q, Q′, Q^2 and the temperature of the oil may be gradually raised by employing well water, bottom water, hot water, or a combination thereof, as required. Preferably the temperature of the water admitted to the first tank Q is 64° F.; that admitted to the second tank Q is 75° F., and that admitted to the third tank Q^2 is 85° F. In this way the oil is raised to the temperature best fitted for the alkali treatment. In the settling tank T the oil is separated from any water which may pass over from the wash tanks with it, such water collecting at the bottom and being drawn off to the sewer pipe G as often as required. The tank T is connected by means of the valved pipes t, t', t^2 with the pipes G and H, and when the system is being emptied the valves may be so operated as to connect the tank T with the pumping-out line H. In this connection it will be observed that the settling tank C is provided with valved pipes c, c', c^2 connecting with the sewer pipe G and the pumping-out line H.

The oil separated from the wash-water flows out from the top of the settling tank T through a pipe U having valves u, u' and enters the bottom of another mixing tank V similar to the tank J hereinbefore referred to. Fresh lye preferably 9° Baumé is supplied under pressure through the pipe W to the top of the tank V and flows down through said tank meeting the oil rising therein and being thoroughly mixed with said oil in the manner hereinafter described. The bottom of the tank V is connected by a pipe V′ having a valve v' with a pipe V^2 through which the spent lye flows continuously during the normal operation of the apparatus, the flow being regulated by the valve v'. The oil passes out through the top of the tank V through a pipe V^3 having a valve v^2 and enters the bottom of the settling tank Y which tank is also connected to the pipe V^2 through which spent lye is delivered as often as required. The purified or finished oil passes from the top of the tank Y through a pipe Z having a valve z to any suitable receptacle. Where naphtha is being treated it is not necessary to further treat it with clay in the manner hereinbefore referred to, but the naphtha when it issues from the pipe Z is ready for final distillation and is then ready for the market. If kerosene is being purified, a further treatment with clay is necessary.

As before specified, all of the twelve tanks are closed air-tight and are supplied with suitable gages, vacuum valves, etc. The check valve p is for the purpose of preventing water from passing from the tank Q to the settling tank N in case of accident, as where the supply of water or the pressure of water may exceed the pressure of oil, this valve p permits the oil to flow freely, as indicated by the arrow in Fig. 1, but it will close if the liquid tends to flow in the opposite direction.

The pipe P, as indicated in Fig. 2, is provided with a valve p' and this pipe connects with a pipe Z′, as indicated in Fig. 2. This pipe Z′ also connects with a pump Z^2 which latter is connected by a pipe Z^3 with the pipe L. The pipe Z^3 is provided with a valve z^3 as indicated in Fig. 1. The pipe L, it will be observed, connects with the tanks J and N so that by closing the valve p' the flow of oil to the wash tank Q may be stopped and the acid-water in the tank Q may be transferred to the pipe L or oil from the mixer J and tank N may be transferred to and put through the tank Q by means of the pump Z^2. In this way the acid may be washed out of the oil and this oil may be pumped out and transferred to a suitable receptacle when emptying the system. When it is desired to stop the operation and entirely empty the pipes, the water and chemicals are first withdrawn from the tanks in the manner before described and then the pumping-out line H is connected by means of the valves, before referred to, with the tanks and said tanks may be emptied of the oil which they contain, the vacuum valves, before referred to, assisting in the emptying of the tanks in a well known way.

The fact that this process may be carried on continuously is largely due to the use of mixers for bringing the acid and oil and the alkali and oil into intimate contact with each other and in a sub-divided or atomized condition. It is largely for this reason that the periods of settling heretofore necessary are avoided.

The mixing apparatus, which is preferably employed, and which in practice has been found to be most efficient is illustrated particularly in Fig. 3 of the drawings to which reference is now invited. This mixing apparatus comprises a cylinder 1 standing vertically, closed at opposite ends by heads 2, 3, and resting on any suitable foundation 4. Centrally arranged within the cylinder is a vertical shaft 5 resting in bearings 6 at its lower end and passing through a stuffing box 7 carried by the upper head 2. The shaft 5 also passes through a shaft mounting 8 which may be provided with ball-bearings 9 and at its upper end the shaft carries a beveled pinion 10 meshing with a corresponding pinion 11 on a driving shaft 12. The cylinder 1 is provided with man-holes 13 and 14 and it is equipped in its side near its lower end with an inlet 15 for oil and at the top with an outlet 16 for oil. It is also provided with an inlet 17 at the top for acid or lye. Otherwise the container may be of any suitable construction. Within the cylinder 1 is arranged a vertical series of pans 18. These have a general conical shape being of the general construction shown in Figs. 4 and 5. Each of the pans 18 is secured at its periphery 19 to the side wall of the cylinder 1 in any suitable way and it is divided preferably into four pockets by means of radial partitions 20. The pan is open at the top and has a sloping bottom 21 provided with a central opening 22 surrounding the shaft 5. The pans 18 are spaced apart, as shown, and between each two pans are arranged perforated plates 23, 24. Each pair of plates is attached to a hub 25 secured to and revolving with the shaft 5. One means of securing the hub 25 to the shaft is indicated at 26. These plates, which are circular and correspond in form with the interior diameter of the cylinder 1, extend close to the walls of the cylinder without touching it, being free to revolve within the cylinder. The upper plate 23 of each pair of plates is perforated preferably with ¼ inch holes preferably spaced one inch between centers and the bottom plate 24 of each pair is preferably perforated with ⅛ inch holes preferably spaced ½ inch between centers. All of the plates are similarly constructed and are arranged as clearly shown in Fig. 3 of the drawings.

In order to provide a bearing for the shaft 5, about midway between the upper and lower ends of the cylinder 1, one of the pans is provided with a hub 27 which is attached to the partitions 20 in the manner shown in Fig. 4. This provides means for steadying the shaft 5 and is desirable inasmuch as the mixer may be of considerable height. The oil, which enters at 15, passes up through the openings 22 of the several pans 18 while the acid or lye, which enters at 17, descends through the oil to the bottom of the mixer and flows out at 28. The oil passes up through the openings 22 in the pans 18 and then up through the perforated plates. The acid or lye first enters the uppermost pan 18, passes down through the opening 22 of this pan and is received by the uppermost pair of plates 23, 24. Each pan serves to carry the chemicals into the center of the mixer and drop them down onto the revolving plates which throw them out by centrifugal force toward the shell of the mixer, and the oil, naphtha or other liquid being treated passes up through the center of the pan while the chemicals are passing down through said openings and are at this time being mixed.

This apparatus insures an intimate mixture of the chemicals with the oil, the particles being thoroughly atomized and for this reason the flow of oil through the mixer may be made continuous. It is largely due to the use of mixers of the kind described that the process may be performed continuously.

It will be observed that the tanks are all closed air-tight so that danger from fire is reduced to a minimum. The easily volatile gases are saved, whereas in the old method many of these gases were lost because the agitators employed were not closed air-tight. Furthermore by this continuous method there is a large saving of acid because when the oil and acid are passing through the mixer there is a thorough mixing of the two liquids, whereas in the old system the acid does not come in contact with every particle of the oil and it is necessary to use a relatively large amount of acid to obtain the desired results.

A process and apparatus have been described especially intended for use in treating oils, but other liquids, such as naphtha, may be treated in the same way. So much of an oil treating system as is necessary to give a clear understanding of the present invention has been described and shown. It is to be understood that some of the parts of the apparatus are of well known construction and need no specific illustration or description.

What is herein claimed as the invention of the said Oliver J. Shiner, is,

1. In an apparatus for purifying oil the combination of a mixer in which the oil receives an acid treatment, means for supplying acid thereto, a settling tank to which the acid-treated oil passes from the mixer, a pipe for sludge-acid having valved connections with the mixer and the settling tank, a wash tank, a pipe connecting the top of the settling tank with the bottom of the wash tank, a valve in said pipe for closing communication between the settling tank and the wash tank, a valved pipe connecting the wash tank with the sludge-acid pipe, and a pump connected with said last-mentioned pipe, the organization being such that in the normal operation of the apparatus acid-treated oil may pass from the settling tank to the wash tank but by closing the valve between the settling tank and the wash tank and opening communication between the wash tank and the sludge-acid pipe oil may be drawn from the mixer and the settling tank into said wash tank or the acid water in the wash tank may be transferred to the sludge-acid pipe.

2. In an apparatus for purifying oil the combination of a series of closed tanks for chemically treating the oil and for washing it, pipes connecting the several tanks for conveying oil continuously through them, means for supplying purifying agents to some of the tanks, air inlet valves applied to the top of said tanks, and a pumping-out line connected with the tanks for opening the valves and emptying the tanks of oil.

3. In an apparatus for purifying oil the combination of a series of tanks in which the oil is washed and chemically treated, pipes connecting said tanks in series for conveying oil continuously through them, means for supplying water to some of the tanks to wash the oil, means for supplying chemicals

to other tanks in the series, pipes for drawing off water from the bottom of the wash tanks, pipes for drawing off chemicals from the bottoms of other tanks in the series, air inlet valves on the tanks, and a pumping-out line connected with the tanks for emptying them of oil after the water and chemicals have been withdrawn therefrom.

In testimony whereof I have hereunto subscribed my name this 30th day of April 1913.

MAUD E. SHINER,

Administratrix of the estate of Oliver J. Shiner, deceased.

Witnesses:

JOHN F. O'NEILL,

W. J. FLANAGAN.

Correction in Letters Patent No. 1,203,419.

It is hereby certified that in Letters Patent No. 1,203,419, granted October 31, 1916, upon the application of Oliver J. Shiner, deceased, late of Bayonne, New Jersey, for an improvement in "Apparatus for Purifying Oil," an error appears requiring correction as follows: In the grant, lines 10-11, and in the heading to the printed specification, lines 5-6, for "Marie A. Davidson, Administratrix" read *Marie A. Davidson, Executrix;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 28th day of November, A. D., 1916.

[SEAL.]

F. W. H. CLAY,

Acting Commissioner of Patents.

Cl. 196—29.

June 15, 1943. A. A. LEVINE ET AL 2,321,923

APPARATUS FOR EXTRACTION

Filed April 26, 1940

Fig. 1.

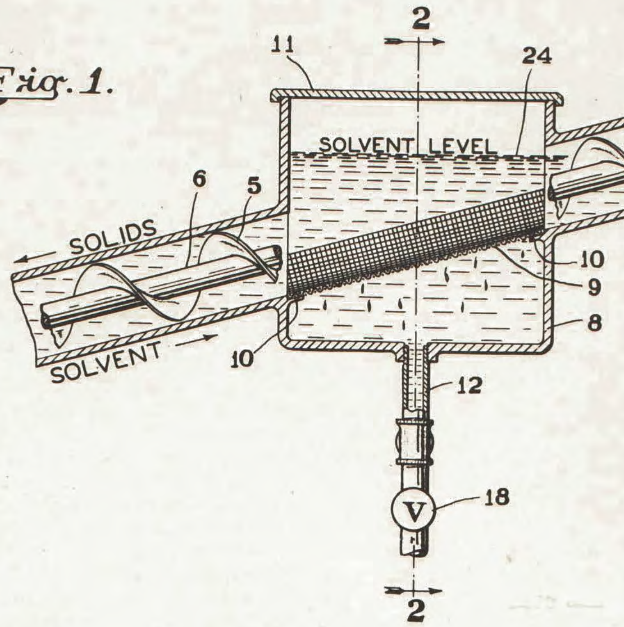
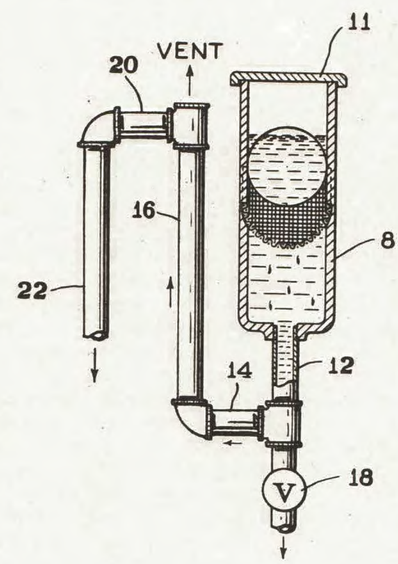


Fig. 2.



INVENTORS.
ARTHUR A. LEVINE
AND ROY J. DENT
BY E. H. O'Brien
ATTORNEY.

Patented June 15, 1943 **2,321,923**

UNITED STATES PATENT OFFICE

2,321,923

APPARATUS FOR EXTRACTION

Arthur A. Levine and Roy Jackson Dent, Niagara Falls, N. Y., assignors to E. I. du Pont de Nemours & Company, Wilmington, Del., a corporation of Delaware

Application April 26, 1940, Serial No. 331,682

1 Claim. (Cl. 23—270)

This invention relates to an apparatus particularly suitable for use in processes wherein soluble materials are extracted from solid particles, usually in the flaked or finely comminuted condition, by means of a liquid solvent such as benzene, naphtha, trichlorethylene, perchlorethylene, or other solvent. An illustration of such a process is the extraction of oleaginous matter from soy beans, ordinarily in the flaked or finely comminuted condition, by means of a chlorinated hydrocarbon solvent such as trichlorethylene.

More particularly, our invention relates to the removal of the miscella from the solid particles, from which the extractable matter has been extracted by means of a liquid solvent, in such a way that clogging of the filter screens through which the miscella is drawn off is entirely avoided.

It is customary in commercial methods for extracting soluble materials such as oils, fats and waxes from solid particles to employ extraction apparatus of the countercurrent type. In the usual form of counter-current apparatus the flaked or finely comminuted solid from which the oleaginous matter is to be extracted is caused to travel through the extraction apparatus in a direction counter-current to the direction of flow of the oncoming solvent. Usually means are provided to insure forcing the flaked or finely divided solid material through the extraction apparatus in a direction opposite to the direction in which the liquid solvent is permitted to travel through the equipment.

Counter-current extraction apparatus of a type now familiar in the extraction industry frequently utilizes two tubes or conduits joined together at their point of intersection, thus providing a continuous V-shaped conduit. The solvent is introduced at the top of one of the legs of the V, and the miscella removed somewhere adjacent the upper portion of the other leg. The solvent is generally fed into the apparatus from an elevation somewhat above that of the miscella outlet, and then flows downwardly through one tube and upwardly through the other tube to the miscella outlet. Flow against the resistance of the tubes is insured by providing an adequate head of solvent above the miscella outlet. The solid material, in the counter-current apparatus, is usually conveyed by some conveyor means in a direction opposite to that of solvent flow.

In the past considerable difficulty has been experienced in removing the miscella from the solid material remaining in the extraction apparatus. The miscella is the mixture or solution of the extracted material in the solvent which must be removed from the residual solid particles in order that it may be further treated to recover the valuable oleaginous materials contained therein. The solid particles, frequently flaked or finely divided, which are subjected to extraction in commercial processes, are often of lower specific gravity than the solvent. This is especially true where chlorinated hydrocarbon solvents such as trichlorethylene, perchlorethylene, carbon tetrachloride, tetrachlorethane, etc. are utilized. Under such circumstances there is a definite tendency for the flaked or finely comminuted solid particles to float on or adjacent the upper surface of the solvent. In the usual counter-current extraction apparatus the miscella is removed from the extraction column adjacent an upper level of the solvent, since the solid particles are ordinarily conveyed downwardly through one portion of the extraction tube while the solvent flows upwardly through this portion, counter-current to the solid, to an outlet pipe from which it is removed for treatment in order to recover dissolved oleaginous matter. In the past the fine particles floating on the upper surface of the solvent have accumulated adjacent the screen or filter through which the miscella is drawn off, and have seriously interfered with withdrawal of the miscella by clogging the screen. In present commercial operations not only is the removal of miscella seriously interfered with by clogging of the screen due to the presence in the solvent of floating solid material, but the apparatus has to be frequently disassembled, and the filtering surface or screen subjected to cleaning at frequent intervals.

It is the principal object of this invention to provide equipment for use in counter-current extraction processes which will permit the withdrawal of the miscella from the extraction apparatus without interference with the withdrawal because of filter screen clogging. In other words, it is one of our principal aims to provide equipment in which there is substantially no danger that solid particles will deposit on and clog the filter screen through which the solution of oily materials in solvent is removed from the apparatus.

Another object of our invention relates to improving the process of extracting oleaginous materials from solid particles in a counter-current extraction apparatus by insuring easy removal of the miscella from the extraction apparatus, this being accomplished by preventing interference with filtering as the result of clogging of the filter screens. By utilizing our improved apparatus, continuous removal of the miscella is insured by operating so that the solid particles floating in the extraction column do not tend to accumulate adjacent the filters.

Still other objects of our invention involve the provision of a weir or dam, or of a conduit acting as such, positioned at a higher level than the level of the filter screen or screens so that the solid particles floating on the surface of the liquid will be maintained at a level higher than that of the screen. In this way the miscella may be withdrawn without any danger of interruption due to screen clogging. Other objects of our invention will be apparent from the ensuing disclosure of certain improved embodiments thereof.

Our invention may best be described with reference to the annexed drawing which represents a preferred but not necessarily the only embodiment of our improved apparatus. Figure 1 represents a cross-sectional view of the miscella withdrawal portion of an extraction apparatus constructed in accordance with our invention, that part of the conveyor adjacent the filter being omitted for the sake of clarity. Figure 2 is a cross-sectional view, some parts being illustrated in elevation, which cross-sectional view is taken at right angles to the cross-section of Figure 1, substantially on the line 2—2 of Figure 1, the section being viewed in the direction of the arrows.

Referring more specifically to the drawing, the arrows and legends on Figure 1 illustrate the direction of travel of the solid particles from which oleaginous material is to be extracted, and the direction of flow of solvent, opposite to that of the solid materials, through the equipment. The portion of the extraction tube shown represents but part of one leg of the usual counter-current extraction apparatus comprising two sections of tube joined together at their point of intersection to form a continuous V-shaped conduit as shown, for example, in the patent to Hutchinson No. 126,300 and in that to Wheeler No. 550,035.

The solid material, which is usually in the flaked or finely comminuted condition, is forced downwardly through this section of the extraction tube by means of a conveyor, while the solvent travels upwardly through this portion of the tube. The conveyor may have the form of a screw conveyor as illustrated, or it may be of any other convenient type.

In spite of the fact that positive means are provided for conveying the solid particles through the extraction apparatus, there is a tendency for "fines" or very small fragments of the solid material to resist positive conveyance and float on the surface of the solvent. In other words, as extraction continues, there is a tendency for some of the solid particles to accumulate adjacent the upper level of the solvent. The portion of the solid material which thus escapes positive conveyance through the extraction apparatus tends to accumulate adjacent the upper level of the liquid. In past operations, where the filter screens are located adjacent the upper level of the solvent, which of course is necessarily the case where the outlet for miscella determines the level of solvent in the leg of the apparatus shown, these solid particles have deposited in and on the filter screen and have clogged that screen, thereby interrupting normal extraction operations.

The construction shown in the drawing definitely eliminates any such tendency. The numeral 4 represents the extraction tube through which the solid materials from which oleaginous matters are to be extracted are propelled in the direction indicated by the arrow by means of screw conveyor 5 rotating on shaft 6. As previously stated, the solvent flows upwardly through this section of the extraction tube 4 in a direction counter-current to that of the solid material.

The extraction apparatus is provided adjacent its upper end with outlet box 8 with removable cover 11, which surrounds extraction tube 4 and serves for the removal of miscella from the extraction tube. While this outlet box 8 is most conveniently located somewhere adjacent the upper end of the apparatus, it is of course not necessary that it be positioned adjacent an upper level, as it may be located anywhere in the extraction apparatus from which point it is desired to withdraw the miscella.

In the outlet box 8 there is positioned a screen or filter 9 which is seated on extending lips or supports 10 formed on the extraction tube 4. As shown, the filter screen has approximately half the area of the circumferential interior area of the extraction tube.

The interior of outlet box 8 communicates with conduit 12, through which the miscella is discharged. This conduit is provided with a horizontal discharge pipe 14 communicating with it, which discharge pipe 14 in turn communicates with vertical pipe 16. Discharge pipe 22 communicates with pipe 16 through the horizontal connecting pipe 20. There is provided, as shown, a vent in the upper portion of pipe 16 so that discharge of air or vapors to the atmosphere is readily accomplished. Venting is readily effected by leaving the pipe 16 uncapped at this end, open to the atmosphere.

The flow line of horizontal connecting pipe 20 establishes the level of solvent in the extraction apparatus. This pipe therefore serves as a dam or weir over which miscella must flow after having been removed from the extraction apparatus through screen or filter 9 and conduits 12, 14, and 16. It is evident that the level of the flow line of pipe 20 determines the level 24 of the liquid solvent within the extraction tube 4. The level 24 is either identical with that of the flow line or may, under some circumstances, be slightly above it, thus providing a head for the flow of miscella thru the filter.

It is evident that solid particles which tend to float on the solvent within the extraction tube will accumulate adjacent the level of the liquid indicated by the numeral 24. Since this level is above the level of the screen 9, there will be no tendency for the particles to accumulate adjacent that filter screen 9. There therefore will be no tendency whatever for solid particles to clog the filter screen 9, since all solid particles are maintained, because of the elevation of discharge pipe 20, at the level 24 of the solvent within the extraction tube, which level is considerably above the level of the filter screen.

Conduit 12 is, as shown, provided with a valve 18. When this valve is opened, liquid present within the outlet box 8 may be withdrawn from the extraction apparatus without going through conduits 16, 20 and 22. This procedure may be followed when it is desired to completely drain the apparatus.

The extraction apparatus and process herein described are not restricted in their use to methods in which a soluble material is extracted by means of a solvent, but are of general application wherever a solid is suspended in and tends to float on the surface of a liquid. Our invention might therefore be utilized for purposes entirely unrelated to solvent extraction, such as, for example, in an apparatus wherein oil or any other liquid is treated with a decolorizing agent under circumstances wherein solid particles of decolorizing agent, or other solid particles, would have a tendency to float on the surface of the oil or liquid.

It should be understood that our invention is not restricted to the precise details described as illustrative of certain improved embodiments thereof. Many changes might be made in the construction as described which would still come within the scope of our invention. Accordingly, the scope of the invention is to be construed in accordance with the appended claim and prior art.

We claim:

In a counter-current extraction apparatus for extracting a desired constituent by means of a solvent therefor from solid particles having a specific gravity less than the solvent, an inclined tube leading from and to a filtering chamber interposed in the upper end thereof, a conveyor in said tube extending through said chamber and arranged to convey the solid particles downwardly through said tube against upwardly flowing solvent, a filtering screen arranged in said chamber to form a continuation of the bottom portion of said tube, a solvent outlet conduit from said chamber below said screen, said conduit and chamber being so arranged and constructed as to provide a solvent trap, whereby the solvent level in said chamber is maintained above the filtering area of the screen.

ARTHUR A. LEVINE.
ROY JACKSON DENT.

Aug. 6, 1946. C. E. MENSING 2,405,158

MULTIPLE CONTACT COUNTER-CURRENT EXTRACTOR

Filed Jan. 16, 1945

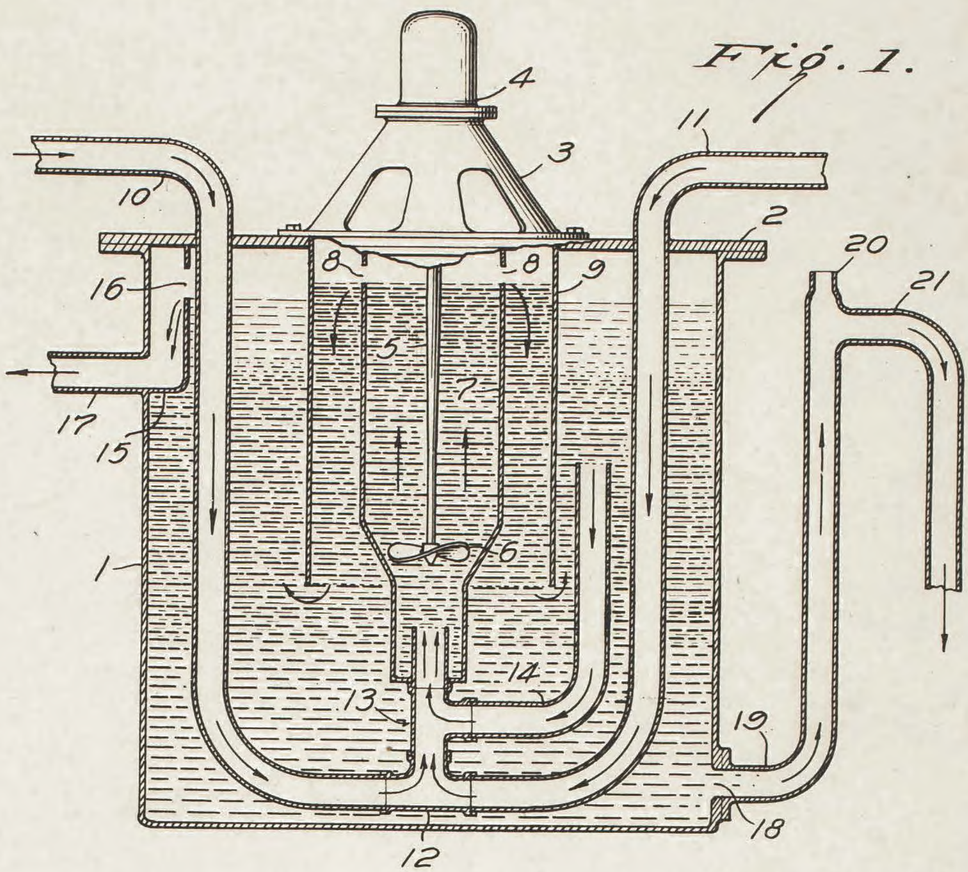


Fig. 1.

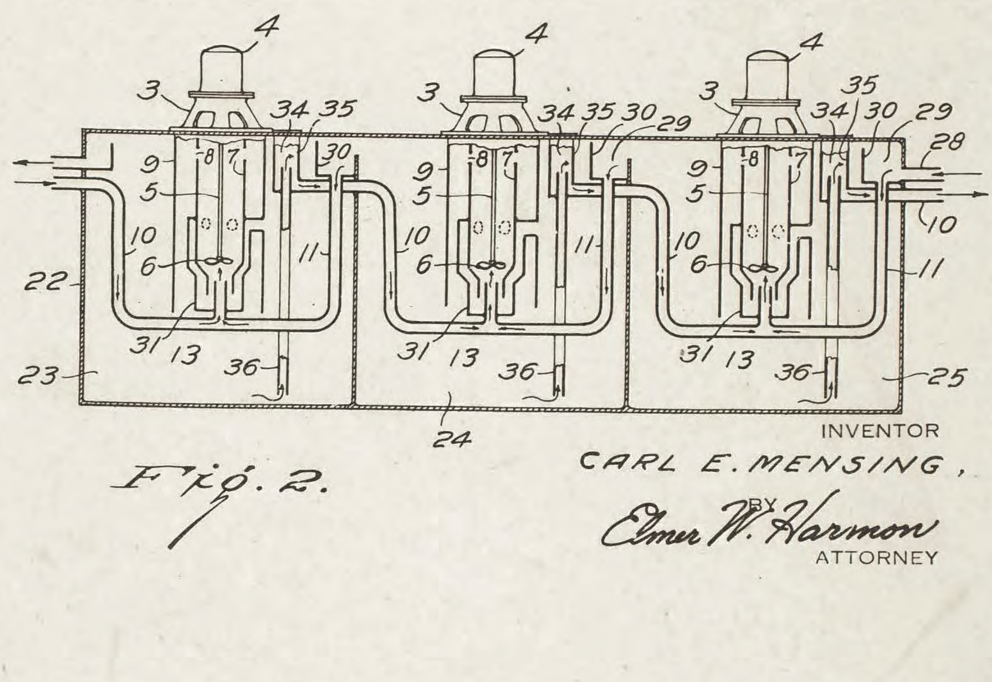


Fig. 2.

INVENTOR

CARL E. MENSING,

BY Elmer W. Harmon

ATTORNEY

Patented Aug. 6, 1946

2,405,158

UNITED STATES PATENT OFFICE

2,405,158

MULTIPLE CONTACT COUNTERCURRENT EXTRACTOR

Carl E. Mensing, Somerville, N. J., assignor to American Cyanamid Company, New York, N. Y., a corporation of Maine

Application January 16, 1945, Serial No. 573,129

2 Claims. (Cl. 23—270.5)

1

The present invention relates to a new and novel multiple-contact, countercurrent mechanical extractor. More particularly, it relates to an improved apparatus for the solvent extraction of one material from a mixture thereof, adapted to require a minimum amount of extracting solvent and to eliminate the necessity for pumps between stages.

Many different manufacturing operations advantageously make use of solvent extraction procedures. For example, chemical reactions in the production of drugs and dyestuffs are frequently carried out in organic solvents. It is usually necessary to recover and/or purify these solvents. One well-known process of so doing is that of extracting the mixture with an additional solvent which has a selective affinity for the material to be removed from the mixture but little or no affinity for the residue.

In the past, various flow schemes have been proposed for carrying out such operations. They cover a wide range. The simplest are those used with small amounts of easily-separable material in which the material to be extracted is simply agitated with the extracting solvent and allowed to separate into layers, the layers decanted and the extracting solvent removed. However, since the solvent ratio is in many cases high, if the volumes to be treated are large, excessively large volumes of selective solvent must be handled. In order to decrease the required volume of solvent, procedures of step-wise, multiple-contact, countercurrent extraction have been developed. It is with these procedures that the apparatus of the present invention is primarily concerned.

In the past, such operations have been customarily carried out by agitating the liquid to be extracted together with the solvent in one vessel, pumping the resultant emulsion into a separating chamber, allowing the emulsion to separate, and separately pumping both layers to the next stage. The solvent flows in one direction and the material to be extracted in the other through a series of such operations. Such a procedure involves an extensive arrangement of tanks and pumps. It involves a considerable power consumption, since each stage requires the operation of an agitator and several pumps. Further, large quantities of both the material being extracted and the extracting solvent are being processed which again unduly increases the required apparatus and consequently the fixed overhead. A still further disadvantage lies in the fact that in ordinary agitating operations, the maximum extracting ability of the solvent

2

cannot be utilized since there is a finite time limit in practical operation and equilibrium conditions between solvent and material to be extracted are not attained.

It is the object of the present invention to provide an extracting device which is not subject to these major difficulties. It is, therefore, a principal object to construct an apparatus in which multiple contacts between solvent and material to be extracted are carried out under conditions such that the maximum extracting power of the solvent is more nearly utilized. Another object is to construct an apparatus in which the agitating and separating operations are carried out in the same chamber. Still another, and not the least important object, is to provide an apparatus in which no pumping between stages is required when a step-wise operation is employed.

The invention will be more fully illustrated in conjunction with the accompanying drawing in which:

Figure 1 represents an elevation, partly in section, of one form of such an apparatus; and

Figure 2 shows a further modification indicating the arrangement of elements for a continuous, countercurrent, step-wise operation.

The basic apparatus, as illustrated in Figure 1, comprises a chamber 1, closed by a cover 2 having mounted thereon a standard 3 which supports a motor 4 which in turn rotates a shaft 5 which extends down into the chamber and terminates in an impellor 6. It is a feature of the present invention that the impeller 6 is arranged to deliver an upward thrust. Dependent from the cover and surrounding the shaft and impellor is a sleeve 7, shown in Figure 1 as closed at the bottom and having overflow ports 8 therein near the top. Surrounding sleeve 7 and also dependent from cover 2, is a baffle 9 closed at the top and open at the bottom. Baffle 9 does not extend quite as far down into the chamber as does sleeve 7, although this is not a limiting feature. In the drawing, sleeve 7 and baffle 9 are shown as sections of concentric cylinders. The invention, however, is obviously not so limited since they may be of other cross section.

Fluid to be extracted enters chamber 1 through a conduit 10 extending down nearly to the bottom of chamber 1 to a point directly below impellor 6. A second conduit 11 also enters the chamber, joining with conduit 10 directly under impellor 6 in a T connection 12, the third arm 13 of which extends vertically upward under impellor 6 and into the space enclosed by sleeve 7. Above the T connection 12 but below sleeve

7, conduit 13 is joined by an additional conduit 14 which extends vertically upward outside baffle 9 to a point roughly midway the height of chamber 1.

Provision is made for the removal of material from chamber 1 at two points; one near the top, and the other near the bottom. At one side of chamber 1, near the top thereof, is a small space formed by a baffle 15 having a port 16 therein to open into the main chamber. Any liquid reaching the height of port 16 will flow into the small chamber and then out of the apparatus through a conduit 17.

At another point in the side wall of chamber 1, near the bottom thereof, a port 18 connects with a conduit 19 which extends vertically upward to approximately the height of chamber 1, being provided with a vent 20 at the end thereof. Near the upper end of conduit 19 it is joined through a T connection by a conduit 21 which extends vertically downward, thus forming with conduit 19 a swing U connection which permits control of the height of the interface between fluid layers in chamber 1.

The operation of the apparatus is essentially simple. Fluid to be extracted enters through conduit 10 and extracting solvent enters through conduit 11. They mix in conduit 13 through which they enter the space enclosed by sleeve 7 and become thoroughly and intimately agitated by the action of the impellor. The latter being designed for upward thrust forces the mixture up through the sleeve, out through openings 8 into the annular space between sleeve 7 and baffle 9, down through the annular space, under the lower edge of baffle 9 and out into the main space of chamber 1. At this point, due to the action of the agitator the mixture is a very highly dispersed emulsion which forms a layer filling the vertical central portion of the chamber. This emulsion breaks and the solvent, containing the desired dissolved constituents, rises into a relatively quiescent supernatant layer which comprises the organic phase and overflows through opening 16 and out of the chamber through conduit 17.

It will be apparent that the flow capacity through the sleeve 7 and the annular space between the sleeve and baffle is potentially much larger than through the feed conduits 10 and 11. Advantage of this fact is taken to provide an important feature of the present invention, namely, the use of conduit 14 through which, as shown in Figure 1, unseparated or only partially separated emulsion is drawn in by the action of the impellor and recycled. While in Figure 1 the length of conduit is fixed, in practice it is often highly desirable to make the inlet to conduit 14 adjustable in height so that the recycled fluid if so desired may be drawn from either the separated or unseparated layers. By recycling fluid in this manner both fluids or phases are repeatedly broken up and recontacted, thus taking maximum advantage of the solvent power and conversely requiring the use of a minimum of solvent.

As shown in Figure 1, sleeve 7 is closed at the bottom, fitting tightly around conduit 13. However, this is not necessarily a limitation. In fact, where it is desired to circulate fluid from the lower part of the chamber in excess it is of advantage not to do so.

The extracted material, being the heaviest, eventually settles out of the emulsion, forming the lower layer in the chamber 1. The static

head of liquid in chamber 1 forces liquid from this lower layer out through opening 18, up through conduit 19 and down through conduit 21. By adjusting the height of the inverted U formed by the conduits 19 and 21, the height above the bottom of the chamber and therefore the volume of the organic phase, i. e. the quiescent solvent layer, may be controlled.

In Figure 2 a modification of the apparatus particularly well adapted for step-wise, continuous, multiple-contact, countercurrent treatment is shown. Although somewhat differently arranged, it will be noted that each of the elements described in connection with Figure 1 are present in the apparatus arrangement of Figure 2.

In Figure 2 it will be seen that the apparatus comprises a plurality of the extractors shown in Figure 1. For purposes of illustration, three such units are shown although it is obvious that the invention is not limited to any particular number. A large chamber 22 is seen to be divided into three subsidiary chambers 23, 24 and 25, of approximately equal size, by two dividing walls 26 and 27. Each chamber is provided with a standard 3, motor 4, shaft 5, impellor 6, sleeve 7, openings 8 and baffle 9 supported from the cover as in the case of Figure 1. Each of the chambers is provided with a conduit 10 for introducing fluid to be extracted as in the case of Figure 1. As to chamber 23, this conduit enters from outside the apparatus and in chambers 24 and 25 introduces fluid from the immediately preceding chamber.

Each of the chambers is also provided with a conduit 11 for introducing solvent thereto in a countercurrent direction to the flow of material to be extracted. It will be noted that instead of conduit 11 entering through the top of the chamber as in Figure 1, it is introduced into chamber 25 through a conduit 28 into a pocket 29 formed by a baffle 30, from which pocket the solvent is carried through a conduit down into the T connection below the impellor as in the case in Figure 1. It will be further noted that each of the chambers has a corresponding pocket 29 and baffle 30 but that the solvent flow from one chamber to the next is over the top of the dividing walls 26 and 27, which do not extend the entire height of the chambers.

In each chamber, the mixture of solvent and material to be extracted is carried by conduit 13 up into sleeve 7 beneath impellor 6 as in Figure 1. However, in order to obtain a more uniform recirculation, conduit 14 has been replaced. In each of the chambers a third concentric baffle 31 is located between sleeve 7 and baffle 9 and extending about half the height of sleeve 7. This baffle is closed at the top by an annular plate 32. Admission into the annular space between sleeve 7 and baffle 31 is by means of a plurality of short conduits 33 spaced approximately equally around the baffle.

The external inverted U formed by conduits 19 and 21 in Figure 1 in each of the chambers 23, 24 and 25 is replaced by a pocket 34 formed at the top of each chamber by a closed cylindrical baffle 35. Extracted liquid from the bottom of each chamber is forced by the action of the impellor up into pocket 34 through a conduit 36 which extends vertically from a point near the bottom of the chamber up into pocket 34. By adjusting the distance to which conduit 36 extends up into pocket 34 it is possible to control the height of the fluid interface within the chamber as is done by the use of the externally-located, inverted U in Figure 1. Extracted fluid leaves pocket **34** through conduit **10**, leading to the next step in the extraction in the case of chambers **23** and **24**, or out of the apparatus in the case of chamber **25**.

I claim:

1. In an apparatus adapted to carry out countercurrent, stepwise, multiple-contact, solvent extraction: the combination of a closed chamber having a vertically-positioned impellor shaft located therein, said shaft extending downward from the cover of the chamber and terminating in an impellor adapted to produce an upward fluid thrust; a vertical sleeve surrounding said shaft and impellor, said sleeve having at least one overflow port near the top thereof; a baffle surrounding said sleeve and extending at least substantially to the top of the chamber, said baffle being open at the bottom and providing a passage vertically downward along the major portion of the length of said vertical sleeve; a plurality of converging inlet conduits joining a common conduit, said common conduit terminating within the said sleeve below said impellor; a fluid-conducting means having at least one inlet opening in the central space of the chamber outside said baffle and arranged to deliver fluid within said sleeve below said imepllor; an overflow means to the exterior of said chamber from the space outside of said baffle and outlet means from the bottom of said space, said outlet means being arranged to permit gravity flow and to retain an effective head of liquid above said impellor.

2. An apparatus according to claim 1 characterized in that the bottom of said sleeve is closed about said means for introducing mixed fluids thereinto.

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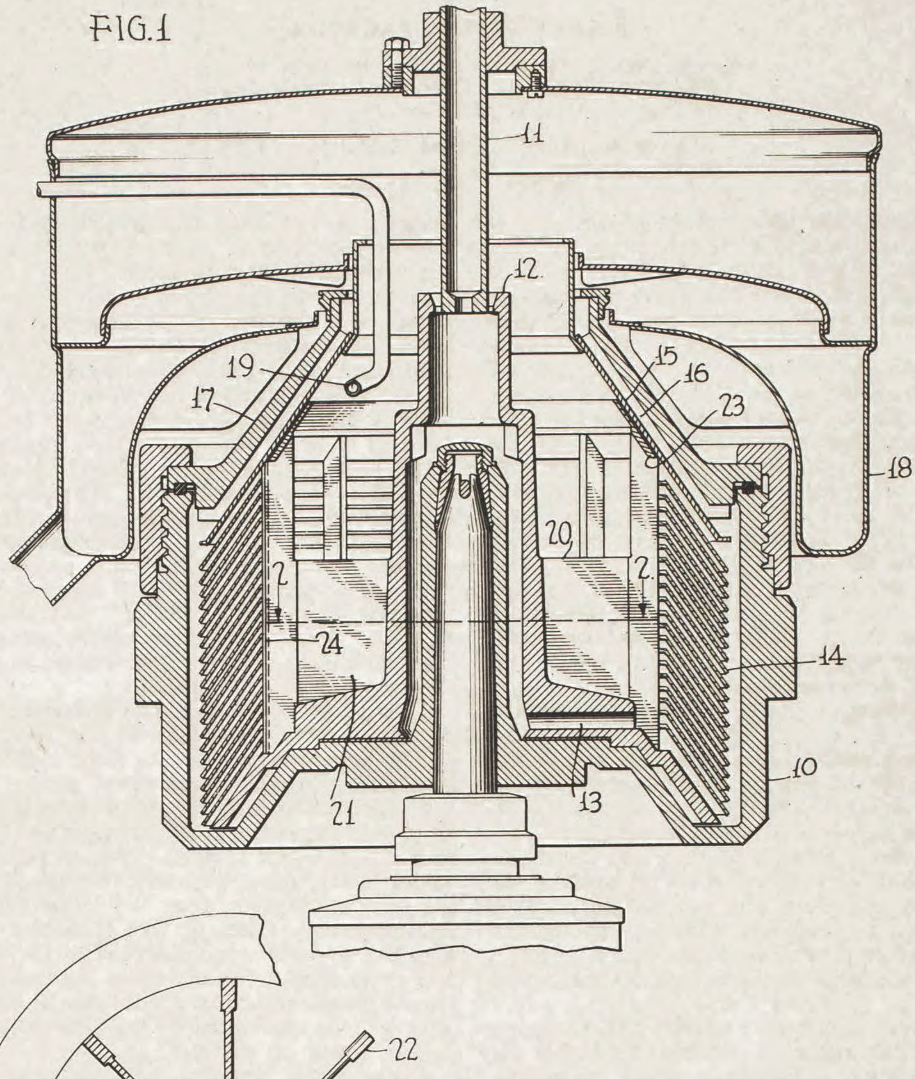
Aug. 3, 1937. L. D. JONES 2,089,123

CENTRIFUGAL SEPARATOR

Filed April 22, 1936

FIG. 1



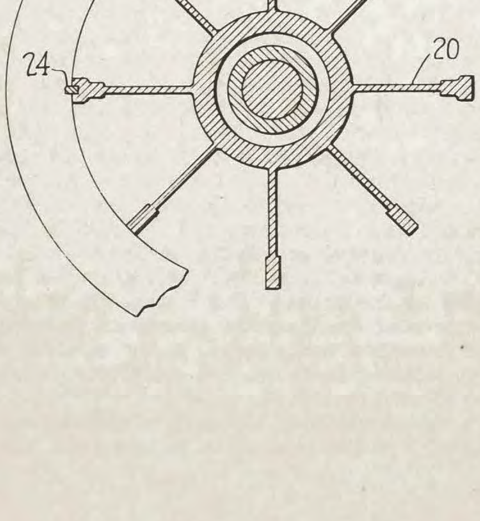


FIG. 2.

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2,089,123

CENTRIFUGAL SEPARATOR

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Application April 22, 1936, Serial No. 75,668

4 Claims. (Cl. 233—28)

The present invention relates to the art of centrifugal separators and is concerned with the development of a centrifugal separator adapted to effect efficient separation from a liquid of a viscous material of lower specific gravity than said liquid. The invention was conceived in connection with the development of a centrifugal separator capable of continuously discharging from an imperforate centrifugal rotor a viscous material stratified from a liquid within said rotor and which is of such a viscous or dry consistency as to present serious difficulty in connection with attempts to discharge such material under liquid balance from the liquid from which it has been stratified. In order to effect continuous discharge of material of this consistency, the inertia of the rotating material within the rotor is taken advantage of to effect dislodgment of that material from the rotor. To this end, a stationary inertia dislodging means, such as a skimming nozzle or a dislodging knife, is used.

In the particulars discussed above, and in the general design of the centrifugal rotor of the present invention, the invention resembles the invention of my prior application Serial No. 751,336, filed November 3, 1934 for Method and apparatus for separating wax from oil. The present invention was conceived and reduced to practice as a solution of problems arising in connection with the use of a centrifugal separator designed in accordance with my prior application above identified.

In a general way, it may be said that the present invention consists in improvements over the prior application designed to effect continuous and steady discharge of the stratified viscous material under the influence of the dislodging tool. Specific difficulties which have been overcome and whose solution constitute most important features of the invention can best be understood after a general discussion of the type of centrifugal separator involved and its method of operation.

Referring to the attached drawing for an illustration of the invention, Fig. 1 of that drawing constitutes a central longitudinal cross-section through the centrifugal separator of the invention and

Fig. 2 is a transverse cross-section taken on the line 2—2 of Fig. 1.

The invention was conceived as the solution of the problem of separating waxes of various consistencies from petroleum stocks diluted with a solvent adapted to render such stocks of higher specific gravity than the precipitated wax, and will be described in connection with a separating problem of this character.

Referring to the drawing by reference characters, the numeral 10 designates a centrifugal rotor. The mixture to be subjected to a centrifugal separating operation, such as a suspension of wax in a solution of petroleum stock in a solvent of high specific gravity, is fed to the centrifugal rotor by means of a feed nozzle 11 communicating with a central tube 12 constituting a part of the centrifugal rotor. The mixture to be centrifuged passes from the central tube 12 into the main body of the rotor through radially extending passages 13. The rotor contains a plurality of stratifying plates 14 adapted to facilitate centrifugal separation of constituents of the mixture, these stratifying plates being in the form of nested frustro-conical discs in the form of the invention illustrated.

It is to be noted that the discharge passages 13 deliver the mixture to be subjected to centrifugation to a zone of the rotor within the inner termini of the stratifying plates 14. The purpose of delivering the mixture to this zone is to effect subsidence of a large part of the lighter and more viscous material without passing such material to the zone occupied by the stratifying plates. As explained in my prior application identified above, this feature of design makes it possible to avoid rapid cloggage of the space between the stratifying plates by the viscous material and has important advantages in connection with an operation such as the separation of wax from a heavy oil solution.

The rotor is provided with a frustro-conical dividing wall 15, and the heavier material stratified as the outer layer within the rotor is continuously discharged around the outer edge of this dividing wall and through passages 16 located between this dividing wall and the upper part 17 of the rotor. This liquid effluent is continuously discharged into the receiving cover 18 of the centrifuge. A dislodging tool in the form of a skimming nozzle 19 which is reciprocable toward and away from the stratum of viscous lighter material occupying the inner radial zone of the material stratified within the rotor is provided for discharge of this viscous material. The features of the machine design discussed above are described and claimed in my prior application referred to above, and constitute no part of the present invention.

A consideration of the mode of operation of this machine in the separation of wax from a heavy oil solution of a centrifugal separator incorporating these features of design will illustrate the background of the present invention and the advantages attained by the practice of the invention. In the separation of wax from a heavy oil solution, the rotor is first set in operation and the chilled waxy oil solution is fed to the stratifying section of the rotor through the feed nozzle 11 and the central tube 12 with its radiating passages 13. At this stage of the operation, the skimming nozzle 19 is set at a position radially inward of its normal operative skimming position. As the mixture accumulates in the rotor, the heavier oil solution will be stratified from the wax and flow outwardly, around the frustro-conical dividing wall 15 and through the passages 16 into the liquid receiving cover 18. The layer of wax gradually accumulates within the portion of the rotor lying inwardly of the inner termini of the discs 14. When this layer of wax accumulates to the desired depth, the skimming nozzle 19 is slowly moved outwardly into the inner part of the zone occupied by the wax layer stratified within the rotor. The nozzle 19 should be moved outwardly until a continuous and uniform discharge of wax is obtained. Such an operation is obtainable in connection with the dewaxing of certain types of oils, notably cylinder stocks, but great difficulty is encountered in attempts to obtain the desired uniformity of wax discharge with other types of oils, notably oils containing fine and granular waxes, such as those which occur in distillates of intermediate gravity and viscosity.

When working with stocks containing fine and granular waxes, as the nozzle 19 is moved into the wax layer, wax is initially discharged through that nozzle. As the nozzle is gradually moved further outwardly toward the point at which the most satisfactory operation should be obtained with respect to the thickness of the wax layer and relative freedom of wax from entrained oil, however, the wax discharge suddenly becomes very thin due to the discharge of heavy oil solution therewith and if the nozzle is moved inwardly to reduce the quantity of oil picked up by the nozzle and to thicken the wax, the discharge of the wax suddenly ceases almost entirely and the wax stratum within the rotor moves outwardly largely into the zone occupied by the stratifying plates 14, leaving the skimming nozzle high and dry.

If now the nozzle 19 is moved outwardly until it again reaches the wax layer, satisfactory wax discharge can be obtained for a while, but after a short period of operation, the wax becomes suddenly very much thinner again and this can be temporarily corrected by movement of the nozzle inwardly. The entire undesired sequence must soon be repeated in order to obtain continued operation of the process, however.

The object of the present invention has been to improve upon the features of design of a centrifugal rotor of the character described above in such a manner as to afford uniform and continuous discharge of the viscous and lighter effluent, such as the wax of the above illustration, and to avoid the difficulties discussed above.

This object is accomplished, in the practice of the invention, by the provision of means 20 for maintaining the lighter subsided material which occupies the portion of the rotor lying inwardly of the inner termini of the stratifying plates at a speed of rotation substantially the same as the speed of rotation of the rotor. These means constitute, in the form of the invention illustrated, accelerator structure in the form of a plurality of radially extending webs or wings which may be formed integrally with the central tube 12 and extend radially from this central tube to the inner termini of the stratifying plates 14. These wings contain portions in the form of webs 21 extending a substantial distance longitudinally of the rotor and occupying the full depth of the inner wax stratum within the rotor. These webs, at their outer radial extremities, are preferably enlarged to form ribs 22, which also assist in maintaining the viscous material at approximately the speed of bowl rotation and which extend throughout substantially the entire longitudinal zone of the rotor occupied by the viscous material. The zone of the rotor adjacent the skimming nozzle 19 is of course left free of accelerator structure in order to afford provision for unobstructed movement of the skimming nozzle. The upper ends of the ribs 22 are preferably connected together by means of an annular frustro-conical rigidifying disc 23. The outer radial extremities of the ribs 22 preferably abut the inner radial extremities of the stratifying plates 14 and tend to center these stratifying plates within the rotor. One of these ribs is preferably provided with a key 24, as illustrated, which enters into slots formed in the stratifying plates and thus insures the rotation of these plates at the same speed as the rotor.

It has been found that the provision of the simple expedient described above in conjunction with the dislodging tool 19 serves to maintain the wax stratum at substantially the speed of rotation of the rotor and to avoid the difficulties discussed above in connection with the continuous discharge of fine and granular waxes.

Modifications will be obvious to those skilled in the art and I do not therefore wish to be limited except by the scope of the sub-joined claims.

I claim:

1. A centrifugal separator comprising an imperforate rotor in which subsidence of a mixture of liquid and solids of lower specific gravity than said liquid is adapted to take place under the influence of centrifugal force, and means for feeding a mixture of liquid and solids to the rotor, said rotor comprising a main body portion, means for directing a mixture fed to the rotor into a central unobstructed part of said main body portion provided with radially extending accelerator members, and a series of closely spaced frustro-conical discs having their inner circumferential termini radially a substantial distance without said zone of feed, whereby to afford a substantially unobstructed subsidence zone provided with accelerator members within which the major portion of the solids of said mixture is adapted to be stratified from the liquid content of the mixture and a radially outer disc zone within which residual solids which flow outwardly with liquid from said unobstructed subsidence zone are adapted to be collected and returned to the unobstructed zone, and a skimming nozzle located in a position adapted to contact subsided solids within the rotor and effect continuous discharge of such solids therefrom under the influence of the inertia of said solids.

2. A centrifugal separator comprising an imperforate rotor in which subsidence of a mixture of liquid and solids of lower specific gravity than said liquid is adapted to take place under the influence of centrifugal force, and means for feeding a mixture of liquid and solids to the

rotor, said rotor comprising a main body portion, means for directing a mixture fed to the rotor into a central unobstructed part of said main body portion provided with radially extending accelerator members, and a series of closely spaced frustro-conical discs having their inner circumferential termini radially a substantial distance without said zone of feed, whereby to afford a substantially unobstructed subsidence zone provided with accelerator members within which the major portion of the solids of said mixture is adapted to be stratified from the liquid content of the mixture and a radially outer disc zone within which residual solids which flow outwardly with liquid from said unobstructed subsidence zone are adapted to be collected and returned to the unobstructed zone, and a stationary dislodging tool located in a position adapted to contact subsided solids within the rotor and effect continuous discharge of such solids therefrom under the influence of the inertia of said solids.

3. A centrifugal separator comprising an imperforate rotor in which subsidence of a mixture of liquid and solids of lower specific gravity than said liquid is adapted to take place under the influence of centrifugal force, and means for feeding a mixture of liquid and solids to the rotor, said rotor comprising a main body portion, means for directing a mixture fed to the rotor into a central unobstructed part of said main body portion provided with radially extending accelerator members, and a series of closely spaced frustro-conical discs having their inner circumferential termini radially without said zone of feed, whereby to afford a substantially unobstructed subsidence zone provided with accelerator members within which the major portion of the solids of said mixture is adapted to be stratified from the liquid content of the mixture and a radially outer disc zone within which residual solids which flow outwardly with liquid from said unobstructed subsidence zone are adapted to be collected and returned to the unobstructed zone, and a skimming nozzle located in a position adapted to contact subsided solids within the rotor and effect continuous discharge of such solids therefrom under the influence of the inertia of said solids.

4. A centrifugal separator comprising an imperforate rotor in which subsidence of a mixture of liquid and solids of lower specific gravity than said liquid is adapted to take place under the influence of centrifugal force, and means for feeding a mixture of liquid and solids to the rotor, said rotor comprising a main body portion, means for directing a mixture fed to the rotor into a central unobstructed part of said main body portion provided with radially extending accelerator members, and a series of closely spaced frustro-conical discs having their inner circumferential termini radially without said zone of feed, whereby to afford a substantially unobstructed subsidence zone provided with accelerator members within which the major portion of the solids of said mixture is adapted to be stratified from the liquid content of the mixture and a radially outer disc zone within which residual solids which flow outwardly with liquid from said unobstructed subsidence zone are adapted to be collected and returned to the unobstructed zone, and a stationary dislodging tool located in a position adapted to contact subsided solids within the rotor and effect continuous discharge of such solids therefrom under the influence of the inertia of said solids.

LEO D. JONES.