Jan. 17, 1956 G. J. STREZYNSKI 2,731,331

COUNTERCURRENT EXTRACTOR BOWL

Filed Sept. 25, 1953 4 Sheets-Sheet 1

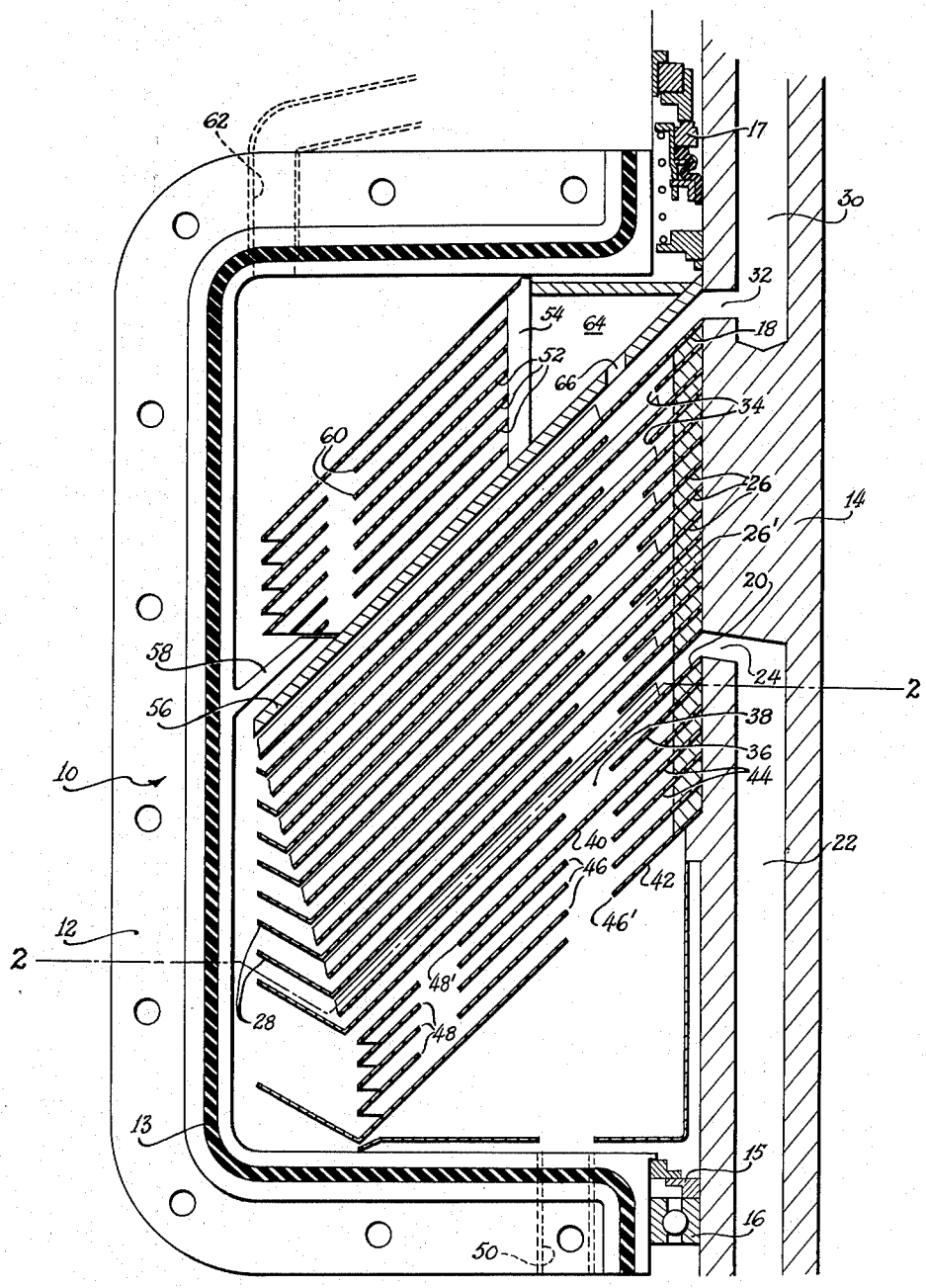

FIG. 1

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COUNTERCURRENT EXTRACTOR BOWL

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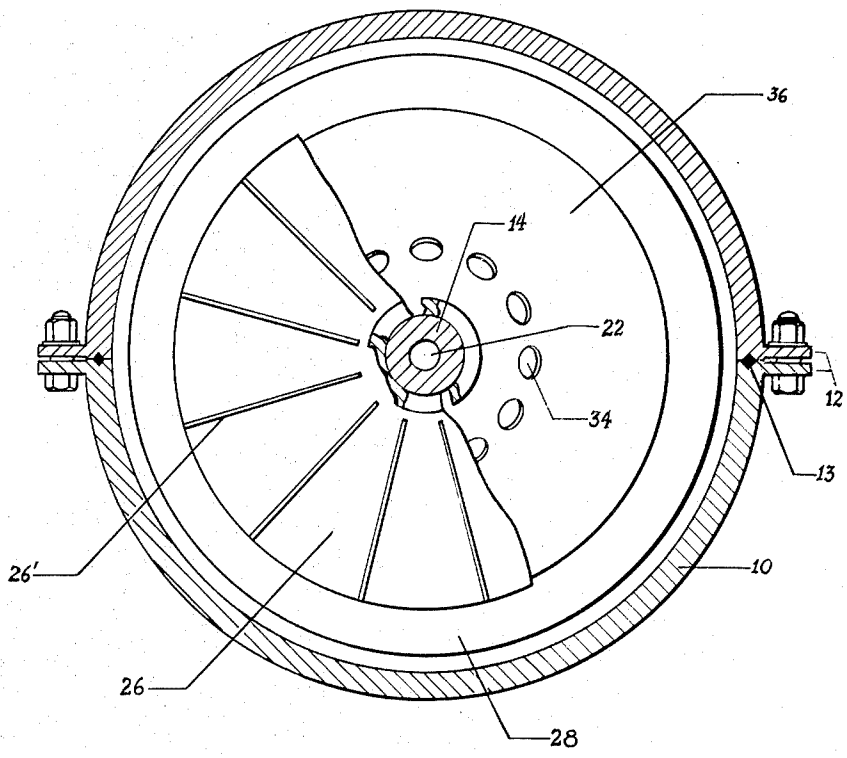

FIG. 2

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COUNTERCURRENT EXTRACTOR BOWL

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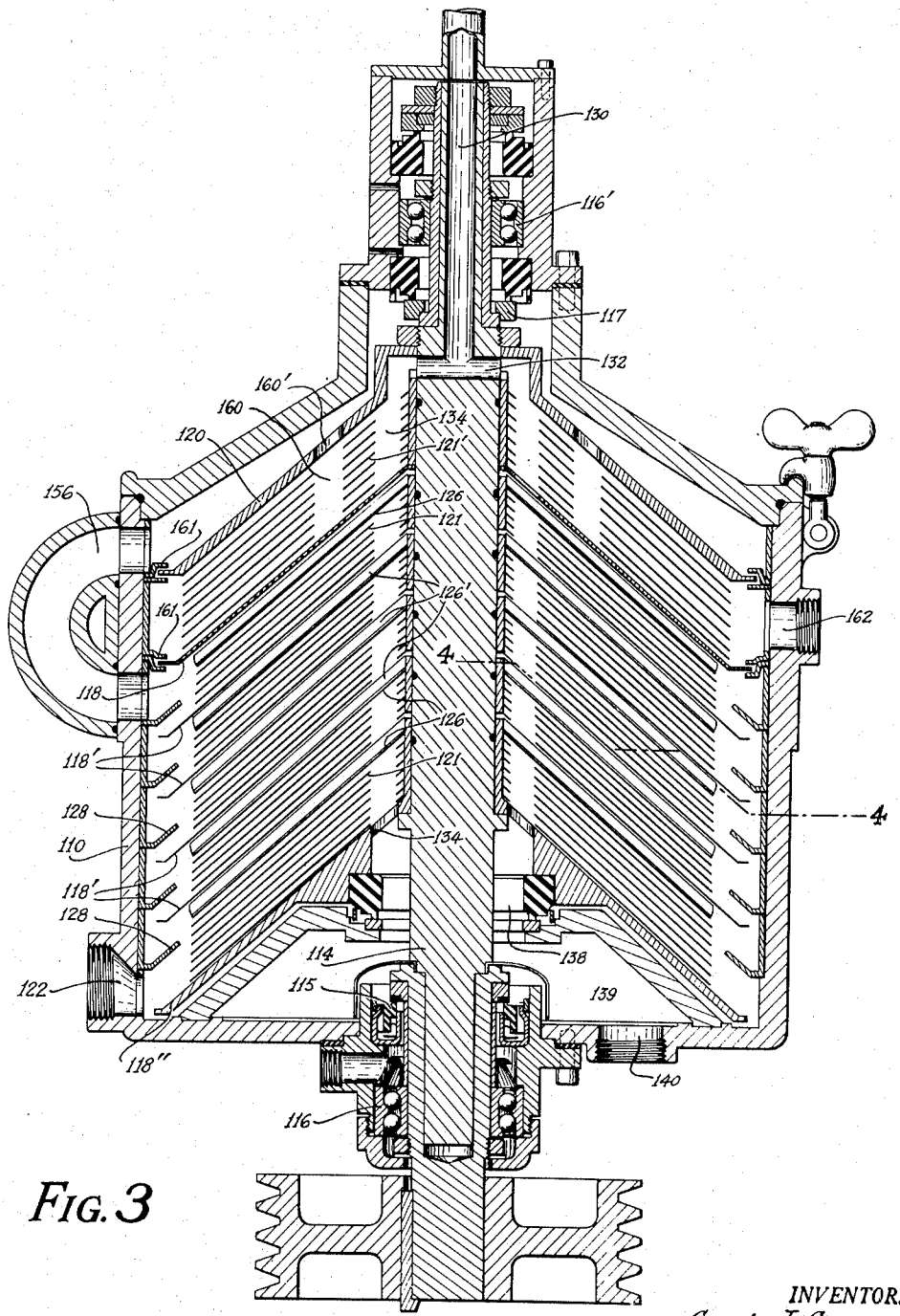

FIG. 3

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COUNTERCURRENT EXTRACTOR BOWL

Filed Sept. 25, 1953 4 Sheets-Sheet 4

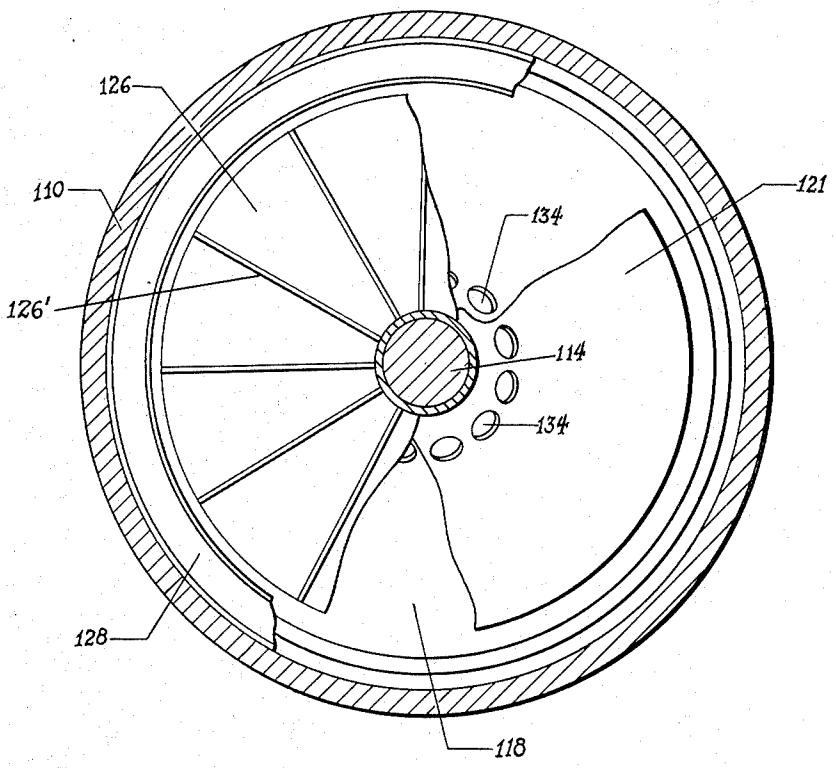

FIG. 4

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2,731,331

COUNTERCURRENT EXTRACTOR BOWL

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Application September 25, 1953, Serial No. 382,367

20 Claims. (Cl. 23—270.5)

This invention relates to centrifugal machines and more particularly to centrifugal machines of the type wherein is effected a mixing and a separation or extraction of two liquids of different specific gravities.

In the preparation of antibiotics, such as penicillin, one of the steps involved is the dissolving of an active ingredient from the penicillin broth by a relatively lighter liquid solvent such as amyl acetate. After the active ingredient has been dissolved by the amyl acetate, the broth and solvent must be purified and separated.

Objects of this invention are to provide a centrifugal machine which provides a maximum of intermixing and contact between two liuqids, which separates and purifies the liquids after the intermixing, which is continuous in operation, which has a minimum of moving parts and is rugged, and which does not retain solids introduced into the bowl in either of the feed streams.

A machine according to the invention comprises a rotor mounted upon a shaft for rotation within a cavity formed by a stationary hollow shell. The rotor is provided with baffles spaced axially therealong and extending outwardly in the cavity with their outer edges in proximity to but spaced from the shell periphery. The baffles form a tortuous path for the lighter liquid, which winds alternately inward and outward relative to the rotor axis and substantially reverses its direction at the outer edges of the baffles. The ends of this tortuous path are spaced apart axially of the rotor and form, respectively, an inlet and an outlet for the lighter liquid. Ducts forming an inlet and outlet for the heavy liquid lead to and from the shell cavity outside the tortuous path at points spaced apart axially of the rotor. Thus, the heavy liquid moving from its inlet to its outlet forms an annulus against the shell around the tortuous path for the light liquid, under the action of centrifugal force due to the revolving baffles. Consequently, as the light liquid flows along its tortuous path and each time it reverses its direction at the outer edges of the baffles in or adjacent the heavy liquid annulus, a turbulent flow is created with strong intermixing and intimate contact between the two liquids. This action is enhanced by the outward flow of the heavier liquid which is carried into the spaces between the baffles by the lighter liquid as a result of the turbulence.

The cavity chamber occupied by the baffles is preferably provided at one end with the inlet for the heavy liquid and the outlet for the light liquid, and at the opposite end with the inlet for the light liquid and the outlet for the heavy liquid. As a result, the liquids flow countercurrently through the cavity so as to facilitate their intermixing where the light liquid reverses its direction at the region of the heavy liquid annulus.

In the preferred construction, the shell cavity also contains a barrier carried by the rotor and dividing the cavity into a main chamber containing the baffles and a secondary chamber at one end of the main chamber. The secondary chamber has communication with the liquid outlet at the adjacent end of the main chamber, for example, the heavy liquid outlet, and also has a discharge

passage for this liquid. A stack of conical discs on the rotor forms thin intercommunicating spaces in the secondary chamber through which the heavy liquid passes from the main chamber on its way to the discharge passage, whereby the heavy liquid is substantially freed centrifugally of the light liquid which it may have picked up and retained in passing through the main chamber. The light liquid thus freed may then be fed into the stream of light liquid entering the main chamber at the end thereof adjacent the secondary chamber. If desired, a similar secondary chamber may be provided by a second barrier on the rotor at the opposite end of the main chamber, whereby the light liquid, for example, from the liquid outlet at the adjacent end of the main chamber is substantially freed of its heavy liquid content by passing through similar disc spaces in the corresponding secondary chamber. The heavy liquid thus freed from the light liquid may then be fed from the secondary chamber into the stream of heavy liquid entering the main chamber.

In one form of the present invention, the baffles subdivide the main chamber into sub-chambers which are serially connected to form the tortuous path for the light liquid; and each sub-chamber is provided with a stack of conical discs mounted on the rotor to form spaces facilitating centrifugal separation of heavy liquid from the light liquid passing along the tortuous path. The separated heavy liquid passes outwardly through the disc spaces into the heavy liquid annulus, while the light liquid passes outwardly to this annulus only along the baffles. With this arrangement, the light liquid discharging from the main chamber will be relatively free of heavy liquid, so that there is no need for a secondary chamber to purify the light liquid. Also, in this form, I prefer additional baffles mounted on the shell and staggered with respect to the rotor baffles, so that the heavy liquid annulus passing through the main chamber is more or less directed into the stream of light liquid passing around the outer edges of the rotor baffles, thereby providing a greater intermixing and contact of the two liquids.

These and other objects and aspects will be apparent from the following presently preferred specific embodiments of the invention illustrated in the accompanying drawings, wherein Fig. 1 is a cross sectional view, with portions broken away, taken through the axis of rotation of one form of the machine; Fig. 2 is a sectional view on line 2—2 in Fig. 1; Fig. 3 is a view similar to Fig. 1 showing another form of the machine; and Fig. 4 is a sectional view on line 4—4 in Fig. 3.

The centrifugal machines illustrated are used for counter current separation and extraction of two liquids having different specific gravities, one of which may contain suspended solids. The machine of Fig. 1 comprises a hollow body such as the stationary shell 10 which is preferably cast of two or more sections bolted together by means of flanges 12. Leakage at the flange joints is prevented by a gasket 13. Supported within the cavity formed by the shell 10 is a rotor having a shaft 14 journalled in ball bearings of which only the lower bearing 16 is shown. Shaft seals 15 and 17 eliminate leakage along the shaft 14. The cavity within the shell 10 is divided into a main chamber and two secondary or end chambers by two conical-shaped imperforate barriers 18 and 20 which are fastened to the shaft or rotor 14 and rotate conjointly therewith.

The heavier of the two liquids is introduced through an axially disposed duct 22 in the shaft 14 which terminates in a substantially radial inlet passage 24 that opens immediately above the barrier 20 at one end of the main chamber so that the liquid entering through the passageway flows along the top of the barrier and is thrown outwardly by the centrifugal force imparted by the rotation of the barrier to form an annulus of heavier

liquid which lies against the inner surface of the side wall of the shell **10**.

The shaft **14** also has secured thereto a plurality of axially spaced conically shaped baffles **26** which are positioned in the main or central chamber to form a tortuous path or labyrinth described hereinafter. These baffles are preferably provided with radial ribs or wings **26'**. The outer edges of the alternate baffles extend into the above described annulus formed by the heavier fluid, the edges of alternate baffles **26** being provided respectively with upturned lips **28**. The lips **28** are inclined reversely in respect to the main portions of the conical baffles. Succeeding baffles are made progressively smaller in diameter so that the edge of the last baffle adjacent the barrier **20** is barely beneath the inner surface of the annulus of heavier liquid. As the baffles **26** are decreased in diameter the correlated lips **28** are made increasingly greater in size so that the outer diameter of the rotor is substantially the same throughout the length of the main chamber.

The lighter liquid is introduced through a second axial passageway **30** in the shaft **14**, the bottom end of the passage **30** being connected with a radial inlet **32** which opens immediately above the barrier **18**. The baffle **26** located immediately below the barrier **18** is provided with a plurality of equally spaced apertures **34** which are located equally distant from the axis of rotation of the shaft **14**. Similar apertures are provided in alternate succeeding baffles **26**. These apertures, only one of which in each alternate baffle **26** is shown in the drawing, interconnect the spaces on either side of such baffles so that the lighter fluid is moved by the centrifugal force developed by the rotation of the rotor along the top of the barrier **18**, thence around the outer edge of the barrier, thence back underneath the barrier and through the apertures **34** in the first baffle **26** and thence in a similar manner around the edges of the remaining imperforate baffles **26**, the reversal of flow around the edges being aided by the upturned lips **28** upon alternate baffles. As was mentioned heretofore, the edges of the baffles **26** extend outwardly beyond the inner surface of the annulus formed by the heavier liquid so that the above described reverse flow of liquid around the edges of the baffles takes place within the annulus of heavier liquid, resulting in turbulence and violent intermixing and causing a maximum of contact between the droplets of the liquids so that any solvent or other chemical reaction therebetween is facilitated. The mixing action is further aided by the return flow of heavier liquid which is carried up along the baffles **26** by the lighter liquid as a result of the turbulence caused by the reverse flow around the baffle ends.

After progressing through the above described labyrinth, the lighter liquid passes around the end of the barrier **20** and through the outlet space between the barrier **20** and a baffle **26** which is provided with a plurality of equally spaced apertures **38** so that the liquid flows into the end chamber where it is purified and any of the heavier liquid entrained therein is removed as described hereinafter.

The baffle arrangement for accomplishing such separation consists of two end baffles **40** and **42** between which are interposed a plurality of spaced intermediate baffles or discs **44**. Each of the intermediate discs **44** is provided with two sets of equally spaced apertures **46** and **48** which are aligned with the corresponding apertures in the other intermediate discs. The end baffle **40** has one set of apertures **48'** which are aligned with the outer set of distributing apertures **48** in the intermediate discs **44**, so that the liquid discharged from the labyrinth and through the aperture in the baffle **36** will enter the distributing apertures **48**. The heavier liquid is thrown outwardly by centrifugal force whereas the purified lighter fluid is forced inwardly so that it discharges through an aperture **46'** in the end baffle **42** and thence out a discharge passage **50** in the bottom of the shell **10**.

Any of the lighter fluid which may be entrained in the annulus of heavier fluid by the above described mixing action of the baffles **26** in the central chamber is removed by a plurality of conical baffles or discs **52** in the upper end chamber. The discs **52** are attached at their inner edges to a plurality of equally spaced posts or columns **54** which project upwardly from a supporting conical member **56** that extends outwardly from the shaft **14** immediately above the barrier **18**. The outer edge of the supporting member **56** extends under the shelf formed by an inwardly projecting stationary ring **58** which is attached to the inner wall of the shell **10**. Clearance is provided between the ring **58** and the end of the supporting member **56** so that heavier liquid from the annulus flows through the outlet duct therebetween into a plurality of sets of aligned apertures **60** in the discs **52**. The centrifugal force resulting from the rotation of the discs **52** causes the purified heavier liquid to flow out past the ends of the discs and thence through a discharge passage **62** in the top end of the casing **10**. Any entrained lighter fluid is forced upwardly between the columns **54** into a small chamber **64** and thence through the apertures **66** in the supporting member **56** to intermingle with the fresh supply of lighter fluid flowing along the top of barrier **18** from the passage **32** in the shaft **14**.

In the form of the invention shown in Fig. 3, the general operation of the machine is similar to the above described embodiment according to Fig. 1 with the exception that the main chamber and lower end chamber below the barrier **20** have been combined and subdivided into a plurality of identical serially connected sub-chambers, which in effect lengthens the path of travel of the light liquid and thus keeps it under the influence of centrifugal force for an extended time. Due to the relatively extended path of travel of the light liquid, the need for the separate end chamber wherein the light liquid is purified has been avoided.

In the form of the invention according to Fig. 3, the machine comprises a hollow circular stationary body shell **110** having a rotor supported therein on a central shaft **114** journaled on ball bearings **116** and **116'**. Seals **115** and **117** are provided to eliminate leakage along the shaft **114**. The cavity within the shell is divided into a plurality of horizontally arranged, serially connected chambers by a conical-shaped barrier **118** which is fastened to the shaft **114** and rotates therewith. The chamber below barrier **118**, which may be considered the main chamber, is subdivided into a plurality of horizontal serially connected subchambers by baffles **126** likewise attached to shaft **114** and rotating therewith.

The heavier of the two liquids is introduced into the shell through the periphery thereof via an inlet duct **122** in the shell that opens into the space outside of the rotor and adjacent the bottom thereof so that the liquid entering within the shell flows upwardly along the shell wall and forms an annulus which will lie against the inner surface of the side wall of the shell.

The shaft **114** also has secured thereto a plurality of axially spaced conically shaped baffles **118'**, one of which is positioned near the bottom of each of the sub-chambers previously described (that is, near the end thereof nearest the heavy liquid inlet **122**), to form the sub-chambers into a tortuous path or labyrinth described hereinafter. A stack of conically shaped discs **121'** is nested about and secured to the shaft **114** between barrier **118** and an overlying barrier **120**, and a similar stack of discs **121** is arranged between each consecutive baffle **126** and the underlying baffles **118'**. The outer edges of barriers **118** and **120** and baffles **118'** but not baffles **126** or the discs **121**, extend into the heavy liquid annulus. The outer edges of barriers **118** and **120** must extend through the heavy liquid annulus to a perimeter adjacent the side walls of shell **110**, while the enlarged baffles **118'** need extend only

to a perimeter substantially within the annulus. With the exception of barriers 118 and 120 and baffles 118', the outer diameter of the rotor formed by the perimeters of baffles 126 and the discs 121 or 121' is substantially the same throughout the axial length of the area enclosed by the shell 110.

The lighter liquid is introduced through an axial passageway 130 in the shaft 114, the bottom end of which is connected with a radial inlet 132. The radial passage 132 opens into the upper chamber within the shell immediately below barrier 120. The barrier 118, baffles 118' and discs 121 and 121' are provided with aligned apertures 134 which are located radially equidistant from the axis of rotation of shaft 114 and form an axial passage for the light liquid through each of the serially connected individual chambers. The baffles 126 contain no apertures, so that the flow of liquid moving axially through the passages defined by aligned apertures 134 above each baffle 126 is blocked off. Accordingly, the lighter liquid is moved by centrifugal force developed by the rotation of the rotor along the top surface of the respective baffle 126, thence around the outer edge of this baffle, then back underneath this baffle to and through the apertures 134 in the disc stack 121 next below. The baffles 126 preferably carry wings 126' similar to the wings 26' in Figs. 1 and 2.

The inner wall of the shell 110 has arranged thereabout, and spaced axially therealong, inwardly extending stationary annular baffles 128 which are located intermediate the outer perimeters of baffles 118' and extend inwardly to a diameter less than the perimeters of baffles 118'. By this means, the upwardly flowing stream of the heavier liquid is caused to follow a tortuous path in and out of the zone defined by the outer perimeters of baffles 118'. Accordingly, the reversal of flow of both the heavier and lighter liquids takes place at approximately the same zone within the shell and results in extreme turbulence and violent intermixing of the liquids. Such intermixing causes a maximum of contact between the droplets of the liquids so that any solvent or other chemical reaction therebetween is facilitated. Since mixing and separating action is repeated in each of the serially connected chambers arranged below barrier 118, a maximum of chemical reaction is obtained.

After passing through the above described labyrinth in each of the serially connected sub-chambers below barrier 118, the lighter liquid is purified within the disc stack 121 of such sub-chamber and passes through the apertures 134 to the upper side of the next lower baffle 126. On leaving the last of the sub-chambers reckoned in the direction of flow of the lighter liquid, the latter liquid passes through outlet apertures 134 in the bottom baffle 118'', through a passage 138 surrounding shaft 114, and into a stationary chamber 139 from which it is led away from the machine via outlet connection 140.

The heavier liquid, after the intermixing with the lighter liquid in each of the serially connected sub-chambers, is thrown outwardly by centrifugal force to rejoin the upwardly flowing heavier liquid stream along the inner side of the wall 110. On leaving the last of the serially connected sub-chambers reckoned in the direction of flow of the heavier liquid, the heavier liquid enters a passage or duct 156 forming the heavy liquid outlet from the main chamber, from which it passes into a heavy liquid passage above barrier 120. The chamber between barriers 118 and 120 contains a stack of discs 121' which is the same as the disc stacks 121 with the exception that a second set of aligned apertures 160 is provided in the discs at a diameter in excess of that of the apertures 134. Barrier 120 is provided with a heavy liquid inlet port 160' in alignment with the apertures 160 in the disc stack. The liquid incoming via duct 156 passes along the passage at the upper side of barrier 120 to the opening 160' and through the same into the disc stack 121' via apertures 160. Within the disc stack 121', centrifugal force resulting from its rotation causes the purified heavier liquid to flow past the outer ends of the discs and thence to discharge from the machine through outlet duct 162 in the shell. Any entrained lighter liquid reaching disc stack 121' is forced inwardly to the apertures 134, which form a light liquid passage as part of the light liquid inlet to the main chamber. Thus, light liquid from disc stack 121' joins the incoming stream of lighter liquid flowing to the main chamber.

The outer perimeter of barriers 118 and 120 move through U-shaped liquid seals 161 affixed to the inner wall of the shell 110 within the zone of the heavier liquid annulus. Accordingly, should there be any by-passing at these points from the upper chamber containing disc stack 121', the by-passed liquid would mingle with the flow through duct 156 and be returned to the chamber via port 160'.

The above-described machines are particularly adapted for the solvent extraction of an active ingredient from penicillin broth by a relatively lighter solvent such as amyl acetate, although they are not limited to this use. The penicillin broth is introduced through the shaft passageway 22 (or 122), the solvent being simultaneously brought in through the second passageway 30 (or 130) so that the broth and solvent are completely intermixed to permit more effective use of the solvent by the turbulent flow in the labyrinth of the main chamber or serially connected sub-chambers as has been described in detail heretofore. After the solvent reaction has taken place the solvent is separated from the broth by the discs 46 (or 121) and discharged through the conduit 50 (or 140). The spent broth is simultaneously purified by the action of the discs 52 (or 121') and discharged through the conduit 62 (or 162). It is to be understood that the above described mixing and separating actions take place continuously, a constant supply of fresh broth and solvent being introduced through the shaft passageways while the spent material is drawn off through the conduits 50 and 62 located in opposite ends of the shell 10 in Fig. 1, and through the conduits 140 and 162 in Fig. 2.

It will be understood that since the extractor has a stationary shell, and the rotating parts project only a small distance into the heavy liquid, there will be a relatively slow speed rotary motion of that liquid. Consequently, there will be only a small centrifugal force generated in the heavy liquid, so that there will be little tendency to pack any entrained solids against the stationary shell. In fact, due to the heavy turbulence at or near the shell, any entrained solids will be kept in motion and thus be carried out with the heavy liquid.

I claim:

1. A centrifugal machine for mixing and separating two liquids having different specific gravities, which comprises a stationary hollow shell forming an enclosed cavity, a rotor mounted to revolve in the cavity relative to the shell, baffles on the rotor spaced axially therealong and extending outwardly in the cavity with their outer edges in proximity to but spaced from the shell, the baffles forming a tortuous path for the lighter liquid winding alternately inward and outward relative to the rotor axis and substantially reversing its direction at said outer edges, the ends of said path being spaced apart axially of the rotor and forming, respectively, an inlet and an outlet for the lighter liquid, and ducts forming an inlet and outlet for the heavy liquid leading to and from the cavity outside said path at points spaced apart axially of the rotor, the stationary shell defining at the outer portion of the cavity a generally annular space extending around the baffles and forming between said inlet and outlet for the heavy liquid a passage by-passing the spaces between the baffles, whereby the heavy liquid moving from its inlet to its outlet forms an annulus against the shell around said path under the action of centrifugal force due to the revolving baffles, and turbulent flow with substantial intermixing and contact

between the liquids occurs in the regions of said outer edges.

2. A centrifugal machine according to claim 1, in which said inlet duct and lighter liquid outlet are at one end of the cavity and said outlet duct and lighter liquid inlet are at the opposite end of the cavity, whereby the liquids flow countercurrently in the regions of said outer edges.

3. A centrifugal machine according to claim 1, in which the baffles are cone-shaped, and extend partly into said heavy liquid annulus.

4. A centrifugal machine for counter current mixing and separation of two liquids having different specific gravities, which comprises a stationary hollow shell forming an enclosed cavity, a rotor mounted to revolve within said cavity relative to the shell, an outwardly extending barrier on the rotor dividing the cavity into a main chamber and a secondary chamber at one end of the main chamber, the main chamber having at one end an inlet for the heavier liquid and an outlet for the lighter liquid and at the other end an outlet for the heavier liquid and an inlet for the lighter liquid, axially spaced baffles on the rotor extending outwardly in the main chamber with their outer edges in proximity to but spaced from the shell, the baffles forming a tortuous path having at its ends said inlet and outlet, respectively, for the light liquid, said path winding alternately inward and outward relative to the rotor axis and substantially reversing its direction at the outer edges of the baffles, the stationary shell defining at the outer portion of the cavity a generally annular space extending around the baffles and forming between said inlet and outlet for the heavy liquid a passage by-passing the spaces between the baffles, the heavy liquid thereby forming an annulus against the shell around said path under the action of centrifugal force due to the revolving baffles, whereby a turbulent flow of the liquids occurs at said outer edges causing an intimate mixing and contact between the liquids, said secondary chamber having communication with said outlet at the adjacent end of the main chamber and also having a discharge passage for the liquid passing through said last outlet, and conical discs in the secondary chamber mounted on the rotor and forming spaces in which said last liquid is substantially freed centrifugally of the other liquid in flowing to said discharge passage.

5. A centrifugal machine according to claim 4, in which the secondary chamber also has communication with said inlet at the adjacent end of the main chamber, whereby said other liquid separated in the secondary chamber joins liquid entering the main chamber from said last inlet.

6. A centrifugal machine according to claim 4, in which said secondary chamber is located at the end of the main chamber having the inlet for the light liquid and the outlet for the heavy liquid.

7. A centrifugal machine according to claim 4, comprising also annular baffles on the inner wall of the shell extending inwardly in the main chamber toward the rotor axis and offset axially from said outer edges of the rotor baffles.

8. A centrifugal machine according to claim 4, comprising also ducts in the shell forming said heavy liquid inlet to the main chamber and said discharge passage from the secondary chamber.

9. A centrifugal machine according to claim 4, comprising also ducts in the shell forming said heavy liquid inlet to the main chamber and said discharge passage from the secondary chamber, said light liquid inlet being formed in the rotor.

10. A centrifugal machine according to claim 4, in which said baffles divide the main chamber into superimposed sub-chambers forming said tortuous path, and comprising also stacks of axially spaced conical discs mounted on the rotor and extending into the sub-chambers to form spaces facilitating centrifugal separation of heavy liquid from the light liquid passing through the sub-chambers.

11. A centrifugal machine according to claim 4, in which said baffles divide the main chamber into superimposed sub-chambers forming said tortuous path, and comprising also stacks of axially spaced conical discs mounted on the rotor and extending into the sub-chambers to form spaces facilitating centrifugal separation of heavy liquid from the light liquid passing through the sub-chambers, said last disc spaces in each stack opening outwardly into said heavy liquid annulus and having near the rotor an interconnecting light liquid passage formed by the discs and extending axially of the rotor between adjacent baffles.

12. A centrifugal machine according to claim 4, in which said baffles divide the main chamber into superimposed sub-chambers forming said tortuous path, and comprising also stacks of axially spaced conical discs mounted on the rotor and extending into the sub-chambers to form spaces facilitating centrifugal separation of heavy liquid from the light liquid passing through the sub-chambers, said last disc spaces in each stack opening outwardly into said heavy liquid annulus and having near the rotor an interconnecting light liquid passage formed by the discs and extending axially of the rotor between adjacent baffles, and an enlarged baffle on the rotor in the end portion of each sub-chamber nearest the heavy liquid inlet and having an opening aligned with said last passage, said last baffles extending outwardly from the rotor beyond the first baffles and into said heavy liquid annulus.

13. A centrifugal machine according to claim 4, in which said baffles divide the main chamber into superimposed sub-chambers forming said tortuous path, and comprising also stacks of axially spaced conical discs mounted on the rotor and extending into the sub-chambers to form spaces facilitating centrifugal separation of heavy liquid from the light liquid passing through the sub-chambers, said last disc spaces in each stack opening outwardly into said heavy liquid annulus and having near the rotor an interconnecting light liquid passage formed by the discs and extending axially of the rotor between adjacent baffles, an enlarged baffle on the rotor in the end portion of each sub-chamber nearest the heavy liquid inlet and having an opening aligned with said last passage, said last baffles extending outwardly from the rotor beyond the first baffles and into said heavy liquid annulus, and annular baffles on the inner wall of the shell extending inwardly between said enlarged baffles but spaced therefrom.

14. A centrifugal machine according to claim 4, comprising also a second barrier mounted on the rotor and partly defining said secondary chamber, the second barrier having a heavy liquid inlet port leading into said spaces in the secondary chamber formed by the discs therein, the second barrier also partly defining a heavy liquid passage leading to said port and a duct connecting said last passage with the heavy liquid outlet from the main chamber.

15. A centrifugal machine according to claim 4, comprising also a second barrier mounted on the rotor and partly defining said secondary chamber, the second barrier having a heavy liquid inlet port leading into said spaces in the secondary chamber formed by the discs therein, the second barrier also partly defining a heavy liquid passage leading to said port and a duct connecting said last passage with the heavy liquid outlet from the main chamber, said discs in the secondary chamber forming a light liquid passage communicating with the light liquid inlet to the main chamber.

16. A centrifugal machine according to claim 4, comprising also a second barrier mounted on the rotor and partly defining said secondary chamber, the second barrier having a heavy liquid inlet port leading into said spaces in the secondary chamber formed by the discs therein, the second barrier also partly defining a heavy

liquid passage leading to said port, a duct connecting said last passage with the heavy liquid outlet from the main chamber, and liquid seals between the outer edges of said barriers and the shell and located, respectively, adjacent said last passage and said heavy liquid outlet.

17. A centrifugal machine according to claim 4, in which alternate baffles extend outward beyond the outer edges of baffles adjacent thereto and into the heavy liquid annulus, said last baffles forming light liquid passages near the rotor.

18. A centrifugal machine according to claim 4, in which alternate baffles extend outward beyond the outer edges of baffles adjacent thereto and into the heavy liquid annulus, said last baffles forming light liquid passages near the rotor, the baffles being conical and the outer edge portions of said alternate baffles being reversely inclined with respect to the main portions of the baffles.

19. A centrifugal machine according to claim 4, in which alternate baffles extend outward beyond the outer edges of baffles adjacent thereto and into the heavy liquid annulus, said last baffles forming light liquid passages near the rotor, the baffles being conical and the outer edge portions of said alternate baffles being reversely inclined with respect to the main portions of the baffles, said outer edge portions progressively decreasing in area

from the region of the heavy liquid inlet to the region of the heavy liquid outlet, while the radii of the baffles exclusive of said outer edge portions progressively increase from the region of said heavy liquid inlet to the region of said heavy liquid outlet.

20. A centrifugal machine according to claim 4, comprising also a second barrier at the end of the main chamber remote from the first barrier and forming another secondary chamber having communication with said light liquid outlet at the corresponding end of the main chamber, said last secondary chamber also having a discharge passage for light liquid passing through said last outlet, and conical discs in said last secondary chamber mounted on the rotor and forming spaces in which the light liquid is substantially freed centrifugally of the heavier liquid in flowing to said discharge passage.

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