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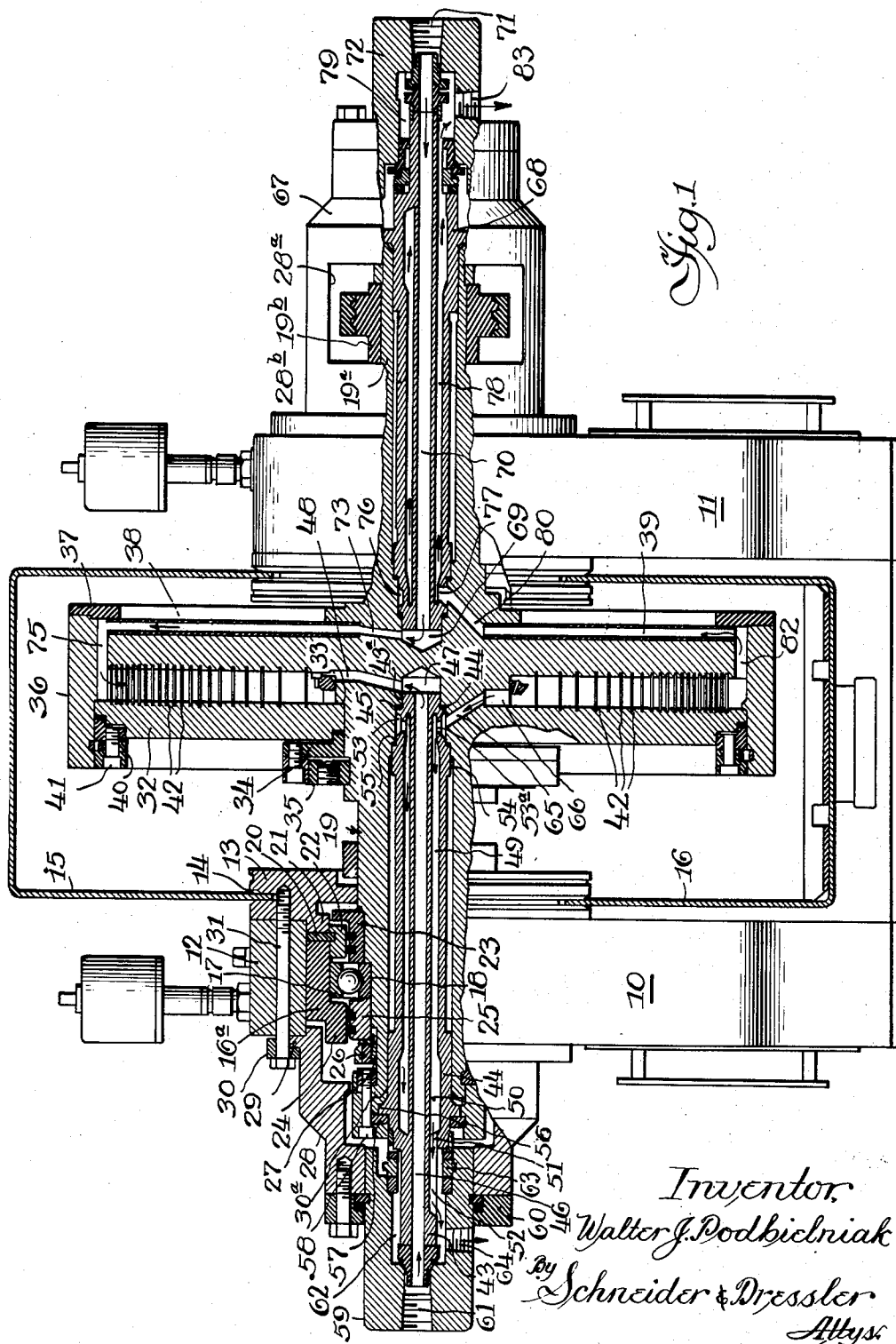
W. J. PODBIELNIAK

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CENTRIFUGAL COUNTERCURRENT CONTACT APPARATUS

Filed Aug. 19, 1949

3 Sheets-Sheet 1



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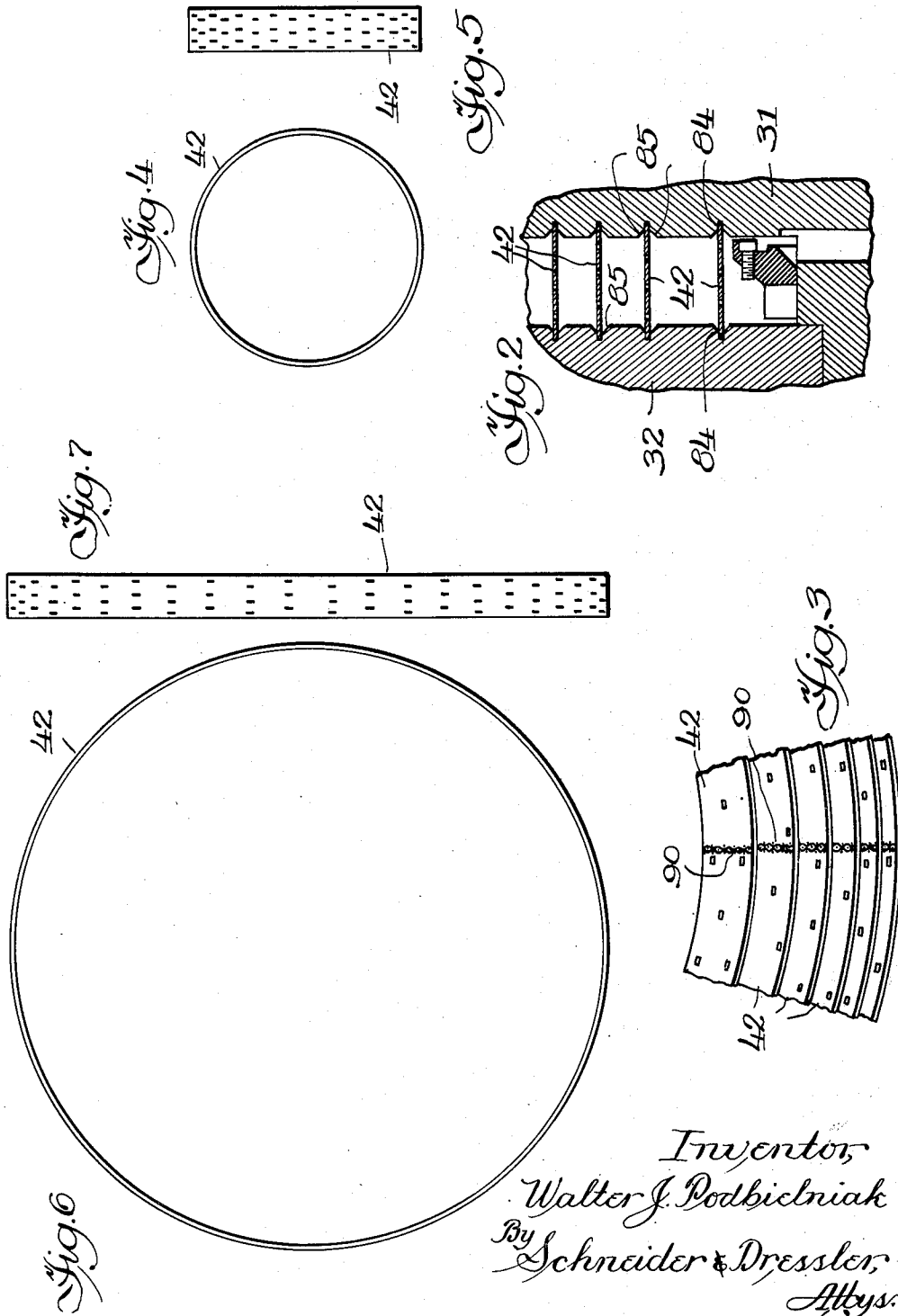
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3 Sheets-Sheet 2



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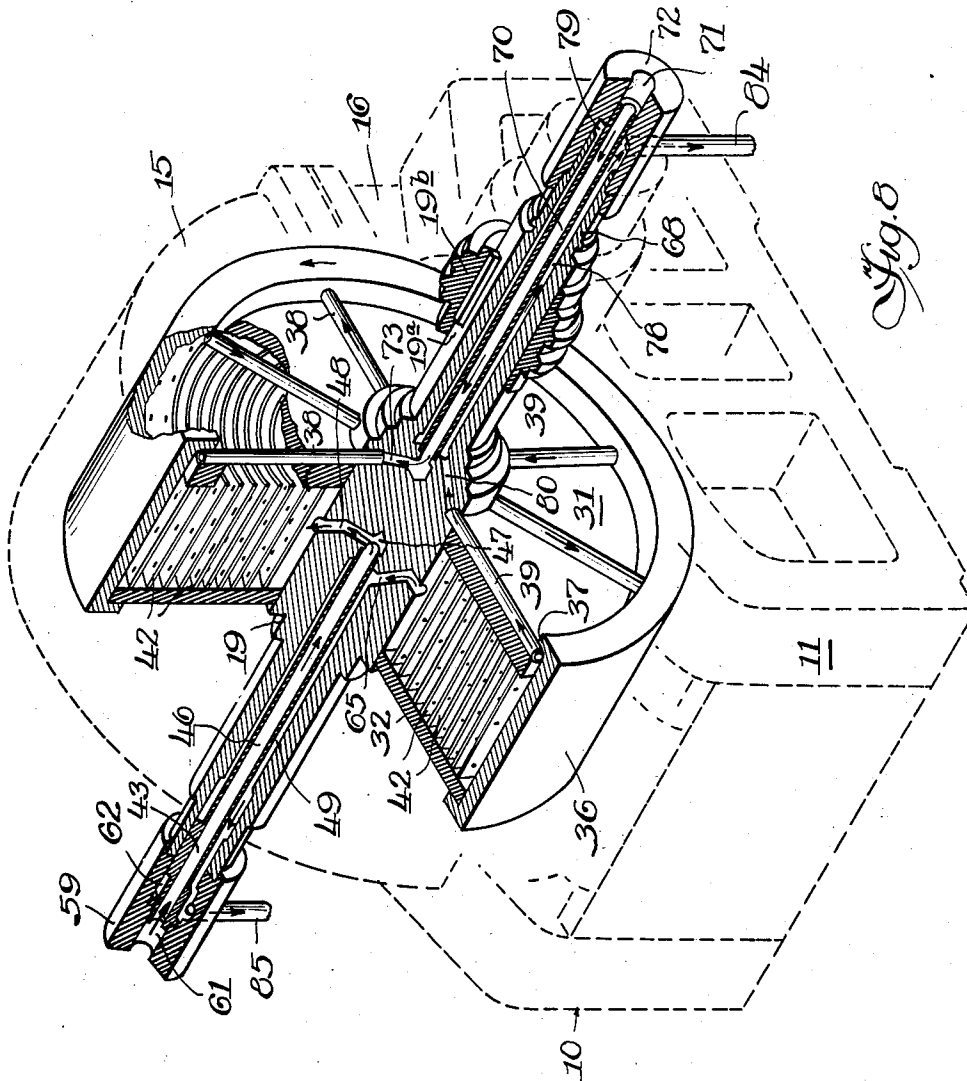
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CENTRIFUGAL COUNTERCURRENT CONTACT APPARATUS

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3 Sheets-Sheet 3



Inventor,
Walter J. Podbielniak
By Schneider & Dressler
Attys.

UNITED STATES PATENT OFFICE

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CENTRIFUGAL COUNTERCURRENT
CONTACT APPARATUSWalter J. Podbielniak, Chicago, Ill., assignor of
one-half to Wladzia G. Podbielniak

Application August 19, 1949, Serial No. 111,218

12 Claims. (Cl. 233-15)

1

The present invention relates to improvements in countercurrent contact devices of the general type illustrated in my prior Patent No. 2,281,796, granted May 5, 1942. It is more particularly intended for effecting countercurrent contact between liquids of different densities that are immiscible or largely so, for example, for solvent extraction, chemical treatment and like purposes, and may likewise be employed for countercurrent contact between liquids and gases or vapors, if so desired.

The invention will be fully understood from the following description, illustrated by the accompanying drawings in which:

Figure 1 is an elevation of a device embodying the invention, shown partly in vertical section through the central line of the apparatus;

Fig. 2 is a fragmentary detail sectional view illustrating the manner of placing the rings within the rotor of the contacting device;

Fig. 3 is a broken perspective view of a detail showing suitable relative placing of the rings of the rotor and of the openings therein in a typical embodiment of the invention;

Fig. 4 is a side view of an inner ring of the rotor;

Fig. 5 is a view illustrating the placing of the holes or perforations in the ring of Fig. 4;

Fig. 6 is a side view of an outer ring of the rotor and Fig. 7 is a view illustrating the placing of the holes or perforations in the ring of Fig. 6; and

Fig. 8 is a diagrammatic perspective view of the centrifugal contacting device of the present invention, partially broken away to illustrate schematically the operation of the rotor of the device. Parts of the mounting and other stationary parts are indicated by dotted lines.

Referring more particularly to Fig. 1, the numerals 10 and 11 indicate two spaced standards which carry the rotor of the contacting device and its stationary casing. The supporting and journal parts carried by each of the standards 10 and 11 being similar except for the provision of the driving means on the shaft portion carried by standard 11, they will be described more particularly in connection with those carried by the standard 10.

The standard carries a split ring 12, to which is bolted on the inside of the standard a supporting member 13 of generally annular form, provided circumferentially with an annular groove into which fits the inner periphery of the upper and lower casing members 15 and 16. The casing members 15 and 16 together form a stationary

2

cylindrical casing for the rotor, as will be apparent from the diagrammatic showing in Fig. 8. The two parts 15 and 16 of the casing may conveniently be hinged together so that the upper part 15 can be raised when desired.

Within the ring 12 and fitting closely to the interior thereof is mounted the stepped sleeve 16a, the interior surface of which serves to support the outer race of a ball bearing 17, the inner race of which bears against a shoulder 18 on the stepped rotatable shaft member 19 which carries the rotor and auxiliary parts, as will be hereinafter more fully pointed out. The ring 16a, on its side toward the rotor, abuts against a split annular key or stop 20, which in turn contacts a stepped down portion 21 of reduced diameter on the supporting member 13. The stop or key 20 holds in position a sealing ring 22 which cooperates with a corresponding sealing ring 23 on the shaft 19. The stepped down portion 24 of the ring 16a likewise serves as a sealing ring on the opposite side of the ball bearing 18 and cooperates with the sealing ring 25, mounted on the shaft 19. Those elements of the bearing and seal assembly just referred to that are mounted on the shaft 19 are held in position by a ring 26 which is internally threaded and is screwed on to a corresponding threaded portion 27 on the shaft 19. Those portions of the bearing and seal assembly mounted on the ring 12 are held in position by a stepped cap member 28 having a cylindrical portion of larger diameter adjacent the standard 10. It is provided with a flange 29 contacting the ring member 12. A locking ring 30 engages the flange 29 of the cap member 28, ring member 12, and the supporting member 13 and related parts are held in their proper positions by bolts 31. The shaft 19 extends outwardly beyond its threaded portion on which is mounted the internally threaded ring 26 and is provided at its end with a shoulder 30a, the purpose of which will be indicated hereinafter.

Within the casing formed by the members 15 and 16, the rotatable shaft 19 carries two disks 31 and 32 forming the sides of the rotor of the contactor. As illustrated, the disk 31 may be formed integrally with the shaft, although, as is readily apparent, it may be formed separately and fitted on the shaft. The disk 32 is formed as an annular plate and is forced against a shoulder 33 on shaft 19 by a sealing ring 34 and by screws mounted in the locking member 35 which fits into a groove suitably provided on the shaft 19.

A cylindrical shell or ring 36 surrounds the

rotor disks 31 and serves as a closure for the outer circumference of the rotor. Mounted on one side of the cylindrical shell 36 is an inwardly directed flange 37, the inner periphery of which is turned inwardly to engage the disk 31 except for notches provided for the passage of the tubes 38 and 39, the functions of which will be referred to hereinafter. At the opposite end of the cylindrical shell 36 there is secured to it internally a locking ring 40. Bolts 41 screwed through the locking ring force the disk 32 in the direction of the opposing disk 31. The spaced, perforated cylindrical rings 42 are held in position between the disks 31 and 32 as hereinafter more fully described.

In operation, the heavier liquid must be supplied to and the lighter liquid withdrawn from the inner portion of the rotor and the lighter liquid must be supplied to and the heavier liquid withdrawn from the outer circumference of the rotor. The means by which these are accomplished will now be described.

The ends of the rotor shaft 19 are drilled to provide axial openings extending to approximately the center of the shaft, but not meeting. These openings are reduced in diameter at their inner ends. Referring first to the portion of this shaft at the left of the rotor, as viewed in Fig. 1, a stationary hollow rod or tube 43 enters the opening in the shaft 19 and is provided at its inner end with a portion 43a of reduced diameter which fits in the inner end of the opening in the shaft. The rod 43 is likewise provided near its inner end with a shoulder 44 which abuts against a corresponding shoulder formed within the rotor shaft, suitable sealing means 45 being provided thereby. A central opening or hole 46, drilled axially through the rod or tube 43 opens into a small chamber 47 within the rotor shaft, this chamber being the end of the opening formed in the left hand portion of the shaft 19. The opening or hole 46 above referred to forms the conduit for introduction of heavy liquid. The opening 47 in the rotor shaft 19 at the end of this conduit is connected by hole 48 drilled approximately radially through the shaft 19 to the interior of the space within the rotor between the disks 31 and 32, and within the first of the circular rings 42.

Within the hollow rod 43 and concentric with the opening or conduit 46, an annular chamber 49 is formed. At its outer end, this chamber terminates in a somewhat enlarged space 50 and this in turn communicates through an opening 51 with groove 52, cut on the outer surface of the rod or tube 43.

At its inner end the annular space 49 terminates near the end of the rod 43. The rod 43 is reduced in external diameter near the shoulder 44 and seal 45, forming a groove 53 which serves as a collecting space for the light liquid withdrawn from the rotor. Holes 53a are drilled through the rod 43 at the bottom of this groove to communicate with the inner concentric space 49 so that the light liquid withdrawn from the rotor can enter the concentric space 49 and be conveyed through it to the exterior of the apparatus. Back of the groove 53, cooperating shoulders 54 and 55 are formed on the outer surface of the rod 43 and on the interior of the shaft 19, respectively, between which suitable sealing means may be provided to prevent flow of liquid out of the chamber formed by the groove 53, flow of liquid in the opposite direction being prevented by the seal 45.

The rod 43 projects beyond the outer end of

rotor shaft 19 and is provided with an annular shoulder 56. A locking ring 57 abuts against this shoulder and is provided with a flange ring directed towards the rotor casing and extending beyond the shoulder 30 formed on the outer end of the shaft 19. Bolts 58 passing through the locking ring 57 terminate in lugs which abut against the shoulder 30a formed on the shaft 19 and thereby serve to retain the rod 43 in its proper position within the shaft.

A second cap member 59 fits into the end of cap member 28 and is retained in position by a lock ring 60. At its outer end the cap member 59 is provided with an opening 61, and at the inner end of this opening it is fitted against the outer end of the rod 43, any suitable sealing means being provided at this point. Suitable provision is made for the connection of a pipe to the opening 61 in the cap member 59; thus, the interior of this opening may be provided with pipe threads.

Beyond the opening 61, the cap member 59 is provided with an enlarged opening forming a chamber 62 and beyond this, suitable sealing shoulders formed on the interior of the cap member 59 and on the exterior of the rod 43. The groove 52, which communicates with the interior annular space 50 within the hollow rod 43, opens into chamber 62. Opening 64 is provided through the cap member 59 into the chamber 62 and this opening is likewise provided with threads or other suitable arrangements for connection of a pipe or other conduit.

At the opposite end of the hollow rod 43, where the chamber is provided by the groove 53, a hole 65 is drilled through the rotor shaft and communicates with the space within the rotor between the disks 31 and 32. An enlarged opening 66 may be drilled from the interior of the rotor space for a short distance to meet the opening 65. Light liquid passing out of the rotor will thus be discharged through the openings 66 and 65 into the chamber formed by the provision of the groove 53 in the hollow rod 43; thence into and through the annular space 49 within the hollow rod 43 to the enlarged chamber 50, from which it will pass through the opening 51 and the groove 52 into the chamber formed in the cap member 59 around the end of the hollow rod 43 and then out through the opening 64 and whatever conduit may be provided for its discharge.

The opposite end of the rotor shaft 19 is likewise hollow and means are provided for the supply of liquid and discharge of heavy liquid, these means being generally similar in construction to those described in connection with the left hand side of the rotor shaft as illustrated in Fig. 1. A portion of the rotatable shaft 19 on this side, indicated as 19a, is extended to provide a seat for the drive pulley 19b, a suitable opening 28a being provided in the cap member 28b, which corresponds to the cap member 28 on the opposite side. This end of the rotor shaft 19 is mounted in a manner similar to that previously described for the opposite end and is held in position by a cap member 67 corresponding to the cap member 28. A stationary hollow rod 68 of a construction generally similar to that of rod 43 is mounted within the opening in shaft 19 and terminates so as to leave an opening 69 near the center of the shaft, with which opening the hole or conduit 70 drilled axially through the rod 68 communicates. At its other end this conduit 70 communicates with the opening 71 formed in the end

of the cap member 72, which also retains the rod in its proper position within the opening in the shaft 19. The opening 71 is provided internally with pipe threads or other suitable means for connection of the conduit through which the lighter liquid entering the rotor is introduced. From the chamber 69 at the inner end of the conduit 70, holes 73 are drilled approximately radially and these communicate with the inner end of radially disposed tubes 38. The outer ends of tubes 38 communicate with holes 75 drilled through the rotor disk 31 to the interior of the rotor at its outer circumference. The light liquid entering the rotor may thus pass through conduit 70 into chamber 69 and from the latter through the holes 73, the radial tubes 38 and the holes 75 into the working space within the rotor.

As in the case of the hollow tube 43, the hollow tube 69 is provided near its inner end with an annular groove 76 forming a chamber. Holes 77 are drilled through tube 68 and communicate with the annular chamber 78 formed within the hollow rod 68 and extending to communicate with the chamber 79 formed within the cap member 72. From the chamber formed by the groove 76 in the hollow rod 68, holes 80 are drilled through the rotor to communicate with the inner ends of the radial tubes 39, the outer ends of which communicate with holes 82 drilled through the rotor disk 31 and likewise communicating with the working space within the rotor. Heavy liquid being discharged from the rotor passes out through the openings 82, radial tubes 39, the holes 80 into the chamber formed by groove 76 and thence passes through opening 77 and annular space or conduit 78 to the chamber 79. Openings 83 are provided through which the liquid may be discharged, these openings being suitably provided, for example, with pipe threads or other means by which a discharge conduit may be attached.

As heretofore set forth, spaced, perforated circular rings 42 are provided at intervals within the working space of the rotor between the disks 31 and 32. As shown more fully in Fig. 2, each of these disks is provided with circular grooves 84 into which the rings 42 fit closely, the grooves being enlarged at the surfaces of the disks, as shown at 85 to facilitate the entrance of the rings into the grooves. The rings fit into the grooves tightly and may be forced into position, for example, by hydraulic pressure.

In accordance with the present invention, it has been found important that the spacing or clearance between the perforated rings decrease as the radii of the rings increase, being varied as an inverse function of the radius, so that the more remote they are from the center of the rotor, the less the spacing between the rings. Thus, in accordance with the present invention, the clearance between rings may vary as $1/r^n$, wherein n is from 0.5 to 2. In the form illustrated, the clearance between rings varies approximately as $1/r$. With such an arrangement, markedly superior results have been secured in the countercurrent contacting of liquids of different densities. It has likewise been found desirable, as another feature in accordance with the present invention, which may be used without variable clearance between the rings, but is particularly advantageous with variable clearance, as above described, that the openings in the rings for the passage of fluid between adjacent spaces in the operation of the device be restricted in at least one direction and that in one dimension they

should not exceed 0.080 inch and in general should not be less than about 0.007 to 0.010 inch. A minimum dimension of from 0.010 to 0.050 inch is preferred. If restricted in one dimension, it is not necessary that they be restricted in the other, except as convenience dictates. The perforations may be circular, in which case their dimensions are the same in all directions, or they may be rectangular or oval in shape. Rectangular perforations or slots 0.040 inch wide and 0.150 inch long, for example, have been found to be suitable. The length of the perforations or slots may be up to 0.5 inch or greater if desired. Assuming perforations of the same size throughout, the total area of the perforations in each ring and therefore the number of perforations may be the same and excellent results are secured. However, it is found that the results are greatly improved if the total area of perforations or number of perforations in the successive rings be decreased with enlarged radius of the rings. It has been found desirable, for example, to vary the number of perforations and therefore the area of the perforations in the different rings as an approximate inverse function of the radii of the rings, say as an inverse function of a power of the radius of from about 0.5 to 2.

The variable clearance between rings is illustrated (but not necessarily with mathematical accuracy) in the spacings of the ring as shown in section in Fig. 1 and also in enlarged scale in the fragmentary sectional view Fig. 2. It is likewise illustrated in perspective in Fig. 3. Figs. 4 and 5 illustrate the size and spacing of perforations on a small or inner ring and may be compared with Figs. 6 and 7, which illustrate the size of ring and spacing of the perforations for a larger or outer ring.

The following table is illustrative of the application of the present invention in a particular case, using rings 4 inches wide and with a rotor of 24 inches diameter having 19 rings. In the table, of adjacent pairs of columns, the first column gives the outside diameter of each ring and the second column the total number of perforations in the ring. In this case each perforation was substantially rectangular and was 0.040 inch wide and 0.150 inch long.

Table

Diameter of Ring (in.)	Number of Perforations	Diameter of Ring (in.)	Number of Perforations
8.490	342	15.420	225
9.640	321	15.850	219
10.600	306	16.200	213
11.425	294	16.650	207
12.155	282	17.020	201
12.815	270	17.388	195
13.415	261	17.725	189
13.970	252	18.055	186
14.485	243	18.375	180
14.965	234		

The innermost or in some cases, the outermost ring may be regarded as having the function of screens, in which case they may depart from the arrangement above described as to size or relative area of openings or both.

In the form illustrated, the rotor rings are shown as of uniform width. It will be understood, however, that the rings may be reduced in width with increasing radii, in which case the sides of the rotor will be given a conical form.

The operation will be more clearly apparent from a consideration of Fig. 8, in which the parts are shown somewhat diagrammatically, the same

numbers being applied as in the preceding description in connection with Fig. 1. As shown in Fig. 8, the rotor is made up of the side disks 31 and 32 mounted on the rotor shaft 19 and the space between them is closed at the outside by the ring 36. The rings 42 in the working space of the rotor are spaced and perforated as above described. The heavy liquid, which may be, for example, an aqueous liquid containing a constituent to be extracted by a lighter immiscible solvent, is introduced through the opening 61 and the conduit 46 and passes through the hole 48 drilled in the rotor shaft 19 to enter the working space of the rotor within the inner ring. As the rotor is rotated, the heavy liquid is driven by centrifugal force outwardly through the perforations in the rings 42 against the movement of the light liquid, which is forced under pressure in the opposite direction. The light liquid enters at the opposite end of the rotor shaft through the opening 71 and the conduit 70, and passes through the holes 73 and the radial tubes 38 into the working space in the rotor outside of the outermost ring 42. The pressure placed upon the lighter liquid is such as to force it to enter the rotor and pass inwardly countercurrent to the movement of the heavy liquid. The lighter liquid may be any suitable liquid lighter than the heavy liquid and immiscible or having only a limited miscibility with the heavy liquid, the lighter liquid being selected as a solvent suitable for removing the constituent to be extracted, which may be either a desired valuable constituent or an undesired constituent from the heavy liquid.

The heavy liquid, after it has been forced outwardly through the working space of the rotor, jetting through the openings in the rings countercurrent to the passage of the lighter liquid there-through, collects in the outer portion of the working space of the rotor and passes through the radial tubes 39, the holes 80 drilled in the rotor shaft, and the annular space or conduit 78 to the chamber 79 in the outer cap member 72 and is discharged through the conduit 84.

The light liquid, which is passed through the working space of the rotor countercurrent to the movement of the heavy liquid and has extracted from the latter its valuable constituent, passes out of the rotor space through the holes 65 drilled in the rotor shaft to the annular space or conduit 49 and thence to the chamber 62 formed within the outer cap 59. It discharges from chamber 62 through the conduit 85.

It will be understood of course that under some circumstances the roles of the two liquids are reversed and the constituent to be extracted may be present in the lighter liquid while the heavier liquid serves as a solvent to effect its extraction.

In the form illustrated, the distribution of the perforations in the partitioning rings 42 within the rotor space is substantially uniform over the surface of the ring. This however is not essential, since their distribution may be random or they may be arranged in groups. However, approximately uniform distribution as illustrated is preferred in that it tends to minimize flow in a direction transverse to the radii of the rings. The area of the openings is but a small proportion of the total area of the rings in which they are formed. In general, the area of the openings of the innermost ring should not be over 5% of the total operating area of the ring, decreasing with the increasing radii of the outer rings. Thus, in the case illustrated by the table above set forth, the actual operating width of the rings being

in the order of 3.75 inches, the openings in the innermost ring had a total area amounting to approximately 2% of the total working area of the ring. This proportion was very much reduced in the outer rings.

It will be observed that the openings are not capillary in size. They should have a minimum dimension of from 0.007 to 0.080 inch. The maximum dimension or length of the openings may vary. Circular openings, or elliptical or rectangular slots up to one-half to one inch in length have been found satisfactory. In operation, the primary contacting effect appears to be secured by jet action through openings of such limited size, which brings about a fine subdivision and intimate intermingling of the heavier and lighter liquids. It has not been determined whether the liquids are projected in opposite directions through the same openings or through different openings; but however the action takes place, the resulting interfacial contact is extremely effective.

The action that takes place is complicated by swirl effects due to the momentum of the liquids resulting from the rotational movement of the device imposed upon their radial movement. This swirl effect may have some beneficial action in securing a more effective countercurrent contact but as now appears, is not a primary factor in that direction. A primary function performed by the spaces between rings is that of permitting separation of the heavier and lighter liquids which have been subjected to violent intermingling and agitation as a result of their passage through the perforations or openings. Some circumferential movement of the liquids may be set up, due to the rotation of the device, resulting in some surface contact between separated liquids, such as was secured in the device of my prior patent hereinbefore referred to. Such surface contact between separated liquids is believed not to be an important factor in the operation of the present device and indeed may be reduced or prevented by the insertion of barriers at intervals in the spaces between the rings. Such barriers may be solid partitions or may be of very fine screening or multiple folds of screening. Such barriers are illustrated in Fig. 3 as folds of fine screening designated by numeral 90. Thus the insertion of such barriers in the spaces between the rings 42 at angular intervals of 90° causes no diminution in the effectiveness of the contact action secured in the operation of the device.

The operation of the device as hereinbefore described secures extremely effective countercurrent contact efficiency. In testing the efficiency of such device, it has been found that the contacting of a solution of n-butyl amine in water with kerosene and the extent of removal of the amine from the water provides an effective experimental means of testing the equipment and determining the number of stages secured. With a device such as that described above, the size and number of rings and number of perforations being as set forth in the table above given, it has been found that, operating at about 4,000 R. P. M., as high as 10 stages of efficiency are secured with a combined flow of up to 1,200 gallons per hour. Both in efficiency and capacity, the effectiveness is in the order of two times or more than that of prior centrifugal countercurrent contacting devices.

The apparatus is particularly effective for use in such processes as the separation of antibiotics such as penicillin, aureomycin and the like from the aqueous solutions resulting from the fermentative processes in which they are pro-

duced. The apparatus has been found particularly useful in the extraction of penicillin since very high contacting efficiency and solvent extraction effect is secured with exceedingly rapid traverse of the liquids through the equipment, the actual time involved in the operation being very small. This is of great importance, since, under the conditions under which the solvent extraction of the penicillin must be effected, a progressive destruction of the penicillin with time takes place and it is extremely important that this be reduced to a minimum. Thus, by means of the device of the present invention, it has been found possible to secure the extraction of penicillin with a suitable solvent with an efficiency of 6 or more stages and handling combined streams amounting to 1500 to 2000 gallons per hour with retention times as low as 15 to 30 seconds.

The apparatus may likewise be used for contacting liquids with vapors in apparatus suitably equipped with devices for the admission and withdrawal of the liquids and vapors under treatment, for example, as illustrated in my prior Patent No. 2,209,577, granted July 30, 1940. In such apparatus the jet action or high velocity effect secured in the passage of the liquid through the small openings of the device of the present invention is extremely effective in securing a high degree of intimate contact with the vapors passing countercurrent thereto.

Although the present invention has been described in connection with devices embodying the same, it is to be understood that the invention is not to be limited to the details thereof, except insofar as included in the accompanying claims.

I claim:

1. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings within the rotor and forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.007 to 0.080 inch and through which, on rotation of the rotor, the liquids are forced to pass as jets, the spacing between adjacent rings varying as an inverse function of a power of the radius from 0.5 to 2.

2. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings within the rotor and forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.007 to 0.080 inch and through which, on rotation of the rotor, the liquids are forced to pass as jets, the spacing be-

tween adjacent rings varying as an inverse function of the radius.

3. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings within the rotor and forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.007 to 0.080 inch and through which, on rotation of the rotor, the liquids are forced to pass as jets.

4. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings within the rotor and forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.010 to 0.050 inch and through which, on rotation of the rotor, the liquids are forced to pass as jets.

5. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings within the rotor and forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.007 to 0.080 inch through which, on rotation of the rotor, the liquids are forced to travel as jets, the number of said openings in successive rings varying as an inverse function of a power of the radius from 0.5 to 2.

6. Apparatus as set forth in claim 5, wherein the number of openings in successive rings within the rotor varies as an inverse function of the radius.

7. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spacing concentric partitioning rings within the rotor and forming a plurality of spaces therebetween, each of said rings being provided

with openings distributed over the surface area of the rings, through which, on rotation of the rotor, the liquids are forced to pass as jets, all of the said openings having one dimension of from 0.007 to 0.080 inch, the spacing between adjacent rings varying as an inverse function of a power of the radius from 0.5 to 2 and the number of said openings in successive rings varying as an inverse function of like powers of the radius.

8. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings between the rotor and forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.007 to 0.080 inch and through which, on rotation of the rotors, the liquids are forced to pass as jets, and barriers at intervals within the spaces between said rings to limit circumferential movement of liquids therein.

9. In centrifugal countercurrent contact apparatus for effecting intimate contact between fluids of different densities, at least one of said fluids being a liquid, means for supplying heavier fluid to and means for removing lighter fluid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter fluid into and means for discharging heavier fluid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings within the rotor and forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.007 to 0.080 inch and through which, on rotation of the rotor, the fluids are forced to pass with high velocity, the number of such openings decreasing in successive rings of increasing radius and the total area of the openings in the innermost ring being not over 5% of the operating area of the ring.

10. The apparatus of claim 9, wherein the spacing between concentric rings decreases with increasing radii of the rings.

11. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings within the rotor forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.007 to 0.080 inch and through which, on rotation of the rotor, the liquids are forced to pass as jets, and a screen ring within the innermost of said rings, said screen ring being perforated whereby it serves to screen liquids passing therethrough.

12. In centrifugal countercurrent contact apparatus for effecting intimate contact between immiscible or partially immiscible liquids of different densities, a rotor having an interior working space, means for supplying heavier liquid to and means for removing lighter liquid from the interior of the rotor in the proximity of the axis thereof, means for forcing lighter liquid into and means for discharging heavier liquid from the interior of the rotor in the proximity of its periphery, spaced concentric partitioning rings within the rotor forming a plurality of spaces therebetween, each of said rings being provided with openings distributed over the surface area of the rings, all of which openings are small and have one dimension of from 0.007 to 0.080 inch and through which, on rotation of the rotor, the liquids are forced to pass as jets, and a screen ring within the rotor and outside the outermost of said rings, whereby said screen ring serves to screen liquids passing therethrough.

WALTER J. PODBIELNIAK.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
2,176,982	Thayer	Oct. 24, 1939
2,281,616	Placek	May 5, 1942
2,286,157	Podbielniak	June 9, 1942
2,291,849	Tomlinson	Aug. 4, 1942