Sept. 5, 1939. W. J. PODBIELNIAK 2,172,222

CENTRIFUGAL FLUID-TREATING APPARATUS AND SEAL

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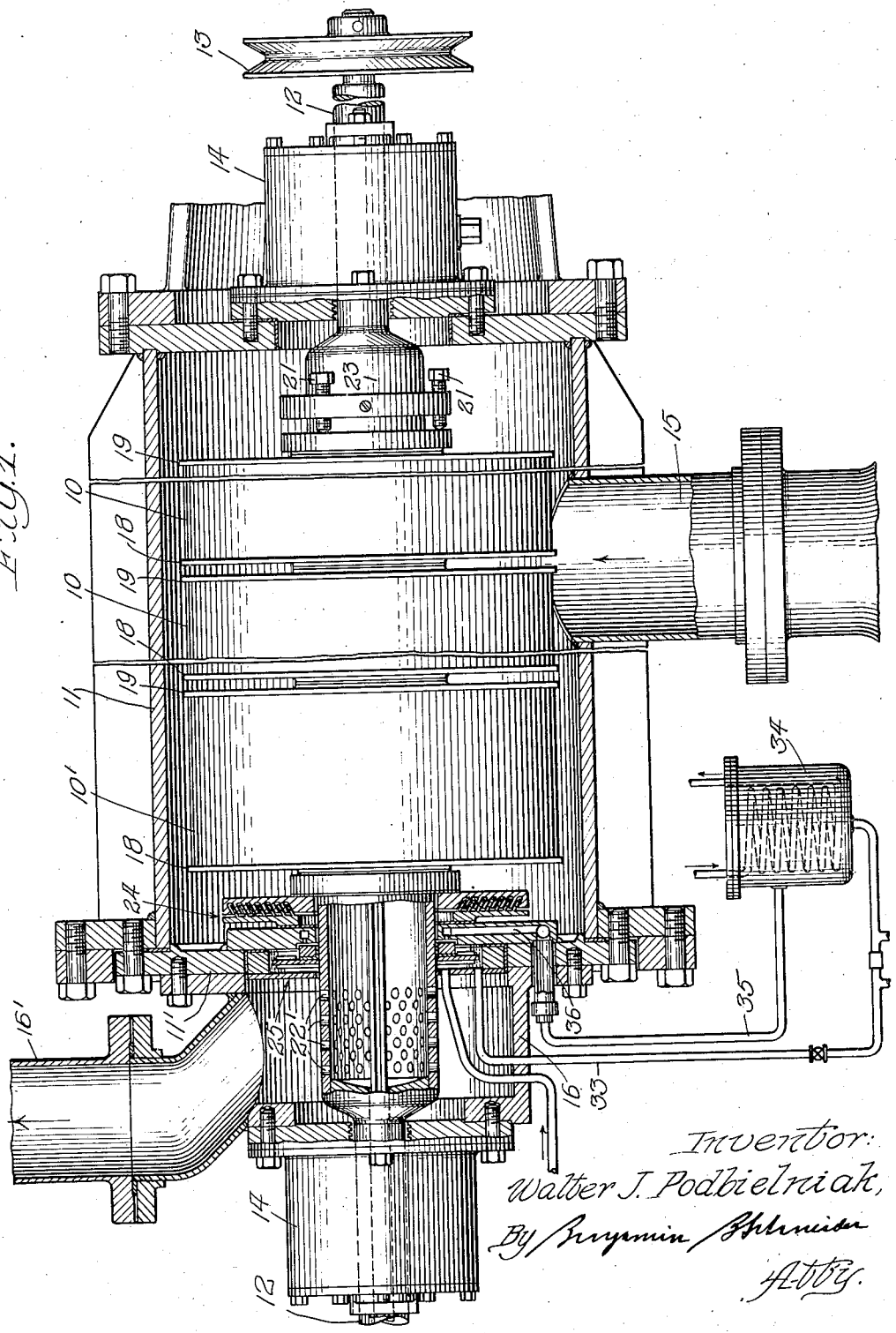


FIG. 1.

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Fig. 2.

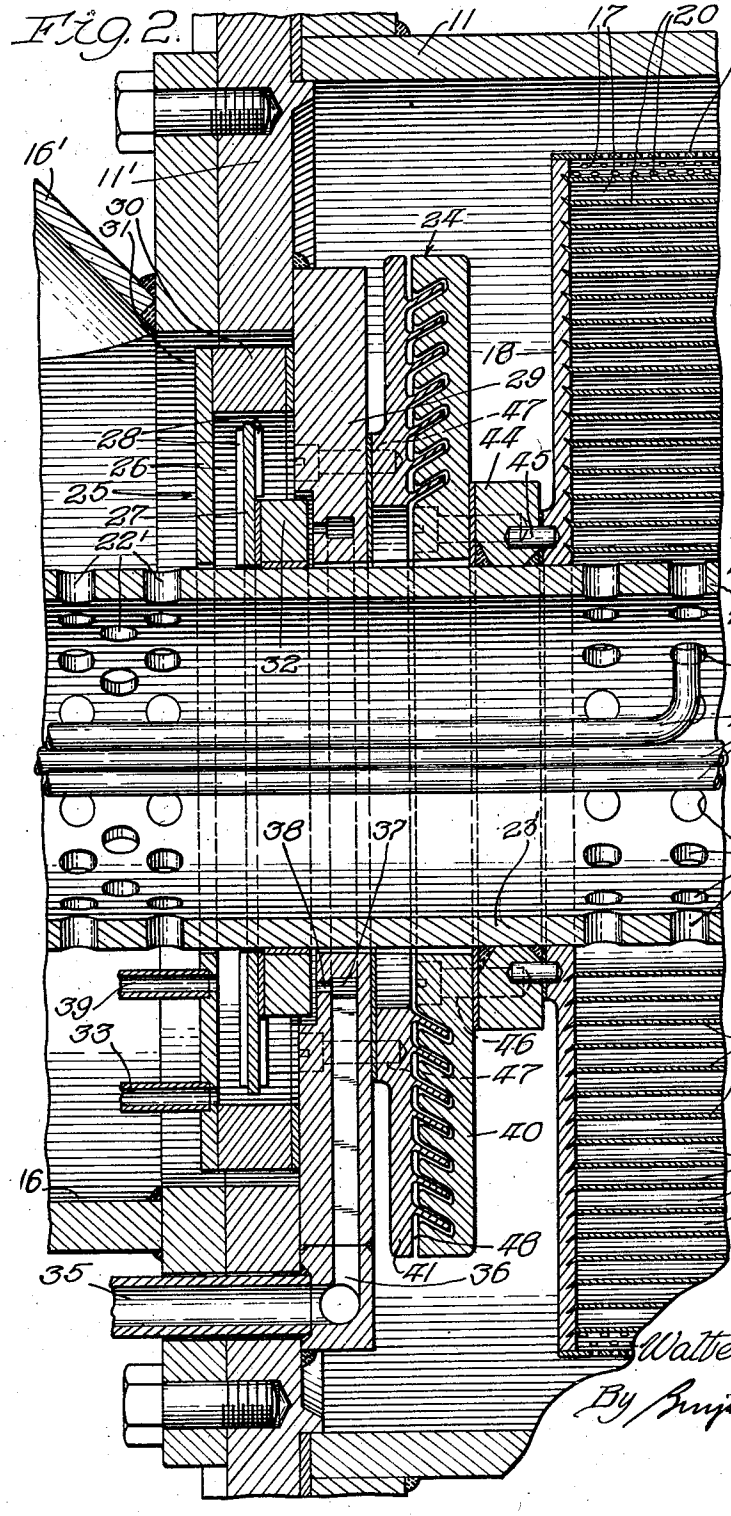


Fig. 3.

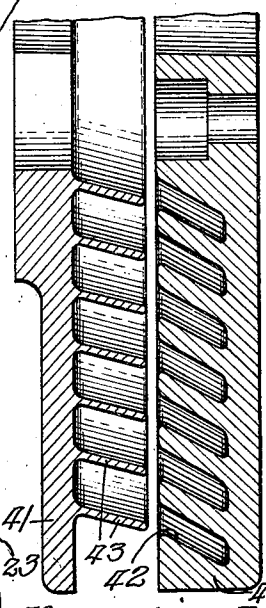
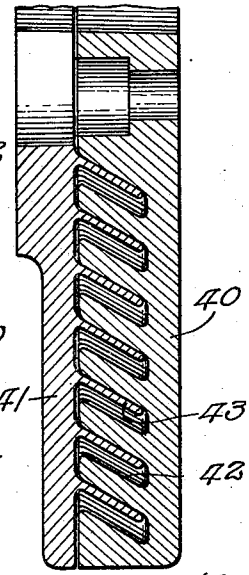


Fig. 4.



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UNITED STATES PATENT OFFICE

2,172,222

CENTRIFUGAL FLUID-TREATING APPARATUS AND SEAL

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Application August 5, 1937, Serial No. 157,516

10 Claims. (Cl. 261—83)

The present invention relates to improvements in the method and apparatus for effecting counter-current exchange between fluids, as between liquids and vapors or gases, or between liquids of different densities that are more or less completely immiscible; and more particularly to sealing devices for use in connection therewith and with other devices having rotatable parts such as centrifugal fractionating apparatus, centrifugal pumps, turbines and like apparatus.

In my prior Patent No. 2,004,011 issued June 4, 1935, and my prior applications Serial No. 5,059, filed February 5, 1935, and Serial No. 19,327, filed May 1, 1935, which applications have issued as Patent 2,093,645, dated Sept. 21, 1937, and Patent 2,044,996, dated June 23, 1936, respectively, and in my prior application to a Centrifugal treating apparatus Serial No. 87,224, filed June 25, 1936, I have described methods and apparatus for the counter-current treatment of fluids of different densities for reaction, gas absorption, fractional distillation or heat exchange purposes, etc. wherein a more effective counter-current treatment and more accurate fractionation or distillation may be effected. In employing the methods and apparatus therein set forth, counter-current flow between a liquid condensate or reflux and a lighter fluid or vapor is brought about by means of centrifugal force, the reflux or heavier liquid being caused to flow outwardly through a rotating spiral passageway of increasing radius, counter-current to an inwardly moving lighter fluid or vapor. Thus, a much greater efficiency in fractionation, absorption, chemical or contact action may be secured than in apparatus of the types hitherto known.

The present invention is a continuation-in-part of the invention described and claimed in my prior co-pending application to a Centrifugal fluid-treating apparatus and seal, Serial No. 87,223, filed June 25, 1936. It is related to my co-pending application, Serial No. 87,224, and may be readily adapted to treat air to condition it as therein described and claimed.

In centrifugal counter-current treating apparatus of the type hereinabove described and in like apparatus, I have found it advisable, and in larger apparatus, necessary to use a liquid seal to prevent leakage and by-pass of the gases or vapors and of the reflux passing through the rotor, as the conventional packing constructions such as the stuffing box, spring-held packing rings, etc., leak too rapidly and are not practicable for large diameters, high rubbing velocities and vibrating joints and are not readily constructed to handle corrosive liquids, vapors or gases.

In my prior application Serial No. 87,223, I described and claimed a liquid seal for centrifugal counter-current exchange and fractionating apparatus, centrifugal pumps, turbines and the like which would operate effectively for liquids of a large range of densities, internal pressures, viscosities and surface tensions, such as water, salt water solutions and glycerine, aromatic hydrocarbons such as benzene, toluene, xylene and mixtures thereof, various petroleum fractions, pine oil, coal tars, coal tar acids, and the like. In the operation of such seals, I have found that under some circumstances, such for example, as excessively high pressures or surges of the vapors undergoing fractionation or other treatment from the kettle, some of the vapors may pass directly into the seal and contaminate the seal liquid and ultimately the treated vapors. To overcome this tendency I have provided a seal device which may be employed separately, or conjointly with the aforementioned seal to effectively and substantially completely prevent the by-pass of kettle vapors through the seal regardless of the surging tendencies of the vapors issuing from the kettle and which treats or fractionates any vapors which force their way therethrough, so that any condensate thereof which may form in the seal chamber will not contaminate the seal liquid. The seal device serves in effect as a buffer and fractionator for the vapors or gases in the rotor tending to by-pass through the centrifugal liquid seal and is positioned intermediate the liquid seal and the rotor and in operative relationship with respect thereto.

This seal device may be suitably referred to as a multiple radial labyrinth. It is formed by a pair of opposed relatively movable members one of which is provided with a plurality of concentric, angularly disposed reentrant grooves and the other with a plurality of concentric webs positioned in the grooves. The mutually coacting parts of the seal device form a restricted labyrinth path of great length through which the gases or vapors must first find their way before they can enter the liquid seal chamber. In the movement of the gases through this path, condensation of portions thereof takes place and this condensate serves to cool and fractionate additional vapors tending to pass therethrough. The arrangement of the path is such as to resist the flow of any vapors tending to pass therethrough and in consequence to cooperate with

the liquid seal to enable the latter to withstand high pressure drops across the seal.

This invention possesses many other advantages which may be made more easily apparent from a consideration of an embodiment of the invention. For this purpose there has been shown one form of the invention in the drawings accompanying and forming part of the present specification. This form shall now be described in detail to illustrate the general principle of the invention; but it is to be understood that the invention is not limited to the details thereof, except as set forth in the appended claims.

Referring to the drawings:

Figure 1 is a diagrammatic view, with parts in section and partly broken away, of apparatus suitable for carrying the invention into effect;

Fig. 2 is an enlarged fragmentary sectional view thereof showing the construction of both the centrifugal liquid and labyrinth seals;

Fig. 3 is an enlarged fragmentary sectional view of the elements comprising the labyrinth seal, showing these elements in position preparatory to assembling the seal; and

Fig. 4 is a similar view showing the relationship of the elements in a subsequent stage of the assembly operation.

In the form of the invention shown in the drawings, a plurality of rotor sections 10 are provided in which the fluids to be treated are brought into contact by a counter-current movement set up by centrifugal force as described in my prior applications and patents. The rotor sections 10 are rotatably mounted within a stationary housing 11 on a hollow hub 23 secured at its ends to horizontally disposed rotatable shafts 12. The power for rotating the shafts 12 and rotors is transmitted from some suitable source to the pulley 13 mounted on one of shafts 12, as by a motor and belt (not shown). The shafts 12 rotate in and are steadied by stationary radial bearings or the like positioned within combination stuffing and bearing boxes 14. The housing 11 is fluid-tight and is provided with an inlet 15 through which the light fluid or vapor undergoing treatment enters.

The rotor sections 10 within the housing 11 are each provided with a passageway 17 (see Fig. 2) of increasing radius which opens at its outer turn within the casing 11. The passageway may be a spiral or of other suitable form, for example, properly communicating concentric passageways. Each rotor section 10, the first being designated 10', is in the form of a drum and is provided with circular end plates 18 and 19 between which the turns of the spirally wound sheets 20 are retained to form the spiral passageway 17. The edges of the spirally wound sheets 20 are forced into spiral grooves in the opposed faces of the end plates 18 and 19 to form fluid-tight joints as shown in my prior applications and the assemblies of the rotors are retained in a unitary structure as by the end pressure bolts 21.

A perforated shell 20' surrounds each rotor section and is secured to the end plates 18 and 19 in any desireed manner as by a weld. The perforations in shells 20' are of a size and number to permit the ready ingress of the vapors from the casing 11 to the spiral passageways. The innermost turn of each passageway 17 opens adjacent the cylindrical hub 23, which is provided within the rotor sections with series of openings 22 for the passage of fluids into and out of the rotor sections. The hub 23 extends beyond the casing 11 through an opening in end plate 11', into a chamber 16 provided with outlet 16'. The portion of the hub 23 outside of the rotor section 10' and intermediate this section and the chamber 16 is imperforate and provides a passageway for the fluid passing from the rotor to the outlet 16 as well as for the reflux or heavier fluid passing into the rotors. It is now apparent that the vapors, gases or other light fluid will pass under a suitable pressure differential through the inlet 15 into the casing 11 and from it into the spiral passageway 17, transverse the latter and pass out through the openings 22 in hub 23, through the imperforate portion of hub 23 outside of the rotor section, through openings 22' in hub 23 and through the outlet 16'. From the outlet, the treated vapors or fluids may pass to a condenser or other receiving device.

Heavy fluid supplied to the apparatus, for example, or condensate or reflux in a fractionation operation, or the absorption or counter-current exchange fluid is made use of in a sealing device to prevent the escape of vapors between the housing 11 and the outlet 16' and to prevent the vapors issuing from the apparatus without first being treated in the rotor sections. In fact, this sealing device may include a liquid centrifugal seal 25 of the vane and recess type as described in my prior application Serial No. 87,223. In addition, I provide a form of seal, which for convenience may be called a labyrinth seal, designated as a whole by the numeral 24, which is positioned within the housing 11, suitably adjacent the centrifugal seal, designated as a whole by the numeral 25, and in the path of the vapors between the housing 11 and the seal 25. Seal 24 serves to prevent direct communication between the gases or vapors in housing 11 and seal 25 or the exterior of the housing and is adapted to modify the character of gases or vapors passing therethrough for a purpose and in a manner to be hereinafter more fully described.

The seal 25 is of the type described in my prior application Serial No. 87,223 and is formed with an annular liquid seal chamber 26 between the casing 11 and the exit chamber 16 and surrounding the imperforate portion 23' of hub 23. This chamber receives liquid, such as vapor condensate or other suitable liquid, which in operation forms an annular body of sealing liquid, into which extends an intermediate rotating vane 27 dividing the annular chamber. The vane 27 is secured to the imperforate portion 23' of hub 23 between the hub openings 22 and 22' and rotates therewith. Ribs 28 may be suitably formed on one or both sides of the vane to aid in imparting motion to the seal liquid. The rotatable vane propels the liquid centrifugally to form an annular body in the seal chamber and the outer end of the vane extends into the body of seal liquid to keep it in motion during operation and prevents the by-pass of fluids passing through the apparatus.

The seal chamber 26 may be suitably supported by a stationary annular plate 29, which is secured, suitably by welding, to the inner faces of end or cover plate 11' and forms one side of the chamber 26. The inner opening of plate 29 is of somewhat larger diameter than the outside of the hub 23. A ring 30 is secured to plate 29 and forms the peripheral wall of the chamber, and an annular plate 31 is secured to ring 30 to form the other side of the chamber. A collar 32 may be secured as by a drive fit to hub 23 adjacent to vane 27 for a purpose to be described. This

collar extends into a recess in member 29 with a sufficient clearance to form a passageway to the seal chamber 26.

As set forth in my prior application Serial No. 87,223 a liquid seal of the character described operates effectively with proper clearances between the vane 27 and the opposed faces of the seal chamber 26 and with various sealing liquids. As therein set forth, these clearances may vary between the limit of three-eighths of an inch and five-eighths of an inch.

For example, a seal of the type shown in the drawings in which the inside diameter of the vane is in the order of four inches, its outside diameter in the order of nine inches and with cleats or ribs on the upper and lower side of the vane in the order of one-eighth of an inch in height, the seal will operate effectively at a clearance in the order of five-eighths of an inch between the vane and the opposed faces of the seal chamber when the vane is rotated in the order of 1200 to 2000 R. P. M. with any liquid likely to be distilled in the chemical industry, including water and hot gasoline, and is capable of resisting pressure drops of from ten inches to fifteen inches and more of mercury. Obviously, the ability of the seal to resist pressure drops is dependent upon the specific gravity of the liquid used in the seal; the greater the specific gravity of the liquid, the greater the centrifugal pressure at the periphery of the seal and hence, the greater the pressure drop that can be resisted.

It is obvious that these clearance limits as above set forth may be somewhat varied, depending upon the dimensions of the seal, the surface tension of the liquid used and the speed of the moving parts, without destroying the operativeness of the seal.

As the seal chamber 26 communicates with the interior of the casing there is a tendency for the vapors or gases in the latter to diffuse through the passageway entering the seal chamber and condense in the relatively cold liquid of the seal, thus contaminating the seal liquid, impairing the effectiveness of the seal, and ultimately contaminating the condensed fractions of the distilled vapor. As set forth in my prior application Serial No. 87,223, above referred to, I have found that this can be effectively prevented either by continuously withdrawing a small amount of seal liquid under the full pressure of the periphery and flashing it at a point in the path of the vapors entering the seal; or preferably by continuously withdrawing a portion of the liquid from the seal, vaporizing it and continuously introducing the vaporized liquid at a point inside the liquid level of the seal on the side toward the casing.

As illustrated in the drawings, the seal liquid under the full pressure at the periphery may be bled through conduit 33 and vaporized in a vaporizer or heater 34 which may be heated in any convenient manner, as for instance by steam, electricity or gas firing. The liquid is vaporized and the vapors conducted through return conduit 35 and a radial passageway 36 in plate 29 and subsequently into an annular chamber 37 formed in the plate 29. The vapor then enters the high pressure side of the seal chamber through a passageway 38 leading to the small clearance space between the collar 32 and the member 29. This clearance space, which is also the only passageway through which vapors from the casing may enter the seal, is advantageously made quite small so that a minimum amount of vapor will serve to counteract effectively the diffusion of vapors from the casing into the seal chamber. Clearances in the order of one-sixteenth of an inch and even less have been found quite effective. As vapors of the seal liquid are thus used to counteract the diffusion of the kettle vapors, condensation of any part thereof within the seal will not contaminate the seal liquid. The uncondensed portion may force its way into the stationary housing 11 through the labyrinth seal 24 and may be returned to the kettle through a suitable trapped return pipe (not shown). In order to prevent the withdrawal of an unnecessary quantity of liquid from the seal chamber, the rate of flow can be determined by a flow-meter in the line 33 and controlled by a valve as shown and described in my prior application, Serial No. 87,223.

In a fractional condensation process, the centrifugal seal operates under non-equilibrium conditions. As the body of liquid on the inner side of the vane 27 is subjected to the pressure of the vapors in the kettle and the vapors from the vaporizer 34, it is obvious that the level thereof, centrifugally considered, is further removed from the axis of rotation of the rotor than the level of the liquid on the outer side of the vane. In addition, the liquid on the inner side of the vane is heated by both the kettle vapors and the vapors from the vaporizer 34 whereas the liquid on the outer side of the vane is positively cooled with added reflux to overcome the effect of heat transfer through the rotating vane and otherwise, and to cool the body of liquid to improve its sealing properties. To accomplish this, reflux liquid from the condenser flows through a conduit (not shown) and a regulated quantity thereof is introduced into the upper part of the seal as by a pipe 39 which enters the outer side of the seal chamber through the member 31 of the seal chamber at a point adjacent the desired level of the liquid. This added reflux serves both to maintain the desired cooled relationship of the liquid on the outer side of the vane and to maintain the liquid at the desired level. It is obvious that the liquid level on the inner side of the vane is a function of the liquid level on the outer side of the vane and the pressure difference across the seal. This added condensate may serve to build up the body of liquid in the seal chamber to an excessive level. If this takes place, the added built-up pressure of the liquid on the outer side of the vane urges some of the liquid through the reflux control pipe 39 against the pressure of the reflux entering the pipe until the desired level of the liquid is restored. The desired liquid level is thus automatically maintained at all times during operation of the device. It is thus apparent that the desired non-equilibrium conditions are continuously maintained throughout the operation of the device.

In counter-current exchange operations such as fractional distillation, gas absorption, heat exchange and the like, the centrifugal liquid seal 25 serves efficiently to prevent the by-pass of vapors or gases from the casing 11 and thus prevents the contamination of the seal liquid and the ultimate contamination of the treated vapors or gases passing through the outlet 16'. It may be desirable, however, to provide an additional seal or partial sealing means, referred to above as the labyrinth seal 24, within the casing and intermediate the liquid seal and the rotors, to assist liquid seal 25 to take care of all or part of the pressure drop between the interior of the rotors and the outlet 16' and at the same time to impede the passage, by diffusion or otherwise,

of vapors tending to find their way therethrough. In this manner by-pass of the vapors from the casing, regardless of pressure is substantially entirely prevented and in instances where vapors find their way through the labyrinth seal and into the liquid seal, these vapors have been so treated in their passage through the labyrinth seal that they are substantially free from any undesirable constituents and hence condensation of these vapors in the seal liquid of the centrifugal seal will not contaminate the latter and neither will the vaporization of the seal liquid and the consequent intermingling of these vapors with the treated vapors passing through the outlet contaminate these treated vapors.

As stated above seal 24 is located within the housing 11 and comprises a pair of opposed relatively movable members 40 and 41 (see Figs. 2, 3 and 4). Member 40 is in the form of an annular plate and is provided with inclined concentric grooves 42 in one face thereof. The grooves 42 are inclined outwardly to form annular pockets in which liquid is held by centrifugal force during operation. Member 41 is likewise in the form of an annular plate and is provided with inclined projecting concentric webs 43 which extend into grooves 42 substantially equidistant from the sides thereof to form inclined concentric sealing passageways for a purpose to be described hereinafter.

Member 40 is rotatable by and with the rotor whereas member 41 is stationary. To accomplish this I secure a collar 44 to hub 23 in any desirable manner, as by a weld, and may also secure collar 44 to the end plate of rotor section 10' as by dowel pins 45. Member 40 is then secured to collar 44 as by bolts 46. Member 41 is secured to stationary member 29 as by bolts 47. Suitable packing is provided between parts thus secured together to prevent leakage.

The method of forming this labyrinth seal will be readily apparent from consideration of Figs. 3 and 4. Member 41 is formed with the concentric webs 43 at a slightly lesser angle to the axis than in the desired final position. Member 41 with its projecting webs 43 is first positioned above the grooves 42 in member 40 as in Fig. 3 and the webs are then inserted in the grooves 42 to permit telescoping of the parts, which is accomplished by the application of substantial pressures. In the first stage of the telescoping of member 40 and 41, the edges of webs 43 contact the inclined inner walls of grooves 42 and upon the application of continued and sustained force, the webs 43 are forced outwardly and into the grooves and the parts are fully telescoped as shown in Fig. 4. After members 40 and 41 are in this position they are axially separated until the webs 43 are positioned intermedaite and preferably substantially centrally of the grooves 42, as shown in Fig. 2.

In this manner I form a multiple labyrinth passageway 48 having a small clearance in the order of one-sixteenth of an inch or less through which the kettle vapors must first pass before they can enter the small clearance space forming the passageway into the centrifugal seal as described above. The long labyrinth passageway 48 with its small clearance serves as a buffer or resister to the flow of kettle vapors therethrough. In addition, in a fractionation operation some of the vapors will condense and the condensate collects in pools at the bottoms of grooves 42 and is retained there by centrifugal force on rotation of plate 40 or pools of liquid may be provided in other counter-current exchange processes and the vapors or gases passing through these pools of condensate will be fractionated or treated (at least to some extent). If some of these fractionated or treated vapors or gases are forced into the centrifugal seal and are condensed in the seal liquid, the latter will not become contaminated, as such vapors or liquids will already be in substantially the final desired condition.

In the operation of the apparatus in accordance with my invention, as fully set forth in my prior applications above referred to, gases or vapors enter the housing 11 and pass through the spiral passageways 17 of the rotor sections. The rotor and its associated parts are rotated to develop a centrifugal force which, dependent on radius and R. P. M., may be several hundred times the force of gravity but the tangential component of which in the path of travel of the two fluids may be approximately equal to the force of gravity or even less, although I prefer that it be substantially in excess of the force of gravity. In general, I have found it advisable to employ conditions of operation, rates of rotation and the like so that the tangential component of centrifugal force effective in the operation to force liquid outwardly through the passageway in the rotor is equivalent to three to five or more times the force of gravity. A speed of rotation of 500 to 2000 R. P. M. or higher in smaller devices has been found suitable. The gases and vapors from the kettle are under pressure such that they pass inwardly through the passageways 17, countercurrent to heavier fluid or reflux entering the hollow shaft 23, through the openings 22 and pass out through opening 22' into chamber 16 and enter exit conduit 16'. The vapors then pass to the condenser. Some of the vapors will, in a fractionation process, condense in passageways 17 to form reflux liquid, or reflux or treating liquid may be supplied to the rotors from the reflux condenser or other external source through the liquid supply conduits 49 (Fig. 2) which extend through the stub shaft 12 adjacent the centrifugal seal. Each conduit 49 feeds reflux or treating liquid directly to a single rotor section 10 and thus insures an adequate and uniform supply of liquid for each rotor section to effect the desired counter-current contact. It is of course to be understood that the number of liquid supply conduits will vary, depending on the number of rotor sections mounted on hub 22 and their size.

The portion of reflux or treating liquid which is required to maintain the desired seal level on the outer side of vane 27 is supplied through a valved line (not shown) to conduit 39.

The reflux or treating liquid then flows directly into the passageways 17. Reflux or liquid entering and formed in the passageways 17 flows outwardly therethrough in a film or sheet against one wall of the passageway, due to centrifugal force, counter-currently to the gases and vapors flowing inwardly therethrough. The relatively denser and heavier liquid therefore contacts and scrubs relatively lighter gases and vapors, the two streams of fluid being brought together intimately at their surfaces of contact by the centrifugal force applied. The liquid then discharges from the rotor sections 10 and collects in the bottom of housing 11 from which it drains back to the kettle through a suitable trapped pipe (not shown).

While I have described the combined novel centrifugal and labyrinth seal as part of an apparatus for effecting counter-current exchange be-

tween fluids such as between liquids and vapors or gases, these seals have general applicability for use in centrifugal pumps where a stuffing box would not be practical as in the handling of hot corrosive fluids, in turbines and in like apparatus, and under certain conditions the labyrinth seal may be used alone to prevent the by-pass of the kettle vapors or to effect sealing. In centrifugal pumps, due to the absence of thermal effects no special provisions are required, such as the vaporizer, to prevent the leakage of gas through the seal liquid by diffusion, solution, etc. The same is true when the seal is used in an apparatus designed for oil absorption purposes.

While my description of a specific embodiment of the invention has included a centrifugal seal of the stationary recess type, it is obvious that the seal may be made of the rotating recess type in which the vane is stationary. This form of seal operates substantially the same as regards break-down of the seal liquid due to pressure differences, velocity gradients etc. In the rotating recess type of seal the ribs or cleats may be formed on the opposed faces of the seal chamber in order to aid in keeping the seal liquid in motion during operation. The stationary recess type of seal is more advantageous from the standpoint of assembly and disassembly and also because of the fact that a rotating vane is lighter and more easily balanced than a rotating recess.

I claim:

1. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid and means forming a passageway between said seal chamber and the housing in which the lighter fluid in the housing tending to flow towards the seal chamber is caused to traverse a tortuous path which resists such flow.

2. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid and means forming a passageway between said seal chamber and the housing in which the lighter fluid in the housing tending to flow towards the seal chamber is caused to traverse a tortuous path of decreasing radius which resists such flow.

3. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means outside the housing forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid and means forming a passageway between said seal chamber and the housing, a portion of said passageway being within the housing, said portion being so constructed and arranged that the lighter fluid therein tending to flow towards the seal chamber will be forced to traverse a tortuous path of decreasing radius which resists such flow.

4. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means outside the housing forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid and means forming a passageway between said seal chamber and the interior of the housing, the entrance to said passageway being within the housing and being in the form of a multiple labyrinth of decreasing radius whereby the tendency of the lighter fluid in the housing to flow towards the seal chamber is impeded.

5. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid, means forming a multiple labyrinth passageway of decreasing radius in communication with the lighter fluid in the housing and means forming a passageway between said first named passageway and the seal chamber, said passageway having a relatively small cross-sectional area and said first named passageway being so constructed and arranged as to impede the flow of lighter fluid tending to enter the seal chamber.

6. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid, means within the housing forming a labyrinth passageway comprising a plurality of coacting relatively movable members, said labyrinth passageway serving to impede the flow of fluid tending to flow therein and means forming a passageway between the labyrinth passageway and the seal chamber.

7. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid

is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means forming a centrifugal liquid seal comprising a chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid, means within the housing forming a labyrinth passageway comprising a plurality of coacting relatively movable members, one of said members being formed with concentric grooves and the other with projecting concentric webs positioned within and substantially centrally of the grooves and forming thereby the labyrinth passageway to impede the flow of any fluid tending to enter therein and means forming a passageway between the labyrinth passageway and the seal chamber.

8. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means for forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid, means within the housing forming a labyrinth passageway comprising a plurality of coacting relatively movable members, one of said members being formed with inclined concentric grooves which is secured to the rotor and adapted to rotate therewith and the other is stationary and is formed with inclined projecting concentric webs positioned within and substantially centrally of the grooves and means forming a passageway between the labyrinth passageway and the seal chamber.

9. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid, means within the housing forming a labyrinth passageway comprising a plurality of coacting relatively movable members, said labyrinth passageway serving to impede the flow of fluid tending to flow therein, means forming a passageway between the labyrinth passageway and the seal chamber, means for withdrawing liquid from the liquid seal chamber and means for vaporizing said liquid and introducing the vaporized liquid in the passageway between the labyringth passageway and the seal chamber.

10. In combination with an apparatus for effecting counter-current exchange between fluids of different densities in which the lighter fluid is caused to flow inwardly through a rotating rotor and counter-currently to a heavier fluid passing outwardly therethrough and in which the rotor is positioned within a stationary housing filled with the lighter fluid, means forming a centrifugal liquid seal comprising a seal chamber into which any liquid likely to be distilled is propelled by centrifugal force to form an annular body of seal liquid and a vane extending into the body of liquid, means within the housing forming a labyrinth passageway comprising a plurality of coacting relatively movable members, said labyrinth passageway serving to impede the flow of fluid tending to flow therein, one of said members being formed with inclined concentric grooves and the other with inclined projecting concentric webs positioned within and substantially centrally of the grooves, means forming a passageway between the labyrinth passageway and the seal chamber, means for withdrawing liquid from the liquid seal chamber and means for vaporizing said liquid and introducing the vaporized liquid in the passageway between the labyrinth passageway and the seal chamber.

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