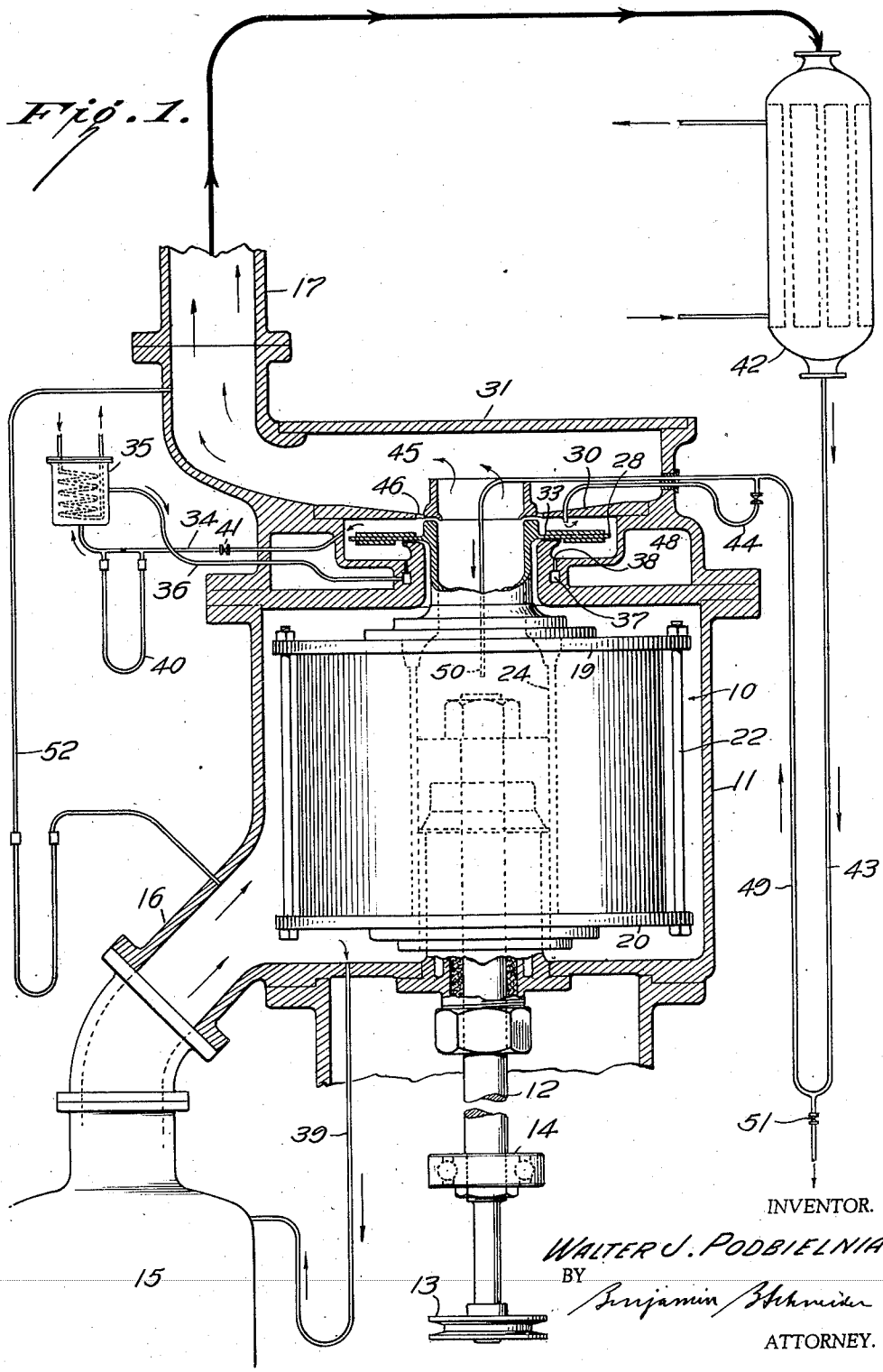
April 11, 1939. W. J. PODBIELNIAK 2,153,640

SEAL FOR CENTRIFUGAL FLUID TREATING APPARATUS

Filed June 25, 1936 2 Sheets-Sheet 1

Fig. 1.



INVENTOR.

WALTER J. PODBIELNIAK,

BY

Benjamin Ehrlich

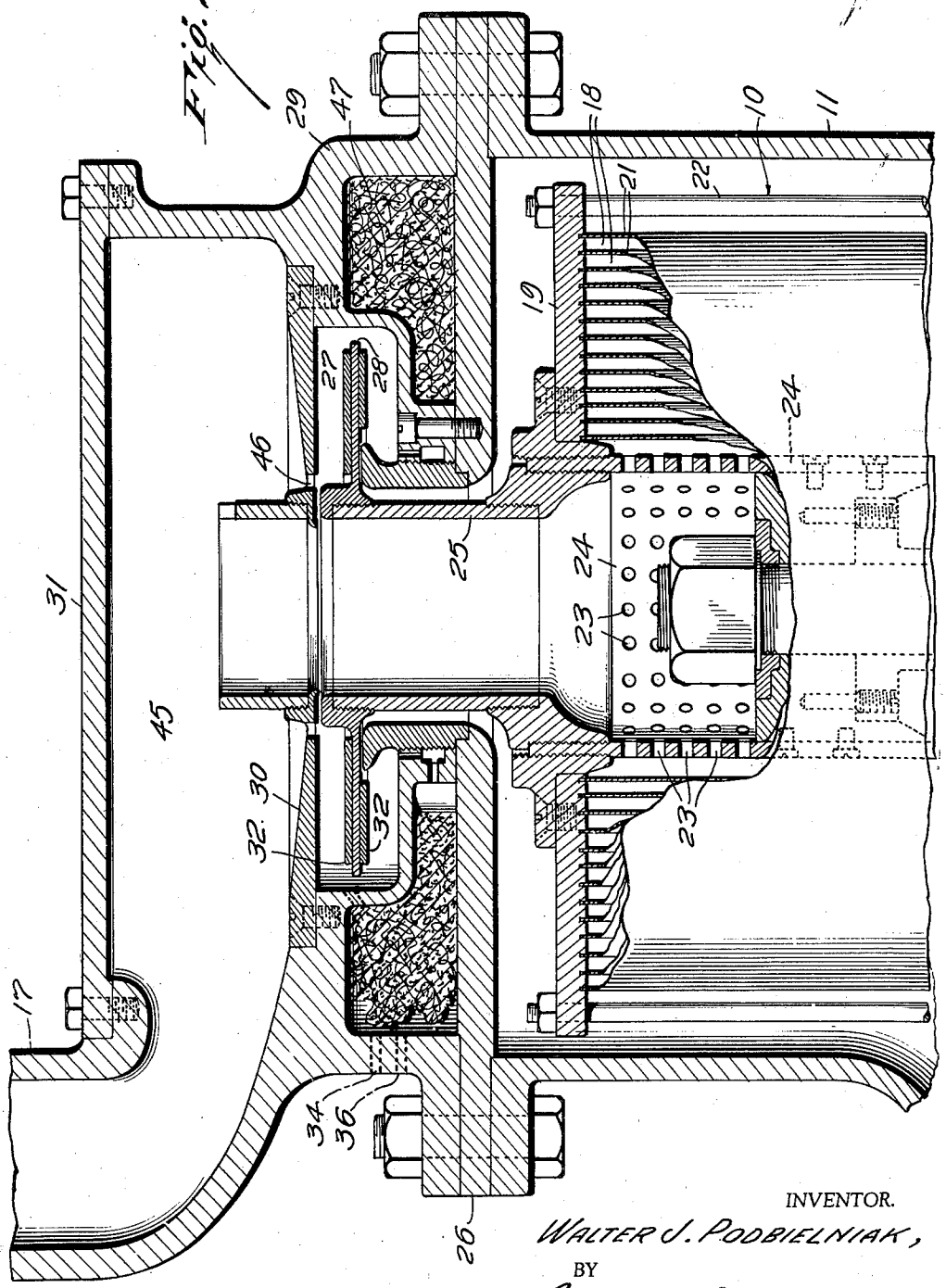
ATTORNEY.

April 11, 1939. W. J. PODBIELNIAK 2,153,640

SEAL FOR CENTRIFUGAL FLUID TREATING APPARATUS

Filed June 25, 1936 2 Sheets-Sheet 2

Fig. 2.



INVENTOR.
WALTER J. PODBIELNIAK,
BY
Benjamin Schneider
ATTORNEY.

Patented Apr. 11, 1939

2,153,640

UNITED STATES PATENT OFFICE

2,153,640

SEAL FOR CENTRIFUGAL FLUID TREATING APPARATUS

Walter J. Podbielniak, Chicago, Ill., assignor to Benjamin B. Schneider, Chicago, Ill.

Application June 25, 1936, Serial No. 87,223

12 Claims. (Cl. 286—9)

The present invention relates to improvements in the art of effecting counter-current exchange between fluids such as between liquids and vapors or gases, or between liquids of different densities that are more or less completely immiscible; and more particularly to a liquid centrifugal seal adapted for use in centrifugal fractionating apparatus, centrifugal pumps, turbines and like apparatus.

Seals of the type embodying my invention may suitably comprise an annular chamber or recess into which a liquid is propelled by centrifugal force to form an annular body of sealing liquid. An intermediate disk or vane divides the annular chamber and its outer extremity is arranged to extend into the sealing liquid to prevent the by-pass of fluids passing through the apparatus. Either the means forming the annular chamber, or the vane can be rotated at a sufficiently high velocity (from 500 to 2000 R. P. M. or higher) to centrifugally propel the sealing liquid into the annular chamber or recess.

In my prior Patent No. 2,004,011, issued June 4, 1935, and my prior application Serial No. 5,059, filed February 5, 1935, now Patent No. 2,093,645, issued September 21, 1937, and Serial No. 19,327, filed May 1, 1935, now Patent No. 2,044,996 issued June 23, 1936; and in my copending application for a Centrifugal fluid treating apparatus Serial No. 87,224 filed June 25, 1926, 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. where 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 thereby caused to flow outwardly through a 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 accordingly be secured than in apparatus of the type hitherto known.

In centrifugal fractionating apparatus of the type hereinabove described and in like apparatus, it is essential to use a liquid seal to prevent leakage and by-pass of the kettle vapors and reflux passing through the rotor as the conventional packing constructions such as the stuffing box, carbon spring-held packing rings, labyrinth rings etc. leak too readily and are not practicable for large diameters, high rubbing velocities and vibrating joints; and, in instances where a centrifugal pump is used, to handle hot corrosive liquids. Liquid seals of either the stationary or rotating recess type work quite satisfactorily at substantially all clearances between the relatively moving parts when the seal is established by water, salt water solutions and glycerine. In such seals with a clearance between the relatively moving vane and recess in the order of approximately one-eighth of an inch, a perfect seal is maintained at speeds in the order of 2000 R. P. M. and pressure differences across the seal of about 6 to 10 pounds. However, if liquids other than water, salt water solutions and glycerine are used to establish the seal, the seal will not operate at all under the same conditions unless the clearance between the relatively moving vanes and recess is critically maintained. Thus I have found that liquids both heavier and lighter than water, ranging from carbon disulphide and carbon tetrachloride to benzine and kerosene, and liquids more or less viscous ranging from lubricating oil to benzene or kerosene; and liquids even of the same viscosity as water, will not operate at all to establish a seal at a clearance in the order of one-eighth of an inch, but permit fluids to rush around the seal. With liquids likely to be distilled other than water, salt water solutions and glycerine it is not possible to maintain an unbroken liquid body between the relatively moving vane and recess as any clearance, when operating at high speeds, at these liquids immediately tear, disrupt and channel, thus permitting fluid to rush around the seal. I presume this is due to the fact that the velocity gradient between the relatively moving parts of the seal overcomes the surface tension of the liquid used to establish the seal.

I have found that either the stationary or rotating recess type of seal can be designed to operate perfectly when utilizing any vaporizable liquid, as for example one likely to be distilled, to establish the seal and maintain an unbroken liquid body between the relatively moving parts thereof at operating speeds. Surprisingly enough, this may be made possible by increasing the clearance between the relatively moving vane and recess of the seal sufficiently that the change of velocity gradient between the relatively moving parts is low enough to maintain the desired unbroken liquid body, and at the same time the clearance must not be so great that the moving part of the seal will not keep the liquid seal body

in motion. Clearances between the relatively moving parts of the seal, in the order of three-eighths of an inch to five-eighths of an inch and slightly more or less will maintain a perfect seal with all vaporizable liquids at operating speeds (about 2000 R. P. M.) and with pressure differences across the seal in the order of 6 to 15 pounds and up to 30 pounds or more.

It is therefore within the purview of my invention to provide a liquid seal for a centrifugal fractionating apparatus, centrifugal pump, turbines and the like which will operate with all vaporizable liquids, as for instance water, salt water solutions and glycerine, as well as liquids heavier or lighter and more viscous or less viscous than water, and also for hot corrosive liquids.

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 this detailed description is not to be taken in a limited sense, since the scope of the invention is defined by the appended claims.

Referring to the drawings:

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

Fig. 2 is an enlarged fragmentary sectional view thereof, with parts in elevation, showing the construction of my novel liquid seal.

In order that the details of design and construction of my novel centrifugal seal may be readily understood, it will be described in connection with the embodiment of my invention shown in Figs. 1 and 2 and a process of treating vapors wherein vapors from a vaporizing still or receptacle are charged into the apparatus and passed counter-current to reflux or condensate travelling outwardly therein.

In the drawings, a rotor 10 is provided in which the fluids to be treated are brought into contact by a counter-current movement set up by centrifugal force. The rotor 10 is within a stationary housing 11 and is mounted for rotation on a vertical rotatable shaft 12. The power for rotating the shaft 12 is transmitted from any suitable source to the pulley 13 as by a motor and belt (not shown). The shaft 12 rotates in and is steadied by a stationary radial bearing 14. The vapors from a suitable still or kettle 15 are introduced into the apparatus through the inlet 16. The housing 11 is fluid-tight and is provided with an upper centrally disposed opening through which communication is established between the interior of the rotor 10 and the outlet 17 for the treated vapors in a manner to be described.

As stated above, the rotor 10 is located within the housing 11 and is provided with a spiral passageway 18 of increasing radius which establishes communication between the inlet 16 and the outlet 17. The rotor 10 is in the form of a drum and is provided with circular end plates 19 and 20 between which the successive turns of the spirally wound sheet 21 are retained to form the spiral passageway 18. The edges of the spirally wound sheet 21 are forced into spiral grooves in the opposed faces of the end plates 19 and 20 to form fluid-tight joints as in my prior applications and the assembly is retained in a unitary structure as by the tightening bolts 22. The outermost turn of the spirally wound sheet 21 forms with the adjacent turn thereof, an entrance for lighter fluids to the passageway 18. The innermost turn of sheet 21 forms with its adjacent turn an exit which communicates with outlet 17 through a series of openings 23 formed in the upper part of hub 24 of the rotor. The hub 24 is secured to the shaft 12 in any suitable manner in order to impart mutual rotation between the shaft and the hub and consequently between the shaft and the rotor. A tubular member 25 is integrally secured to the top end of hub 24 and is adapted to rotate therewith. Member 25 extends up through the central opening in the cover plate 26 of the housing 11 and provides a passageway for the fluid passing from the rotor to the outelt 17 as well as for the reflux passing into the rotor. It is now apparent that vapors issuing from the kettle 15 will flow through the inlet 16 into the spiral passageway 18, through the openings 23 in hub 24, through the tubular member 25 and thus through the outlet 17. From the outlet, the treated vapors pass to a condenser 42 for a purpose to be described.

In a distillation process, condensate or reflux is formed in the passageways of the apparatus and this reflux or added reflux or heavy fluid is made use of in a liquid centrifugal seal to prevent the escape of vapors between the housing 11 and the outlet 17 and to prevent the vapors from issuing from the apparatus without first being treated in the rotor.

The seal comprises an annular liquid seal chamber 27, surrounding tubular member 25, into which liquid reflux or condensate is adapted to be propelled to form an annular body of sealing liquid, and an intermediate rotating vane 28 dividing the annular chamber. The vane 28 is secured to the upper part of member 25 and rotates therewith. Upper and lower ribs or cleats 32 may suitably be formed on the vane to aid in imparting motion to the seal liquid. The rotatable vane centrifugally propels the liquid into an annular body into the seal chamber and the outer end thereof extends into the body of seal liquid to keep it in motion during operation and thus prevent the by-pass of fluids passing through the apparatus.

The seal chamber 27 may suitably be formed by a saucer-shaped depression in the central portion of a casting 29, and a cover member 30 rigidly secured thereto in opposed over-lying relationship to the bottom face of the saucer-shaped depression. An adjustable boss or clearance ring 33 may be secured in any desired manner to the inner end of the saucer-shaped depression of casting 29 (Fig. 2) for a purpose to be hereinafter described. This boss extends upwardly towards the rotating vane 28 and forms with the under face thereof a restricted clearance space. The boss surrounds the tubular member 25 to provide an annular space which communicates with the interior of the housing. The casting 29 is rigidly secured to the plate 26 of housing 11 and is provided with a conduit which is connected to outlet 17 and forms a part thereof. A cover plate 31 is removably secured to an opening in the casting 29 to permit inspection of the apparatus and the ready assembly and disassembly of the seal.

As set forth above, a liquid seal of the character described works quite satisfactorily for substantially all clearances between the vane 29 and the opposed faces of the seal chamber 27 when water, salt water solutions and glycerine are used as the seal liquid. However, if liquids other than

water, salt water solutions and glycerine are used, as for instance liquids adapted to be distilled which are both heavier or lighter and more viscous or less viscous than water, then the seal will not operate to prevent the by-pass of vapors unless a minimum critical clearance between the relatively moving parts is maintained. In other words the clearance between the rotating vane and the opposed walls of the seal chamber is made sufficiently large so that the velocity gradient of the seal liquid between the relatively moving parts is not great enough to cause channeling of the liquid by overcoming the surface tension thereof. I have found that a minimum clearance between the vane 28 and the opposed faces of seal chamber 28 in the order of three-eighths of an inch and slightly more or less will permit the seal to function perfectly for substantially all vaporizable liquids. However, the clearance between the relatively moving parts cannot be so large that the rotating vane, even though ribbed, cannot keep the body of seal liquid in motion. I have found that clearances up to five-eighths of an inch and slightly more will maintain the seal liquid in motion and will function to maintain a perfect seal with all vaporizable liquids.

The following is an example of a specific embodiment of an operative seal. With a seal of the type shown in the drawings in which the inside diameter is in the order of four inches, 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, the seal will operate perfectly 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 2000 R. P. M. This seal will operate effectively with any vaporizable 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.

While I have disclosed that seals with a clearance between the relatively moving parts in the order of three-eighths of an inch to five-eighths of an inch are operative, it is obvious that these limits may be somewhat varied, depending upon the dimensions of the seal, the surface tension of the liquid used and the speed of the moving part, without destroying the operativeness of the seal.

As the kettle vapors are in communication with the seal chamber 27, there is a tendency for these vapors to diffuse and condense in the relatively cold liquid of the seal, thus contaminating the seal liquid and eventually short circuiting to the condenser. If this be permitted, the effectiveness of the seal soon becomes slightly impaired due to slight leakage and the condensed fractions of the distilled vapor become contaminated. I have found that these kettle vapors can be effectively pushed back from the seal chamber by either 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 these kettle vapors; 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. The latter form of my invention may be readily understood from an inspection of Fig. 1, and the following detailed description thereof.

The seal liquid under the full pressure of the periphery is bled through a conduit 34 and is vaporized in a vaporizer 35 which may conveniently be of any desired type as for instance either a steam, electric or gas fired vaporizer. The now vaporized liquid is conducted through a return conduit 36 and is discharged into an annular chamber 37 formed in the casting 29 beneath the seal chamber. The vapor is then forced into the lower portion or high pressure side of the seal chamber through a passageway 38 at a point inside the small clearance space between the boss 33 and the vane 28. The clearance space can be readily adjusted and it is advantageously made quite small so that a minimum amount of vapor will serve to effectively counteract the diffusion of the kettle vapors into the seal chamber. Clearances in the order of one-sixteenth of an inch and even less have been found quite effective. As vaporized seal liquid is used to counteract the diffusion of the kettle vapors, condensation of any part thereof within the seal will mix with the seal liquid and will not contaminate it. The uncondensed portion forces its way into the stationary housing 11 and is returned to the kettle 15 through a trapped return pipe 39. 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 flowmeter 40 in the line 34 and controlled by a valve 41.

In a fractional condensation process, the centrifugal seal operates under non-equilibrium conditions to aid in preventing the liquid body from breaking under the stress of high velocity gradients. As the body of liquid on the under side of the vane 28 is subjected to the pressure of the vapors in the kettle and the vapors from the vaporizer 35, 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 above the vane. In addition, the liquid on the under-side of the vane is heated by both the kettle vapors and the vapors from the vaporizer 35 whereas the liquid on the upper side of the vane is positively cooled with added reflux to overcome the effect of heat transfer through the rotating vane and otherwise. It is thus apparent that the desired non-equilibrium conditions are continuously maintained throughout the operation of the device to prevent breakdown of the liquid body due to velocity gradient stresses.

To accomplish this, the body of liquid above the vane 28 is, as heretofore stated, positively cooled and the level thereof, centrifugally considered, is positively controlled by the addition of reflux liquid. Thus, reflux liquid from the condenser 42 flows through conduit 43, 49 and a regulated quantity thereof is introduced into the upper part of the seal as by a pipe 44 which enters into the upper portion of the seal chamber through the cover 30 of the seal chamber at a point adjacent the desired level of the liquid above the vane. This added reflux not only serves to maintain the desired cooled relationship of the liquid above the vane but at the same time maintains the liquid at the desired level. It is now obvious that the liquid level on the lower side of the vane is a function of the liquid level above the vane and the pressure difference across the seal. As some condensation of the treated vapors may take

place in the chamber 45 above the seal and in the exit conduit 17, the lower walls of the chamber slope towards the axis and the condensate drains into the upper portion of the seal through openings 46 in the cover plate 30 at a point outside the reflux control pipe 44. 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 above the vane urges some of the liquid through the reflux control pipe 44 against the pressure of the reflux entering the pipe until the desired level of the liquid is restored. It is thus apparent that the desired liquid level is automatically maintained at all times during operation of the device.

The casting 29 is provided with a chamber 48 that surrounds the lower portion of the seal chamber 27 and which is filled with some suitable insulation 47 as for instance rock wool or the like to insulate the casting against the transfer of heat from the kettle vapors to the upper portion of the seal chamber.

In the operation of the apparatus and in accordance with my invention, gases or vapors or both from the kettle or still 15 enter into the housing 11 and pass through the spiral passageway 18 of the rotor 10. The rotor and its associated parts are rotated to develop a centrifugal force which 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 centrifugal force effective in the operation is equivalent to five or more times the force of gravity. A speed of rotation of 600 to 2000 R. P. M. or higher has been found suitable. The gases and vapors from the kettle are under pressure such that they pass against centrifugal force set up by rotation, through the passageway 18, counter-current to heavier fluid or reflux through the openings 23 and out through the exit conduit 17. The vapors then pass to the condenser 42. Some of the vapors will, in general, condense in passageway 18 to form reflux liquid, but the main supply of reflux is returned to the system as at 50 from the reflux condenser 42 and conduits 43, 49.

The reflux from the condenser 42 flows down the conduit 43 and that portion not needed by the system is drawn off through a valve as at 51. The remaining reflux is returned to the system through the conduit 49. That portion of the reflux which is required to maintain the desired seal level above the vane 28 is by-passed through the valved line 44, the remainder continues along pipe 49 and enters the rotor as at 50 to treat the vapors.

The reflux flows through the openings 23 and passes into the passageway 18. Reflux entering and formed in the passageway 18 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 reflux 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 reflux liquid then discharges from the rotor 10 and collects in the bottom of housing 11 from which it drains back to the kettle 15 through the trapped pipe 39.

To determine the differential in pressure between the kettle vapors and the treated vapors, and hence across the seal, a differential pressure manometer 52 may be provided which connects the inlet 16 with the exit 17.

While I have described my novel centrifugal seal as part of an apparatus for effecting countercurrent exchange between fluids such as between liquids and vapors or gases, my seal has 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. 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 my invention has been directed to 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 type 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. A centrifugal liquid seal adapted for use in combination with sealing liquids of any surface tension, for centrifugal fractional devices, centrifugal pumps, turbines, and like apparatus, comprising a seal chamber and a vane extending into the chamber between the opposed faces thereof, said seal chamber and said vane being relatively rotatable and so constructed and arranged that the sealing liquid will be propelled by centrifugal force into the seal chamber to form an annular body of liquid into which the vane extends and said vane being spaced apart in the order of three-eighths of an inch from said opposed faces.

2. A centrifugal liquid seal adapted for use in combination with sealing liquids of any surface tension for centrifugal fractionating devices, centrifugal pumps, turbines and like apparatus, comprising a seal chamber and a vane extending into the chamber between the opposed faces thereof, said seal chamber and said vane being relatively rotatable and so constructed and arranged that the sealing liquid will be propelled by centrifugal force into the seal chamber to form an annular body of liquid into which the vane extends and said vane being spaced apart in the order of three-eighths of an inch to five-eighths of an inch from said opposed faces.

3. A centrifugal liquid seal adapted for use in combination with sealing liquids of any surface tension, for centrifugal fractionating device, centrifugal pumps, turbines and like apparatus, comprising a seal chamber, a vane extending into the chamber between the opposed faces thereof, said seal chamber and said vane being relatively rotatable and so constructed and arranged that the sealing liquid will be propelled by centrifugal force into the seal chamber to form an annular body of liquid into which the vane extends and said vane being spaced apart at a minimum of three-eighths of an inch or slightly less from said

opposed faces and means for maintaining the liquid on one side of the vane at a desired level.

4. A centrifugal liquid seal adapted for use in combination with sealing liquids of any surface tension, for centrifugal fractionating devices, centrifugal pumps, turbines and like apparatus, comprising a seal chamber, a vane extending into the chamber between the opposed faces thereof, said seal chamber and said vane being relatively rotatable and so constructed and arranged that the sealing liquid will be propelled by centrifugal force into the seal chamber to form an annular body of liquid into which the vane extends and said vane being spaced apart in the order of three-eighths of an inch to five-eighths of an inch from said opposed faces and means for maintaining the liquid on one side of the vane at the desired level.

5. A centrifugal liquid seal adapted for use in combination with sealing liquids of any surface tension, for centrifugal fractionating devices, centrifugal pumps, turbines and like apparatus, comprising a stationary seal chamber and a rotatable vane extending into the chamber between the opposed faces thereof, said seal chamber and said vane being so constructed and arranged that the sealing liquid will be propelled by centrifugal force into the seal chamber to form an annular body of liquid into which the vane extends and said vane being spaced from said opposed faces in the order of 3/8 of an inch to 5/8 of an inch.

6. A centrifugal liquid seal adapted for use in combination with sealing liquids of any surface tension, for centrifugal fractionating devices, centrifugal pumps, turbines and like apparatus, comprising a stationary seal chamber and a vane extending into the chamber between the opposed faces thereof, said vane being rotatable and so constructed and arranged that it will propel the sealing liquid into the seal chamber to form an annular body into which the vane extends, said vane being spaced from said opposed faces in the order of three-eighths of an inch to five-eighths of an inch so that the velocity gradient between the relatively moving surfaces not sufficient to overcome the surface tension of the liquid.

7. A centrifugal liquid seal adapted for use in combination with sealing liquids of any surface tension, for centrifugal fractionating devices, centrifugal pumps, turbines and like apparatus, comprising a stationary seal chamber, a rotatable vane extending into the chamber between the opposed faces thereof, said seal chamber and said vane being so constructed and arranged that the sealing liquid will be propelled by centrifugal force into the seal chamber to form an annular body of liquid into which the vane extends and said vane being spaced in the order of 3/8 of an inch to 5/8 of an inch apart from said opposed faces so that the velocity gradient between the relatively moving surfaces is not sufficient to overcome the surface tension of the liquid and not so far apart that the relatively moving surfaces will not keep the liquid seal body in motion and means for maintaining the liquid, on one side of the vane, at the desired level.

8. A centrifugal liquid seal adapted for use in combination with sealing liquids of any surface tension, for centrifugal fractionating devices, centrifugal pumps, turbines and like apparatus, comprising a stationary seal chamber, a rotatable vane extending into the chamber between the opposed faces thereof, said seal chamber and said vane being so constructed and arranged that the sealing liquid will be propelled by centrifugal force into the seal chamber to form an annular body of liquid into which the vane extends and said vane being spaced apart in the order of three-eighths of an inch to five-eighths of an inch from said opposed faces so that the velocity gradient between the relatively moving surfaces is not sufficient to overcome the surface tension of the liquid and means for maintaining the liquid, on one side of the vane, at the desired level.

9. The combination as set forth in claim 5 in which the vane is provided with cleats.

10. In a centrifugal seal of the vane and recess type having a seal liquid in the recess into which the vane extends, means to remove some of the seal liquid and means to vaporize the liquid and introduce the vapors into the entrance to the recess.

11. In a centrifugal seal of the vane and recess type having a seal liquid in the recess into which the vane extends and in which the vane is spaced from the opposed faces of the recess in the order of three-eighths of an inch to five-eighths of an inch, means to remove some of the seal liquid, means to vaporize the liquid and introduce the vapors in the entrance to the recess, and means to restore the liquid removed from the recess.

12. In a centrifugal seal of the vane and recess type having a seal liquid in the recess into which the vane extends and in which one side of the seal is subjected to the pressure of untreated fluid and in which the other or low pressure side is in contact with treated fluid, means to prevent the bypass of the untreated fluid from the high pressure side to the low pressure of the seal comprising, means to remove some of the seal liquid and means to vaporize the liquid and introduce the vapors in the entrance to the recess and in the path of the untreated fluid.

WALTER J. PODBIELNIAK.