

Oct. 13, 1942.

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2,298,377

VACUUM DISTILLATION FROM MOVING SURFACES AND APPARATUS THEREFOR

Filed Nov. 3, 1939

3 Sheets-Sheet 1

Fig. 2.

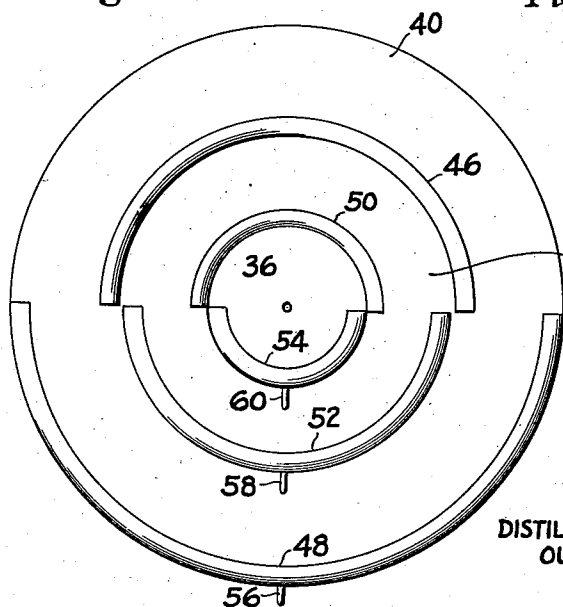


Fig. 1.

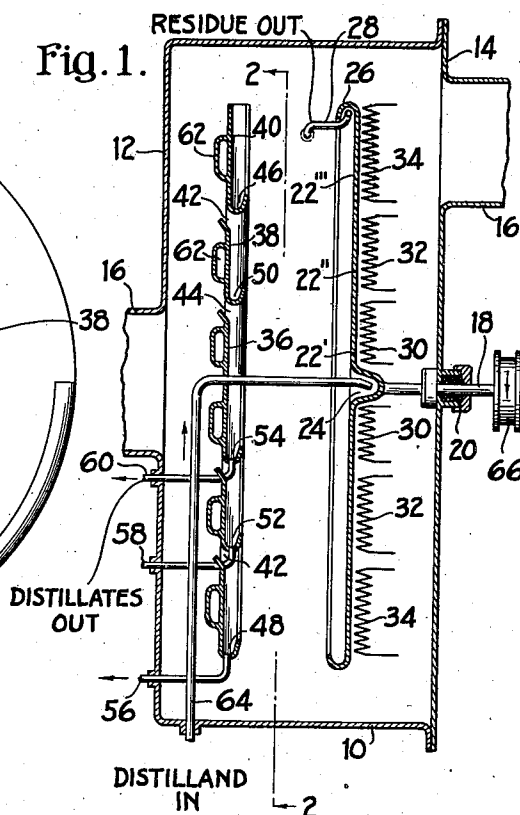


Fig. 3.

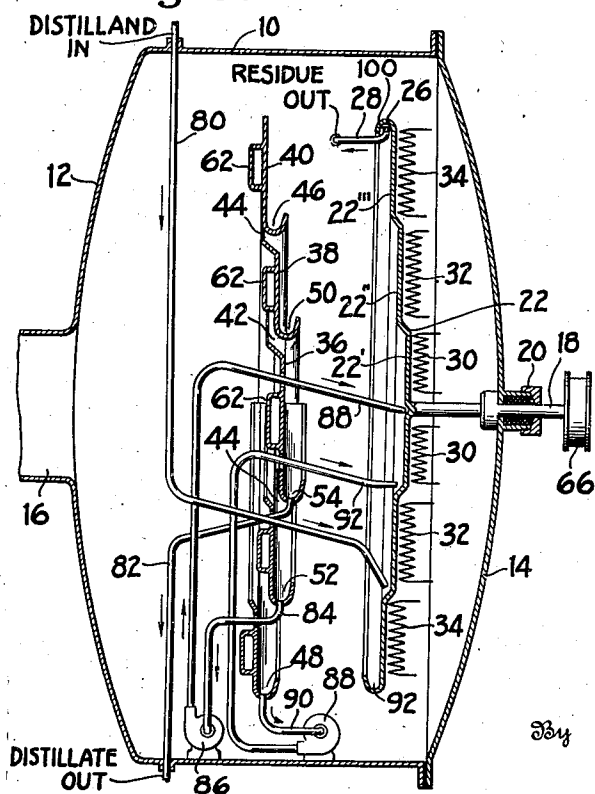
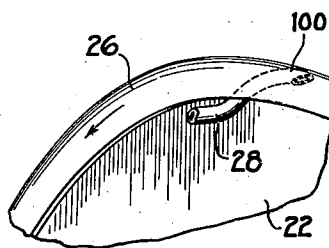


Fig. 4.



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Fig. 5.

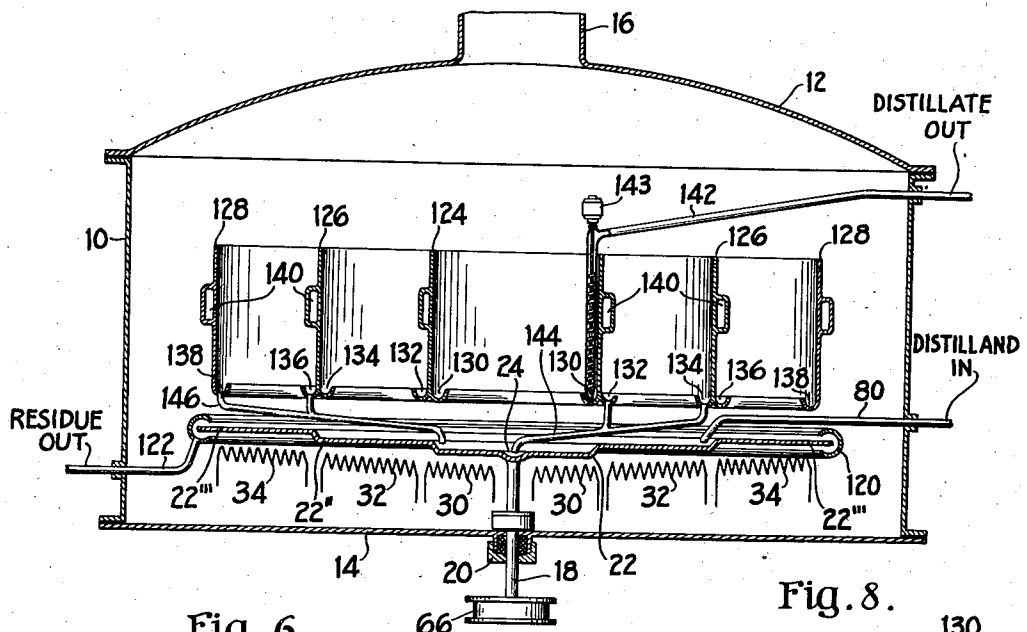


Fig. 6.

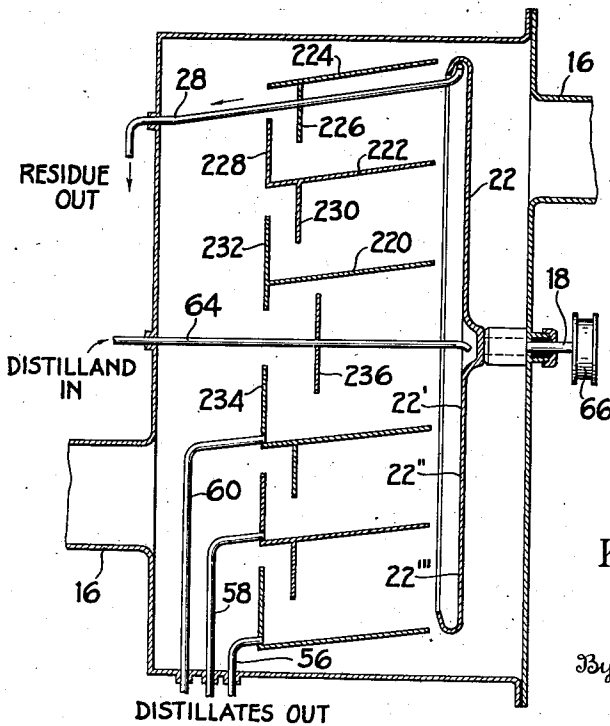
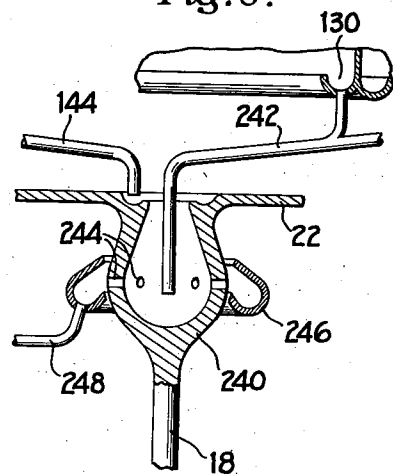


Fig. 8.



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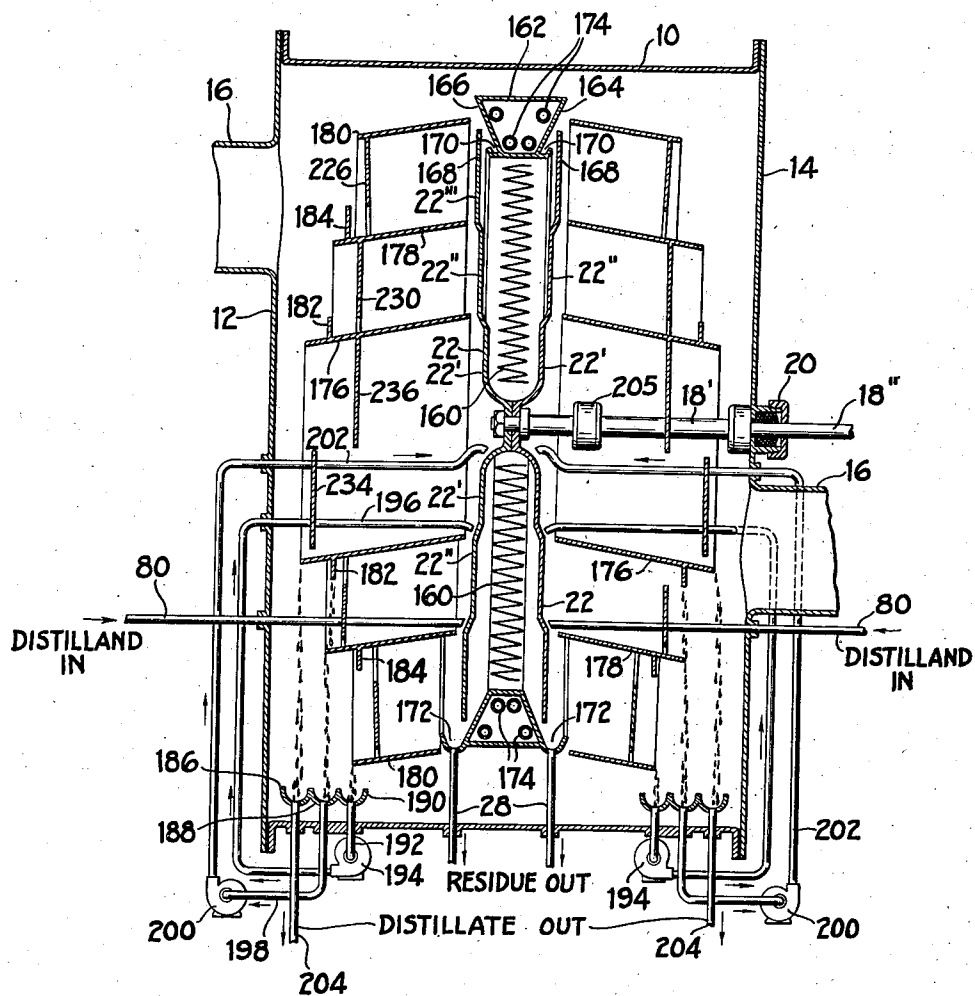
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Fig. 7.



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UNITED STATES PATENT OFFICE

2,298,377

VACUUM DISTILLATION FROM MOVING SURFACES AND APPARATUS THEREFOR

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Application November 3, 1939, Serial No. 302,748

12 Claims. (Cl. 202—52)

This invention relates to the art of vacuum distillation and in particular relates to a method of high vacuum unobstructed path distillation from moving heated vaporizing surfaces.

In application 99,632, filed September 5, 1936, now Patent 2,210,927, dated August 13, 1940, I have described vacuum distillation procedure wherein the substance to be distilled is introduced onto a moving heated surface over which it is caused to pass in a very thin film at a rate substantially greater than would be obtained if the distilland were caused to flow by gravity. One of the methods of distilling in this manner involves introducing the distilland onto the approximate center of a rotating disk or plate which is heated to distillation temperature.

This invention has for its object to provide improved distillation apparatus and process of the nature described above. A further object is to provide high vacuum unobstructed path distillation process and apparatus for distilling from a moving surface whereby fractionation may be accomplished from one moving surface. A further object is to provide a method of distillation whereby distilland can be introduced onto a heated revolving disc, plate, cone, or the like, and a plurality of fractions separated from the distilland during its passage thereover. A further object is to provide method and apparatus whereby fractionation from a single moving member is readily accomplished. A further object is to provide improved high vacuum, unobstructed path distillation process and apparatus. Other objects will become apparent from the following description and claims.

These and other objects are accomplished by my invention which includes method and apparatus whereby vacuum fractional distillation, i. e., separation of a plurality of fractions or repeated fractionating of a single fraction is accomplished by distillation from one heated moving vaporizing surface. A plurality of such multiple effect moving surfaces can be employed.

In the following description I have set forth several of the preferred embodiments of my invention. However, it is to be understood that these are given for the purpose of illustration and not in limitation thereof.

In the drawings in which like numerals refer to like parts,

Fig. 1 is a vertical section in elevation of a single plate centrifugal still which, in accordance with my invention, permits the separation of a plurality of fractions by one passage of distilland therethrough;

Fig. 2 is a section in elevation taken on line 2—2 of Fig. 1;

Fig. 3 is a vertical section of a single plate still which is in many respects similar to Fig.

1 which permits separation and repeated fractionation of a single fraction;

Fig. 4 is a fragmentary section of the periphery of a moving distilling surface of the type shown in Figs. 1 and 3 and illustrated in detail the method of removing liquid therefrom;

Fig. 5 is an elevation in section of a modification of a fractionating still of the type illustrated in Fig. 3 being provided with a horizontal vaporizing plate;

Fig. 6 is an elevation in section of a single vertical plate still provided with concentric condensing surfaces from which the liquid drains by gravity into withdrawal conduits and being provided with baffles;

Fig. 7 is an elevation in section of a multi-plate fractionating still provided with condensing surfaces which are similar to those shown in Fig. 6; and,

Fig. 8 is a fragmentary section in elevation of a modified apparatus for removing the final fraction from gutter 130 of Fig. 5.

Referring to Figs. 1 and 2, numeral 10 designates a squat cylinder which serves as a still casing and which is closed at one end thereof by integral plate 12 and at the other end by removable, but gas tight, plate 14. Numeral 16 designates a conduit of wide admittance integral with plate 14 which conduit is connected to evacuating pumps (not shown). Numeral 18 designates a shaft which passes through packed gland 20 integral with plate 14 and which is rigidly supported thereby. Numeral 22 designates a circular disc integral with shaft 18 and supported thereby in the position shown. Numerals 22', 22'' and 22''' designate concentric, annular vaporizing zones on plate 22. Numeral 24 designates a depression in the approximate center of plate 22. Numeral 26 designates an annular gutter which is formed at the periphery of plate 22 by turning back the edge thereof. Numeral 28 designates a withdrawal conduit, one end of which terminates inside the gutter 26. Numerals 30, 32 and 34 designate heating coils, the heat from which is applied to areas 22', 22'' and 22''', respectively, of plate 22.

Numerals 36, 38 and 40 designate concentric annular surfaces disposed opposite to concentric zones 2', 22'', and 22''', respectively, and are of approximately the same area. The circular or annular members 36, 38 and 40 are so constructed and assembled that annular spaces 42 and 44 are provided therebetween. The upper half of the inside circular edge of member 40 is turned upward to form a gutter 46. The bottom half of the outside edge of the same member 40 is likewise turned upward to form a gutter 48. The upper half of the inside circular edge of member 38 is likewise turned upward to form a gutter 50 and the lower half of

the outer edge thereof is turned upward to form a gutter 52. The lower half of the outer edge of member 36 is turned upward to form a gutter 54. To gutters 48, 52 and 54 are attached withdrawal conduits 56, 58 and 60, respectively. Numeral 62 designates cooling conduits integral with the back portion of concentric annular plates 36, 38 and 40. Numeral 64 designates a conduit which leads into the still and terminates in the recessed portion 24 of plate 22. Numeral 66 designates a pulley integral with shaft 18.

Referring to Fig. 3 numeral 80 designates a conduit which leads into the still and terminates in close proximity to the elevated portion joining concentric portions of the plate 22" and 22'''. Numeral 82 designates a withdrawal conduit which leads into the still and terminates in the bottom of gutter 54. Numeral 84 designates a conduit which leads from pump 86 to the bottom portion of gutter 52. Numeral 88 designates a conduit which leads from pump 86 up to, and terminates in recessed portion 24 at the center of plate 22. Numeral 90 designates a conduit which connects the bottom of gutter 48 to pump 88. Numeral 92 designates a conduit which runs from pump 88 to the elevated portion of plate 22 between annular zones 22' and 22''.

Referring to Fig. 4, numeral 100 designates the end of conduit 28 which terminates inside of gutter 26. This end is curled into the gutter so that it lies near the bottom of gutter 26 and is cut at an angle so that the point of the cut is next to the bottom of the gutter and points in a direction opposite to that in which plate 22 rotates.

Referring to Fig. 5, numeral 120 designates an annular gutter into which protrudes the outside edge of plate 22. The withdrawal conduit 122 is connected to the lower portion of gutter 120. Numerals 124, 126 and 128 designate three concentric cylinders, the lower edges of 124 and 126 being provided with double gutters turned inwardly and outwardly 130, 132, 134 and 136, respectively. Cylinder 128 is provided with inwardly turned gutter 138. Numeral 140 designates cooling coils integral with each of the concentric cylinders 124, 126 and 128. Numeral 142 designates a withdrawal conduit provided with elevating pump 143 the intake of which is located in gutter 130. Numeral 144 designates a conduit which connects to gutters 132 and 134 and terminates in recess 24 at the center of plate 22. Numeral 146 designates a conduit which connects to gutters 136 and 138 and which terminates at the elevated portion of 22 between annular zones 22' and 22''.

Referring to Fig. 6, numerals 220, 222 and 224 designate concentric annular condensing surfaces which are formed of cylinders, the ends of which are cut at an angle so that the ends of the condensing surface when assembled parallel with the vaporizing surface are somewhat lower than the ends nearest the vaporizing surface. The annular space between condensing surfaces 222 and 224 is provided with a pair of baffles 226 and 228 which cooperate to prevent vapor from passing through the condensing zone and into the casing of the still without contact therewith. However, the baffles are so located that ample space for withdrawal of gas is presented. Numerals 230 and 232 designate annular baffles which are similarly located in the space between condensing units 220 and 222. Numerals 234 and 236 designate baffles located within con-

densing ring 220 which cooperate to prevent vapor from passing without at least one contact therewith but which are so located as to permit free passage of permanent gas.

Referring to Fig. 7, which illustrates a still in which two vaporizing surfaces 22 are mounted back to back upon shaft 18', numeral 160 designates an annular heating element rigidly mounted in the space between the two vaporizing plates. Numeral 162 designates an annular member, the cross-section of which is in the form of a truncated cone, the truncated portion of which extends somewhat into the space between the two vaporizing plates 22. The sides 164 and 166 of the annular truncated cone are so located that undistilled residue thrown from the edges of vaporizing plates 22 comes into contact therewith. The inside edge of the upper half of an annular truncated member 162 is provided with an integral flange 168 which extends beyond sides 166 and 164 of the truncated cone member and are turned upwardly so as to form gutters 170. The outside edge of the lower half of the annular truncated member 162 is provided with turned edges to form gutters 172. A plurality of cooling coils 174 are located inside the truncated cone member and during operation cooling fluid is circulated therethrough.

Numerals 176, 178 and 180 designate concentric cylindrical condensing surfaces the ends of which are cut at an angle so that the walls thereof slope downwardly when the cut ends are mounted substantially parallel with the vaporizing surfaces 22. Numerals 182 and 184 designate annular rings integral with the outside surfaces of cylindrical condensing elements 176 and 178 respectively. The bottom edge of ring 184 is so situated that liquid dropping therefrom will drop onto the edge of the bottom upper surface of condensing element 180 in the manner illustrated. The lower portion of ring 182 is similarly located so that liquid dropping therefrom will fall upon the bottom portion of condensing element 178. Numerals 186, 188, and 190 designate a plurality of troughs which are so located within the still casing that liquid dropping from the lower edge of condensing surface 182 will fall into trough 186, liquid falling from the lower edge of condensing surface 178 will fall into trough 188 and liquid falling from the lower edge of condensing surface 180 will drop or fall into gutter 190. Numeral 192 designates a conduit connected to pump 194 and to the bottom of gutter 190. Numeral 196 designates a conduit which delivers liquid from pump 194 onto the elevated portion of vaporizing surface 22 between vaporizing zones 22' and 22''. Numeral 198 designates a conduit which connects to the base of trough 188 and to pump 200. Numeral 202 designates a conduit which delivers liquid from pump 200 onto the center of vaporizing plate 22. Numeral 204 designates a conduit which connects with the lower portion of trough 186 and serves to withdraw final distillate therefrom.

Numeral 206 designates a rigid bearing support for shaft 18' which shaft is shown as being of large diameter inside the still at 18' but of small diameter where it passes through packed bearing 20 at 18''.

During operation of the apparatus illustrated in Figs. 1 and 2, the still is evacuated by vacuum pumps (not shown) connected to conduits 16. Plate 22 is heated to distillation temperature by electrical heating units 30, 32 and 34, and is rotated by power supplied to pulley 66. Distilland

is continuously introduced into the recess 24 at the center of plate 22 by way of conduit 64. As the distilland is introduced onto plate 22, it is caused to rapidly flow toward the periphery thereof in the form of an exceedingly thin film by centrifugal force. During the passage over area 22' a low boiling fraction is vaporized and passes to cool condensing surface 36 where it becomes condensed. Undistilled distilland then passes over vaporizing area 22'' where the next highest fraction is vaporized and the vapors pass to adjacent condensing surface 38 and are condensed thereon. The undistilled portion then passes over distilling area 22''' where the highest fraction is vaporized and condensed on condensing surface 40.

Condensate on surface 36 flows by gravity into gutter 54 and is withdrawn through conduit 60. Condensate on surface 38 flows downward into gutter 50 which prevents it from dripping onto surface 36. The condensate on the upper half of 38 thus flows into gutter 50 which directs it onto the lower half of 38 over which it flows into gutter 52. This fraction is withdrawn therefrom by way of conduit 58. In a similar manner condensate from the upper half of surface 40 collects in gutter 46 is delivered to the lower half thereof and then flows into gutter 48 and is withdrawn through conduit 56. Gases evolved during the distillation or present in the distillation chamber pass around the outside of the condensing surface 40 and thence into vacuum conduit 16 and also pass through openings 44 and 42 between the condensing segments and then into vacuum conduit 16. Substances which remain undistilled collect in gutter 26 and due to their inertia are thrown into opening 100 and finally flow out of the still through conduit 28. It will be noted that any number of fractions can be separated from a unit of this kind employing a single plate. The number of fractions separated can be varied by varying the number of vaporizing areas or zones.

In operating the apparatus of Fig. 3 the system is evacuated and the vaporizing surface heated and rotated as described in connection with Fig. 1. Distilland is introduced through conduit 80 onto the inside edge of vaporizing portion 22''. The distilland then is forced by centrifugal force in the form of a thin film over heated zone 22'''. During such passage distillation of a light fraction takes place. Undistilled residue collects in gutter 26 and is removed from the still by conduit 28. Vapors condense on condensing ring 40 and collect in gutter 48. This condensate is withdrawn by pump 88 and is introduced by way of conduit 92 onto the inside edge of distilling surface 22''. It then flows by centrifugal force over surface 22'' and during its passage thereover vaporization of the most volatile constituents takes place. Undistilled portions thereof flow by centrifugal force onto surface 22''' where they become mixed with fresh distilland introduced thereon by way of conduit 80.

It will be realized that the vapors removed from surface 22'' contain a substantially higher concentration of the desired constituent than the vapors removed from 22''', and that the undistilled residue from area 22'' represents components having a lower vapor pressure than the desired distillate which were unavoidably vaporized on surface 22'''. These unwanted lower vapor pressure constituents are thus returned to the original distilland where they are refractionated, their desired components again stripped therefrom and are then removed from the still

by conduit 28. Distillate from zone 22'' is condensed upon condensing surface 38 and collects in gutter 52. This condensate is withdrawn therefrom by pump 86 and delivered by conduit 88 onto the center of distilling surface 22'. This condensate is thrown over surface 22' by centrifugal force and vapors representing a very pure fraction are condensed on condensing surface 36, collect in gutter 54 and are withdrawn from the still by way of conduit 82. Lower vapor pressure constituents unvaporized on surface 22' pass in sequence over surfaces 22'' and 22''' where refractionation and removal of lighter constituents thereof takes place.

It will thus be seen that exceedingly efficient fractionation is accomplished by the apparatus of Fig. 3 with removal of a very pure fraction and rejection and refraction of lower vapor pressure constituents which might contain small amounts of the desired component. A plurality of very pure fractions can be prepared by employing a series of units analogous to that illustrated in Fig. 3.

In operating the apparatus illustrated in Fig. 5 distilland is introduced through conduit 80 and spread by centrifugal force over area 22''. Undistilled residue is thrown from the periphery of plate 22, collects in gutter 120 and is withdrawn through conduit 122. Vapors condense on the outside wall of cylinder 126 and on the inside wall of cylinder 128. This condensate is withdrawn from gutters 136 and 138 by conduit 146 and introduced onto the inside edge of distilling surface 22'' over which it flows and is redistilled. Undistilled residue therefrom passes onto surface 22'''. Vapors from zone 22'' condense on the outside wall of cylinder 124 and on the inside wall of cylinder 126. This condensate flows into gutters 132 and 134 and is withdrawn therefrom by conduit 144 and introduced onto the center of vaporizing zone 22'. Distillation of the final fraction takes place therefrom and it condenses on the inside wall of cylinder 124, flows into gutter 130 and is withdrawn from the still by pump 143 and conduit 142.

The apparatus of Fig. 5 is substantially horizontal and the condenser is located above the vaporizing plate. Therefore condensate flows back onto the different vaporizing areas by gravity. Consequently the apparatus of Fig. 5 has the advantage that pumps 86 and 88 illustrated in Fig. 3 are unnecessary. On the other hand this apparatus has the disadvantage that the gutters at the base of the condensing elements obstruct the passage of vapors to the condensing surfaces to a certain extent.

In operating the apparatus of Fig. 6, plate 22 is rotated and heated to distillation temperature; distilland is introduced onto the center of the surface by conduit 64. Vapors from zone 20' pass into intimate contact with the inside surface of 220 and baffles 234 and 236 and are condensed thereon and withdrawn through conduit 60. Vapors derived from vaporizing zone 22'' similarly pass into intimate contact with the outside surface of condensing cylinder 220, the inside surface of condensing cylinder 222 and baffles 230 and 232. This liquid collects in the lower portion of cylinder 222 and is withdrawn from the still by way of conduit 58. Vapors from zone 22''' condense in the space between condensing cylinders 222 and 224. This condensate is withdrawn from the bottom portion of cylinder 224 by way of conduit 56. Undistilled residue from the vaporizing plate is withdrawn from the still through conduit 28.

The baffles in the apparatus of Fig. 6 act to effectively condense vapors without the use of long condensing tubes. If desired the condensing units can be made longer to assure contact with vapor, and the baffles eliminated.

In operating the apparatus of Fig. 7, the still casing is evacuated in the usual manner. Heating element 160 is put into operation in order to heat the distilling plates 22 to distillation temperature. Cooling fluid is circulated through conduits 174 located inside of annular truncated cone 162. Liquid to be distilled is introduced through conduits 80 and flows by centrifugal force over zones 22". Undistilled residue is thrown against walls 164 and 166 of the truncated cone 162. At the upper half of the truncated cone this liquid flows downwards into gutters 170. The liquid collecting in gutters 170 flows downwardly and is delivered onto the lower half of the surfaces 166 and 164. The liquid flows thence into gutters 172 located at the outside edge of the lower half of member 162. This undistilled residue is withdrawn through conduits 28.

Vapors from zone 22" condense upon the inside wall of condensing ring 180 and upon the outside wall of condensing ring 178. Liquid condensing on the outside wall of 178 flows by gravity to the base thereof and due to the action of ring 184 drops onto the inside surface of 180. This liquid together with that condensed on the inside surface of 180 flows into trough 190. This liquid is withdrawn from 190 by pump 194 and delivered through conduit 196 onto the inside edge of vaporizing zone 22". The liquid passes over zone 22" and vapors therefrom condense upon the inside surface of condensing ring 178 and upon the outside surface of condensing ring 176. Liquid from the outside surface of 176 flows to the lowest portion thereof and drops from ring 182 onto the bottom inside surface of condensing ring 178. This liquid along with the liquid condensed on the inside surface of 178 drops into gutter 188. Liquid from gutter 188 is withdrawn by pump 200 and is delivered through conduit 202 onto the center of the vaporizing plates. This liquid passes over zone 22' and vapors thus produced condense upon the inside wall of condensing ring 176. The condensate then flows to the lowest portion thereof and drops into gutters 186 and is withdrawn from the still through conduit 204.

This apparatus has the advantage that only one evacuating, heating and enclosure system is required for two vaporizing surfaces. It also has the distinct advantage that the heat required for distillation is substantially reduced due to the fact that the heat from the heating unit is utilized in all directions to heat the vaporizing surfaces which substantially completely surround it.

In Fig. 8 which is a modification of the liquid removal means shown in Fig. 5 the plate 22 is provided with a deep recess 240 at the center thereof. A conduit 242 connects to gutter 130 and terminates inside the recess 240. A plurality of holes 244 are provided in the walls of the recess. Surrounding these walls is a gutter 246 to which is connected a withdrawal conduit 248. During operation condensate flows by gravity from 130 into recess 240 by way of conduit 244. During rotation of shaft 18 and plate 22 this condensate is thrown by centrifugal force through holes 244 and into gutter 246 from which it can be withdrawn.

It will be realized that the mode of recirculation to accomplish efficient fractionation can be varied greatly. Thus the distilland may be in-

roduced onto the intermediate vaporizing segments instead of on the outer or inner segments. Condensate from the different condensing zones may be recirculated in a variety of sequences to improve fractionation or to accomplish a particular fractionating result.

Although I find it useful procedure to heat the different vaporizing zones to different temperatures, this is unnecessary. If desired, the entire vaporizing surface may be at the same temperature but the areas of the different portions thereof may be varied. It is a characteristic of high vacuum unobstructed path or short path distillation that substances all distill over any temperature range, but the rate of distillation varies with the area exposed and the molecular weight, as well as with the temperature. If the area is increased the same result is obtained as if the temperature were increased, but the area maintained the same or reduced. The area of course controls the time of heating of the distilland, which is also affected by the speed of rotation. The different zones can have equal areas and be heated to successively higher temperatures or they may be heated to equal temperatures with increasing areas or any combination of the two. When a plurality of such stills are used in series for the purpose of separating a plurality of narrow fractions, the temperatures in each still unit will be appropriate for the fraction which is to be removed therein.

The degree of mixing of vapors of different fractions in passing to the condensing surfaces will vary with the distance between the condensing and vaporizing surfaces. With short distances the mixing is least. With a 4 foot disc a clearance of 2 inches would not result in serious mixing. The distances shown in the drawings are rather large in proportion but are made so that the drawing and details such as recirculating pipes may be clearly seen and understood.

In order to separate a larger number of fractions than those specifically described any of the different forms of apparatus may be employed in combination by connecting them in series.

I have found my invention to be of particular value for distilling under high vacuum unobstructed path distillation conditions, i. e., at saturation pressures, and/or pressures of residual gas, of below 5 mm. such as for instance 1.0-.001 mm. and with condensing and vaporizing surfaces separated by substantially unobstructed space. When the distance between these surfaces is short such as a distance less than 12", and preferably a distance of about 1/2 to 6", the distillation is a form of high vacuum, unobstructed path distillation known as high vacuum, short path distillation. When the distance is less than the mean free path it is known as molecular distillation. My invention is applicable to all such distillations. In general I prefer to operate with saturation pressures greater than the pressure of residual gas, though this is not essential, particularly with short distances of separation.

It will be apparent that many modifications can be made in the illustrated apparatus without departing from the spirit or scope of my invention. Numerous details of construction will occur to any skilled mechanic and many such are illustrated and described in my application 99,632 referred to above. Reference is made to that application for further details of construction of stills having moving surfaces, their mode of operation and materials operated upon.

In my co-filed application Serial No. 302,747, filed November 3, 1939, I have illustrated a specific embodiment of my invention wherein the vaporizing surfaces are cone shaped. It is to be understood that such surfaces can be employed in accordance with the invention described herein.

Although the description has been restricted to rotating plates, it will be apparent from my description in the above referred to application that surfaces which convey the distilland through the still in a film thinner than that obtained by gravity can likewise be used. For instance the distilland may be introduced onto a moving surface of the nature of moving bands or drums, etc., and the intermediate fractions may be returned to the bands or drums in advance of the crude distilland. Such surfaces are to be understood as being within the scope of my invention.

What I claim is:

1. The method of vacuum distillation which comprises introducing distilland onto a rotating heated vaporizing surface and separately condensing vapor fractions which are vaporized from different areas of the vaporizing surface at successively greater distances from the center of rotation thereof.

2. The method of vacuum distillation which comprises introducing distilland onto a rotating circular disc, concentric areas of which are heated to successively higher temperatures in a direction from the center to the periphery thereof and separately condensing the vapors derived from the differently heated areas.

3. The method of vacuum distillation which comprises introducing distilland onto a moving vaporizing surface and separately condensing the vapors which are vaporized from different segments of the vaporizing surfaces at successively greater distances from the point of application.

4. The method of vacuum distillation which comprises distilling from a moving heated surface, separately condensing the vapors in zones at successive distances from the point of application of distilland to the moving heated surface and conveying the distillate from any zone to a point on the moving distilling surface in advance of the point from which it was distilled.

5. The method of vacuum distillation which comprises introducing distilland onto a rotating circular disc all parts of the surface of which are at approximately the same temperature, and separately condensing vapors derived from successive zones of said surface, the area of the zones progressively increasing from the center to the edge of the disc.

6. The method of vacuum distillation which comprises distilling from a moving heated surface, condensing vapors in a plurality of separate fraction upon a condensing surface separated from the moving surface by substantially unobstructed space and returning distilland or distillate to the moving surface whereby purification or fractionating is improved.

7. The method of high vacuum, unobstructed path distillation which comprises distilling from a rotating, approximately circular heated plate, condensing vapors in a plurality of separate fractions upon a condensing surface separated from the plate by substantially unobstructed space, returning at least part of the distilland or distillate to the heated plate and maintaining a high vacuum in the space between the plate and the condensing surface.

8. The method of high vacuum, unobstructed path distillation which comprises introducing the distilland onto a rotating vaporizing surface which is heated to distillation temperature and which is maintained under a high vacuum, condensing vapors thus produced upon a condensing surface which is separated from the vaporizing surface by substantially unobstructed space, returning the condensed vapors to the heated rotating plate at a point different from that at which the distilland was introduced thereon and separately condensing the vapors which are vaporized from this portion of the plate.

9. The method of high vacuum unobstructed path distillation which comprises in combination introducing distilland onto the outer portion of a heated rotating plate which is maintained under a high vacuum, condensing vapors derived from this portion of the plate upon a condensing surface separated from the plate by substantially unobstructed space, introducing at least part of this condensate onto an inner portion of the heated plate which is nearer the axis of rotation than the portion of the plate upon which the distilland was first introduced and separately condensing the vapors derived from this inner section.

10. Vacuum distillation apparatus comprising a rotatable, approximately circular vaporizing surface, means for heating different concentric areas thereof, the center of which is approximately the center of the axis of rotation to different temperatures which progressively increase from the center to the edge of the vaporizing surface, condensing means for separately condensing vapors derived from the different temperature areas and means for maintaining a vacuum in the space between the vaporizing and condensing surfaces.

11. Vacuum distillation apparatus comprising a rotatable circular vaporizing surface, means for heating it to distillation temperature, means for introducing distilland thereon so that during operation it is caused to travel over a portion of the surface near its edge in a thin film by centrifugal force, a condensing surface for condensing vapors derived from this portion of the heated surface, means for returning at least part of the vapors condensed thereon back to the heated surface but to a portion nearer the center thereof than that upon which the distilland was introduced, condensing means for separately condensing the vapors derived from the returned condensate and means for maintaining a vacuum in the space between the vaporizing and condensing surfaces.

12. Vacuum distillation apparatus comprising a rotatable vaporizing surface, means for heating it to distillation temperature, means for introducing distilland thereon so that during operation it is caused to travel over a portion of the heated vaporizing surface in a thin film by centrifugal force, a condensing surface for condensing vapors derived from this portion of the heated surface, means for returning at least part of the vapors condensed thereon back to the heated surface but to a different portion thereof than that upon which the distilland was introduced, condensing means for separately condensing the vapors derived from the returned condensate and means for maintaining a vacuum in the space between the vaporizing and condensing surfaces.

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