Aug. 15, 1961 R. E. GLOVER 2,996,439

ROTARY STILL

Filed Dec. 16, 1958 3 Sheets-Sheet 1

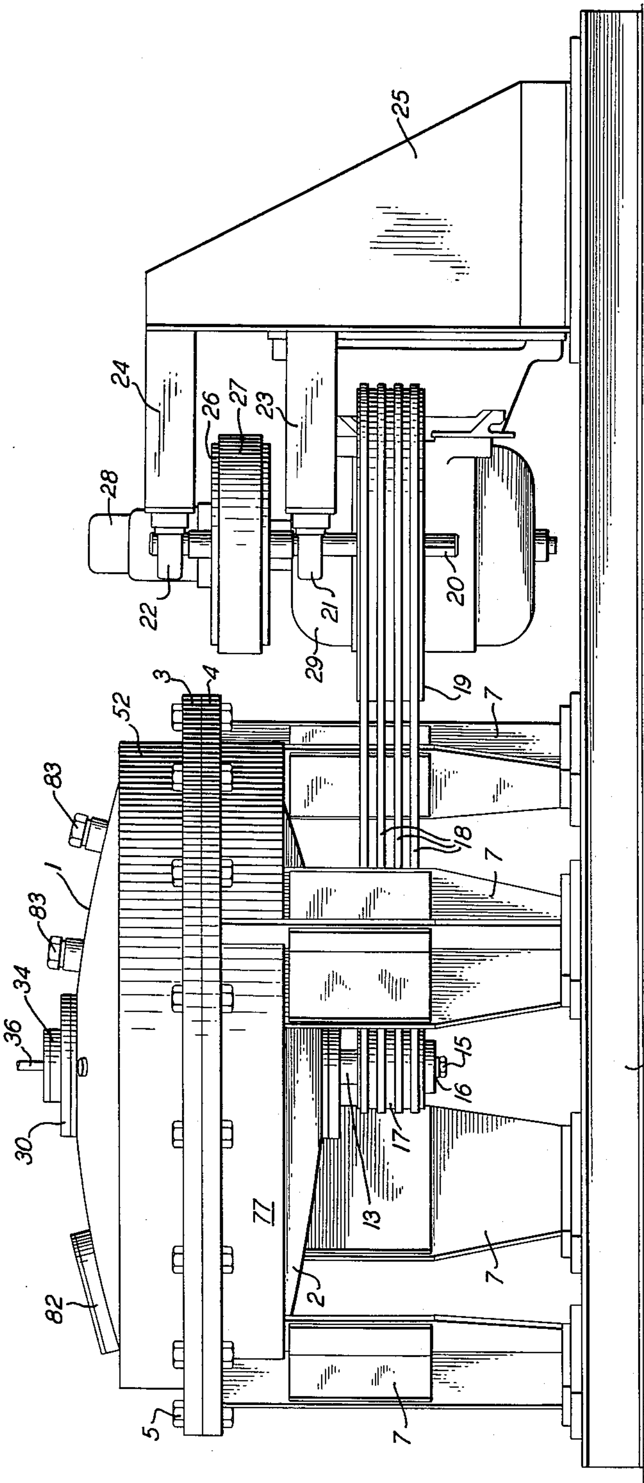

FIG. 1.

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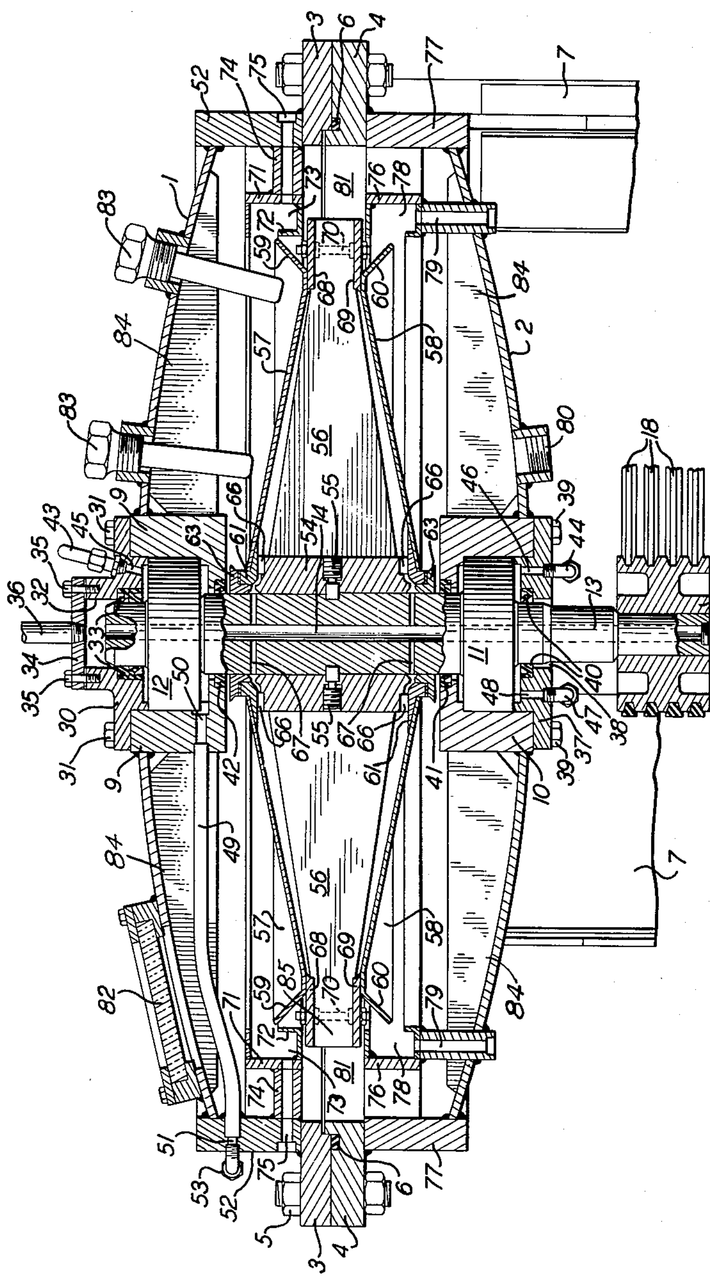

FIG. 2

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Fig. 3.

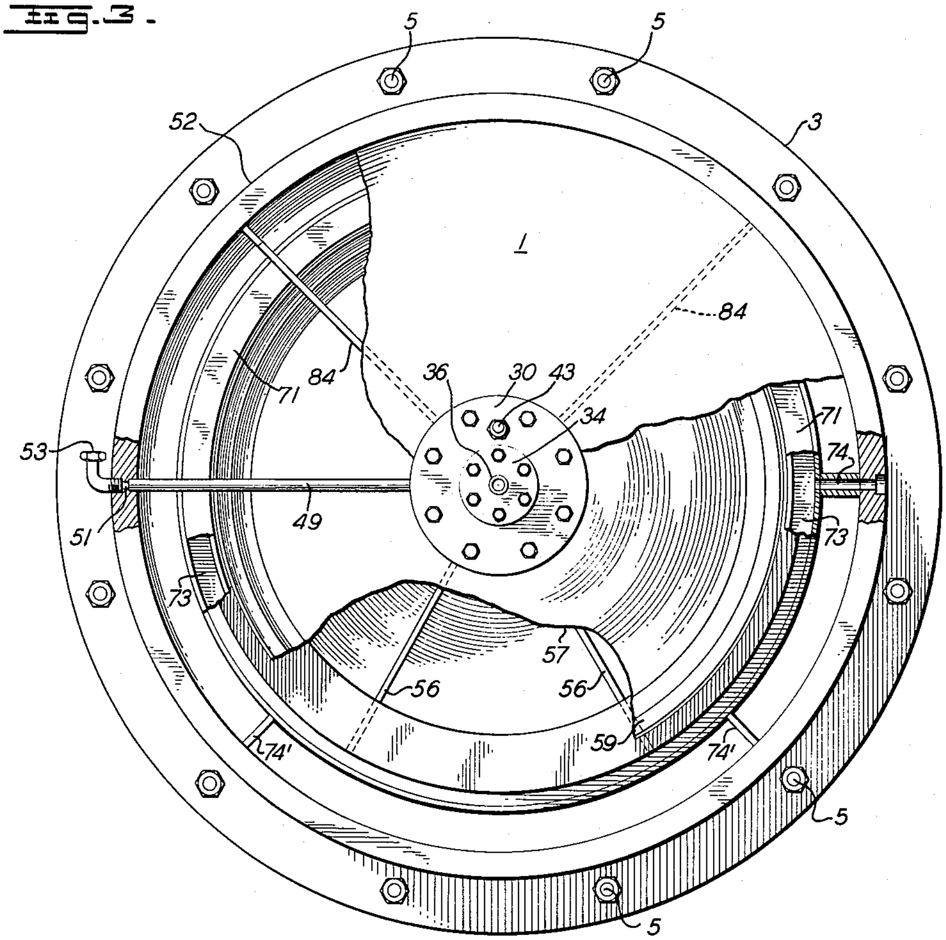
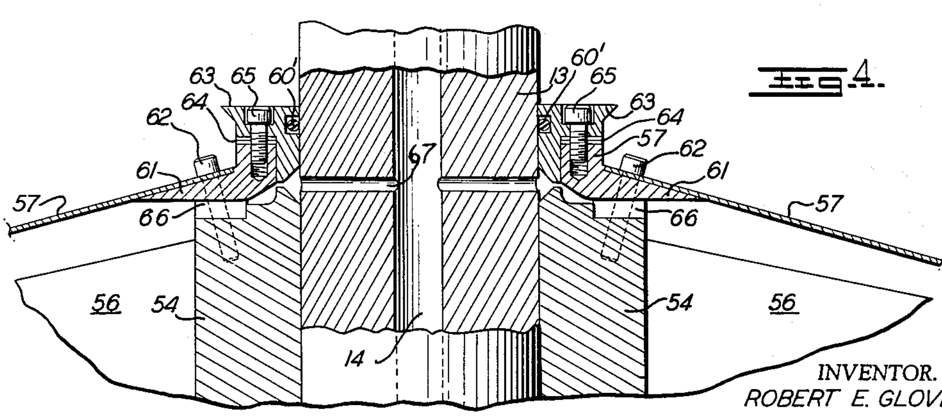


Fig. 4.



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2,996,439

ROTARY STILL

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10 Claims. (Cl. 202—236)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention herein described and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of royalties thereon or therefor.

This invention relates to rotary stills for compression distillation.

In rotary stills proposed heretofore, the distilland is introduced at the center of a rotating disc, or surface of revolution, and spread into a thin outwardly flowing film by centrifugal force. The heat needed for evaporation of this film passes through the disc and is supplied from the heat of condensation given up by vapor condensing on the other side of the disc. Vapors from the distilland film are removed from the evaporation zone and put through a compressor to raise their temperature and pressure before they come in contact with the condensation side of the disc. In this form the evaporation side of the disc is sealed off from the condensation side by a running seal, which is difficult to maintain.

I have found that by incorporating the compressor into the spinning disc arrangement, the need for a separate compressor, and a seal between the evaporation and compression zones is eliminated, and that a more efficient product collection arrangement can be had.

A principal object of this invention therefore is to provide a new and highly efficient rotary compression still and compression distillation method wherein the difficulties inherent in a running seal are eliminated.

It is a further object of this invention to provide a rotary still having a compressor within the evaporation zone defined by upper and lower rotating discs having good heat transfer characteristics, converging toward each other at their peripheries, said discs being mounted within a casing; to provide vanes mounted concentrically with the discs to serve as the vapor compressor; to provide an inlet for liquid to be distilled, such as saline waters, at the central inner surfaces of the rotating discs; to provide a manifold and passageways to convey vapors from the evaporation zones to outer condensation surfaces of the discs; to provide trough or gutter means for withdrawing condensate and residue.

Further objects will become apparent after a consideration of the following specification and claims.

The invention in brief, consists of a rotary still wherein the compressor and heat exchange unit are located in the same zone. Liquid feed is introduced along the inner surfaces of a pair of discs which serve as phase separating barriers, and gives off vapor which is compressed by the centrifugal forces created by rotation. These vapors are discharged from the outer rim of the rotor in a compressed and heated condition, and then are directed toward the outer surfaces of the discs where they supply on condensation the heat required to maintain the evaporation on the inner surfaces. The residual liquid is thrown to the outer rims of the discs where it is collected and discarded. The condensate collecting on the outer surfaces of the discs is diverted to special collecting troughs or gutters by deflectors, and is drawn off as distillate output.

This rotary still is especially useful for the distillation of saline waters, including sea water and brackish water, to produce pure potable water. However, its use is not

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limited thereto, but may be employed with suitable modification for distillation operations in general.

The accompanying drawings illustrate one embodiment of the present invention, in which

FIGURE 1 is a front elevation showing the external appearance of my device.

FIGURE 2 is a partial cross-sectional view in front elevation taken through the rotor axis.

FIGURE 3 is a plan view, partially cut away, of the rotary still.

FIGURE 4 is an enlargement of a portion of FIGURE 2, showing in detail the connection of the upper disc to the rotor shaft.

Referring to the drawing, upper and lower casing members **1** and **2** having rims **3** and **4** fastened together by a series of bolts **5**, with an O ring seal **6** is disposed between the rims. Lower casing **2** has fastened thereto supporting legs **7** for mounting on a suitable base **8**. Fastened to the centers of these upper and lower casing members **1** and **2**, as by welding, are hub members **9** and **10**. Bearings **11** and **12**, which may be spherical roller bearings, are mounted in hubs **10** and **9** respectively, and have journalled therein shaft **13**. A bore **14** extends axially through the shaft and is closed off at the bottom by a threaded plug **15** and washer **16**. Sheave **17**, keyed to shaft **13**, is suitably grooved to receive V belts **18**. Sheave **19** of larger diameter than **17**, is keyed to a vertical jack shaft **20**, journalled in pillow blocks **21** and **22** mounted at the end of horizontally extending supports **23** and **24** mounted on vertical bracket **25** fastened to base **8**. Pulley **26** is keyed to shaft **20** and is driven by V belt **27** connected by a variable speed pulley **28** (partially hidden in FIGURE 1) to a vertically mounted electric motor **29**.

As shown in FIGURE 2, hub **9** is covered by retainer **30**, which is fastened thereto by cap screws **31**. The upper end of shaft **13** fits into bore **32** in retainer **30**, and a tight seal is provided by shaft seal **33**. Bore **32** is covered by plate **34** secured by cap screws **35** to retainer **30**. A feed inlet **36** is threaded into plate **34** at the center thereof.

The bottom hub **10** is covered by retainer **37**, having an aperture **38** for shaft **13**, secured by cap screws **39**. Shaft seal **40** provides a tight seal between shaft **13** and retainer **37**. Also, shaft seals **41** and **42** are provided between hubs **9** and **10** and shaft **13**.

Lube oil fog is injected into bearings **11** and **12** by tube **43** and elbow **44**, threaded into passages **45** and **46** in retainers **30** and **37** respectively. Elbow **47**, threaded into passage **48** in retainer **37**, and connected to a line not shown, acts to remove the continuously injected lube oil from bearing **11**. Lube oil is removed from the upper bearing **12** by tube **49** which is suitably connected at one end to passage **50** in hub **9**, as by brazing, and at the other end to a passage **51** in vertical wall section **52** of casing **1** having an elbow **53** threaded therein.

Rotor **54** is fastened to shaft **13** by set screws **55**. A plurality of truncated generally V-shaped vanes **56** are securely fastened to rotor **54**, as by welding, to rotate therewith. In the embodiment shown herein, six vanes are employed, but the number can be varied as required.

Fastened to shaft **13**, as will be described later, are upper and lower discs **57** and **58**, having high thermal conductivity, which serve as phase separating barriers. These, as shown in FIGURE 2, converge toward each other at their peripheries and have sharply angled deflector portions **59** and **60**, presenting a generally dished-shape. Discs **57** and **58** are joined to shaft **13** in the same manner, so that a description of the mode of fastening disc **57**, shown in enlarged FIGURE 4, will suffice for both.

Orifice ring **61** having a cross-sectional shape, as shown in FIGURE 4, is fastened to rotor **54** by means of a plurality of cap screws **62**. Orifice gland **63** fits snugly about shaft **13**, and has an **O** ring shaft gasket **60'** mounted in a suitable groove to make a fluid tight seal. Shims **64** space orifice ring **61** from orifice gland **63**, and the latter two are joined together by cap screws **65**. The upper surface of rotor **54** and the lower surfaces of ring **61** and gland **63** define a convoluted passageway **66**, which communicates via bores **67** with axial bore **14** of shaft **13**. By varying the number or thickness of shims **64** the cross-sectional area of passages **66** may be adjusted.

Returning to vanes **56**, a pair of upper and lower annular rotor rings **68** and **69** are attached, by any suitable means, to rotor discs **57** and **58** near the outer ends thereof, suitable sealing compound being employed to make the joint liquid-tight. The vanes terminate in short straight portions, having horizontal upper and lower edges upon which the rotor rings rest. A plurality of spacing studs **70**, bolted between the rotor rings, act to maintain them in parallel relationship, and to provide thereby a circumferential opening **85**.

Located in the space between vertical cylindrical wall **52** of upper casing member **1** and deflector **59** of upper disc **57** is an upper annulus of general **C** shape **71**, having a vertical inner section **72** closely adjacent deflector **59**, forming a channel or gutter **73**. A pair of tubes **74**, 180 degrees apart, welded to the annulus **71** and the inner surface of wall **52**, together with struts **74'** (shown in FIGURE 3), serve to rigidly support said annulus, large openings being left between each support member. Holes **75** extend through wall **52** and are coaxial with tubes **74**. It is apparent that by virtue of tubes **74** and holes **75**, annulus **71** is in communication with the exterior of wall **52**.

A lower annulus **76**, similar to upper annulus **71**, is located in the space between vertical cylindrical wall **77** of lower casing **2** and deflector **60** of lower disc **58**. Annulus **76** has a channel or gutter **78**, and is supported in place by struts (not shown) and vertical tubes **79** which are rigidly connected to the bottom of the channel **78** and to the bottom of casing **2**, leading to the exterior. Tubes **79**, additionally, function as drains for channel **78**. Nipple **80** fastened at the bottom of **2** acts as a drain for the lower casing. The region **81** of the casing, bounded by the casing walls and the annuli serves as a manifold. Upper casing **1** has an observation porthole covered by a suitable transparent plastic plate, denoted generally by **82**, and a pair of thermowells **83** for the insertion of temperature recording instruments. Four stiffener ribs **84** are welded to the underside of upper casing **1**, two being shown in FIGURE 3. Similar stiffeners are provided for lower casing **2**.

The operation of my device will now be described. Motor **29** is started, driving the rotor discs by the **V**-belt arrangement shown at any speed between 2000 and 6000 r.p.m. in a device having discs about two feet in diameter, the speed being selected using a conventional variable speed motor pulley. Liquid to be distilled is admitted via inlet **36**. Sea water will be the liquid described herein, but it is to be understood that other liquids may be employed.

Sea water flows through the bore **14** in shaft **13** through passages **67** and **66** and is distributed along the inner surfaces of the rotor discs in a thin outwardly flowing film by centrifugal force. Vapors coming off the sea water film are caused to rotate by vanes **56** and are compressed and heated by the centrifugal force. These vapors leave the outer edge of the rotor, pass rings **68** and **69** and pass into the manifold **81**. Thence they flow around tubes **74** and **79** and annuli **71** and **76** to the outer faces of rotor discs **57** and **58**, where the vapors condense. It is to be noted that the pressure within the chamber, which may be superatmospheric, atmospheric, or subatmospheric, is maintained by the seals around the rotating shaft. Fresh water condensate flows outwardly along the outer surfaces of the rotor discs impelled by the centrifugal force, and passes over deflectors **59** and **60** into channels **73** and **78**, whence it is removed via outlet tubes **75** and **79**. The residual concentrated brine is discharged into the manifold **81** and flows down into the bottom portion of the lower casing, where it is removed through nipple **80**.

On condensing on the outer surfaces of the rotor discs, the vapors give up heat which is transmitted through the discs, and causes evaporation in the sea water film on the inner disc surfaces.

The fresh water is removed, via lines (not shown) connected to **75** and **79** and the brine through lines connected to **80**. When the still is operated at above or below atmospheric pressure water seals are provided in the liquid removal lines at some distance below the disc level.

It is obvious that many variations within the skill of the art may be made in this rotor still without altering the essence of the invention. For example, direct motor drive may be substituted instead of belt drive, and other conventional lubricating methods substituted for that shown. Instead of straight vanes, curved elements may be substituted if desired. Although the vanes are shown in the embodiment described as fixed to the rotor discs near their peripheries, they may be left unattached when conditions of operation warrant. If desired, the vanes may be mounted so as to rotate at a different rate than the rotors. While this embodiment has been described as having but a single pair of discs, it is within the purview of this invention to employ a larger number of discs mounted on a common shaft within the same casing. If desired, stiffener ribs **84** may be omitted.

Any conventional structural material may be employed in this still, the selection of which to use being based primary on the intended use and economics. A rotor still for producing fresh water from sea water would of necessity have to be fabricated from corrosion resistant or specially treated materials, such as stainless steel, aluminum, etc.

I claim:

1. In a compression still, a central shaft means, means for rotating said shaft means, a pair of rotary phase separating barrier means having a high thermal conductivity, each said barrier means comprising an inner evaporating surface and an outer condensing surface, means joining said barrier means to the said shaft means for axial rotation therewith, said inner and outer surfaces being continuous from said jointure at the shaft means to peripheral edges on said barrier means, means for introducing dissilland on the said evaporating surfaces whereby said distilland is distributed over the evaporating surfaces in a thin film by centrifugal force, compression means comprising rotatable elements extending between the said pair of barrier means from points contiguous to said jointure to points contiguous to said peripheral edges and being operatively connected to said shaft means, whereby said elements are effectively disposed adjacent substantially the entire evaporating surface of the barrier means, said compression means being adapted to compress and heat vapor evolved from the distilland film.

2. In a compression still, a central shaft means, means for rotating said shaft means, a pair of rotary phase separating barrier means having a high thermal conductivity each said barrier means comprising an inner evaporating surface and an outer condensing surface, means joining said barrier means to the said shaft means for axial rotation therewith, said inner and outer surfaces being continuous from said jointure at the shaft means to peripheral edges on said barrier means, means for introducing distilland on the said evaporating surfaces whereby said distilland is distributed over the evaporating surfaces in a thin film by centrifugal force, a plurality of vanes rotatably mounted on said central shaft means for rotation therewith, said vanes extending between said pair of barrier means from points contiguous to said

jointure to points contiguous to said peripheral edges, whereby said vanes are effectively disposed adjacent substantially the entire evaporating surface of the barrier means, said rotating vanes being adapted to compress and heat vapors evolved from the distilland film, means for conducting the evolved vapors to the condensing surfaces, means for removing the distilland residue from the evaporating surfaces, said vapors condensing on the condensing surfaces releasing heat of condensation which is transmitted through the barrier means to the evaporating surfaces, and means for recovering condensate from the condensing surfaces.

3. In a compression still, a central shaft means, means for rotating said shaft means, at least one pair of generally dish-shaped phase separating barriers of high thermal conductivity, each barrier having an inner evaporating surface and an outer condensing surface in heat exchange relationship, said barrier being mounted axially on said shaft for rotation therewith, said inner and outer surfaces being continuous from said shaft to peripheral edges on said barriers, the latter being spaced laterally with the dished portions facing each other, compression means disposed between said barriers comprising elements extending from points contiguous to said shaft to points contiguous to said peripheral edges and rotatable with said shaft, means for introducing distillad to the inner evaporating surfaces, whereby the distilland is distributed outwardly over the evaporating surfaces by centrifugal force and vapors are evolved, said compression means being adapted to compress and heat the vapors, means for removing the distilland residue from the evaporating surfaces, means for conducting the evolved vapors to the barrier outer condensing surfaces, where they condense, releasing heat of condensation, said heat being transmitted through the barrier to the evaporating surfaces, and means disposed adjacent the peripheral edges of the barrier for recovering condensate from said condensing surfaces.

4. In a compression still, a central shaft means, means for rotating said shaft means, at least one pair of generally dish-shaped phase separating barriers of high thermal conductivity, each barrier having an inner evaporating surface and an outer condensing surface in heat exchange relationship, said barriers being mounted axially on said shaft for rotation therewith, said inner and outer surfaces being continuous from said shaft to peripheral edges on said barriers, the latter being spaced laterally with dished portions facing each other, a plurality of vanes disposed between said barriers, means joining said vanes ot the central shaft means for rotation therewith, said vanes extending from points contiguous to their jointure at the shaft to points contiguous to said peripheral edges, means for introducing distilland to the inner evaporating surfaces, whereby the distilland is distributed outwardly over the evaporating surface by centrifugal force and vapors are evolved, said rotating vanes being adapted to compress and heat the vapors, means for removing the distilland residue from the evaporating surface, means for conducting the evolved vapors to the barrier outer condensing surfaces, where they condense, releasing heat of condensation, said heat being transmitted through the barrier to the evaporating surface, and means disposed adjacent the peripheral edges of the barrier for recovering condensate from said condensing surfaces.

5. In a compression still, a hollow central shaft means, means for rotating said shaft means, rotary phase separating barrier means having a high thermal conductivity, said barrier means comprising an inner evaporating surface and outer condensing surface, means joining said barrier means to the shaft means for axial rotation therewith, liquid inlet means for admitting distilland into the said hollow central shaft means, conduit means for transferring distilland from the shaft means to the barrier means evaporating surface, whereby said distilland is distributed over the evaporating surface in a thin film by centrifugal force, a plurality of vanes mounted on said central shaft means for rotation therewith, said vanes being disposed adjacent substantially the entire evaporation surface and adapted to compress and heat vapors evolved from the distilland film on the evaporating surface, means for removing the distilland liquid residue from the barrier evaporator surface, means for conducting the compressed and heated vapors to the condensing surface where said vapors condense releasing heat of condensation, said heat being transmitted to the evaporation surface, and means for recovering distillate from the condensing surface.

6. In a compression still, a hollow central shaft means, means for rotating said shaft means, at least a pair of generally dish-shaped phase separating barriers of high thermal conductivity, each barrier having an inner evaporating surface and an outer condensing surface in heat exchange relationship, said barriers being mounted axially on said shaft means for rotation therewith and spaced laterally with the dished portions facing each other, inlet means for admitting distilland into the said hollow central shaft means, conduit means for transferring distilland from the shaft means to the barrier means evaporating surfaces, whereby the distilland is distributed over the evaporating surfaces in a thin film by centrifugal force and vapors are evolved, a plurality of vanes disposed between said barriers, means joining said vanes to the central shaft means for rotation therewith, said rotating vanes acting to compress and heat the vapors, means for removing liquid distilland residue from the evaporating surfaces, means for conducting the evolved vapors to the barrier outer condensing surfaces where they condense releasing heat of condensation, said heat being transmitted through the barrier to the evaporating surfaces, means disposed adjacent the peripheral edges of the barriers for removing condensate from said condensing surfaces.

7. In a compression still, a hollow central shaft, means for rotating said shaft, at least a pair of generally dish-shaped phase separating discs of high thermal conductivity, each disc having an inner evaporating surface and an outer condensing surface in heat exchange relationship, said discs being mounted axially on said shaft for rotation therewith, and spaced laterally from each other with the dished portions facing each other, inlet means for admitting distilland into the hollow shaft, conduit means for transferring distilland from the shaft to the disc evaporating surfaces, whereby distilland is distributed over the evaporating surface in a thin film by centrifugal force and vapors are evolved, a plurality of vanes disposed between said discs, means joining the vanes to the shaft for rotation therewith, said rotating vanes acting to compress and heat the vapors, means for removing liquid distilland residue from the evaporating surfaces, means for conducting the evolved vapors to the outer condensing surfaces of the discs, where they condense releasing heat of condensation, said heat being transmitted through the discs, to the evaporating surfaces, circumferential deflection means mounted at the outer peripheries of the condensing surfaces of the discs, annular channel means located adjacent the deflection means, whereby the condensate on the disc surfaces is impelled by centrifugal force over the deflection means into said channel means, and outlet means for removing condensate from the channel means.

8. A compression still as in claim 7, wherein the said pair of separating discs are spaced apart at their outer peripheries to provide a circumferential opening for the evolved vapors from the evaporating surface.

9. A compression still as in claim 8, wherein the liquid distilland residue is discharged through the circumferential opening, and outlet means for removing said liquid distilland residue.

10. A compression still comprising outer casing means, a hollow central shaft vertically mounted in said casing means, means for rotating said shaft, at least one pair of generally dish-shaped phase separating discs of high thermal conductivity within said casing, each disc having an inner evaporating surface and an outer condensing surface

in heat exchange relationship, said discs being mounted axially on said shaft with the dished portions facing each other, whereby said discs are adapted for rotation in a generally horizontal plane, the discs being spaced apart at their outer peripheries to provide a circumferential opening, inlet means for admitting distilland into the hollow shaft, conduit means for transferring distilland from the shaft to the said inner evaporating surfaces, where distilland is distributed over the evaporating surfaces in a thin film by centrifugal force and vapors are evolved, a plurality of vanes mounted on the shaft for rotation therewith, said vanes being disposed between said discs and adapted to compress and heat the evolved vapors from the evaporating surfaces, passage means including said circumferential opening and the casing means for conducting the evolved vapors to the outer condensing surfaces of said discs where they condense releasing heat of condensation, said heat being transmitted through the discs to the evaporating surfaces, outlet means for re-

moving liquid distilland residue discharged through the circumferential opening and discharging it outside the casing, circumferential deflection means mounted at the outer peripheries of the condensing surfaces of the discs, annular channel means located adjacent the deflection means, whereby the condensate on the condensing surface is impelled by centrifugal force over the deflector means into said channel means, and outlet means for removing condensate from the channel means and discharging it outside the casing.

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