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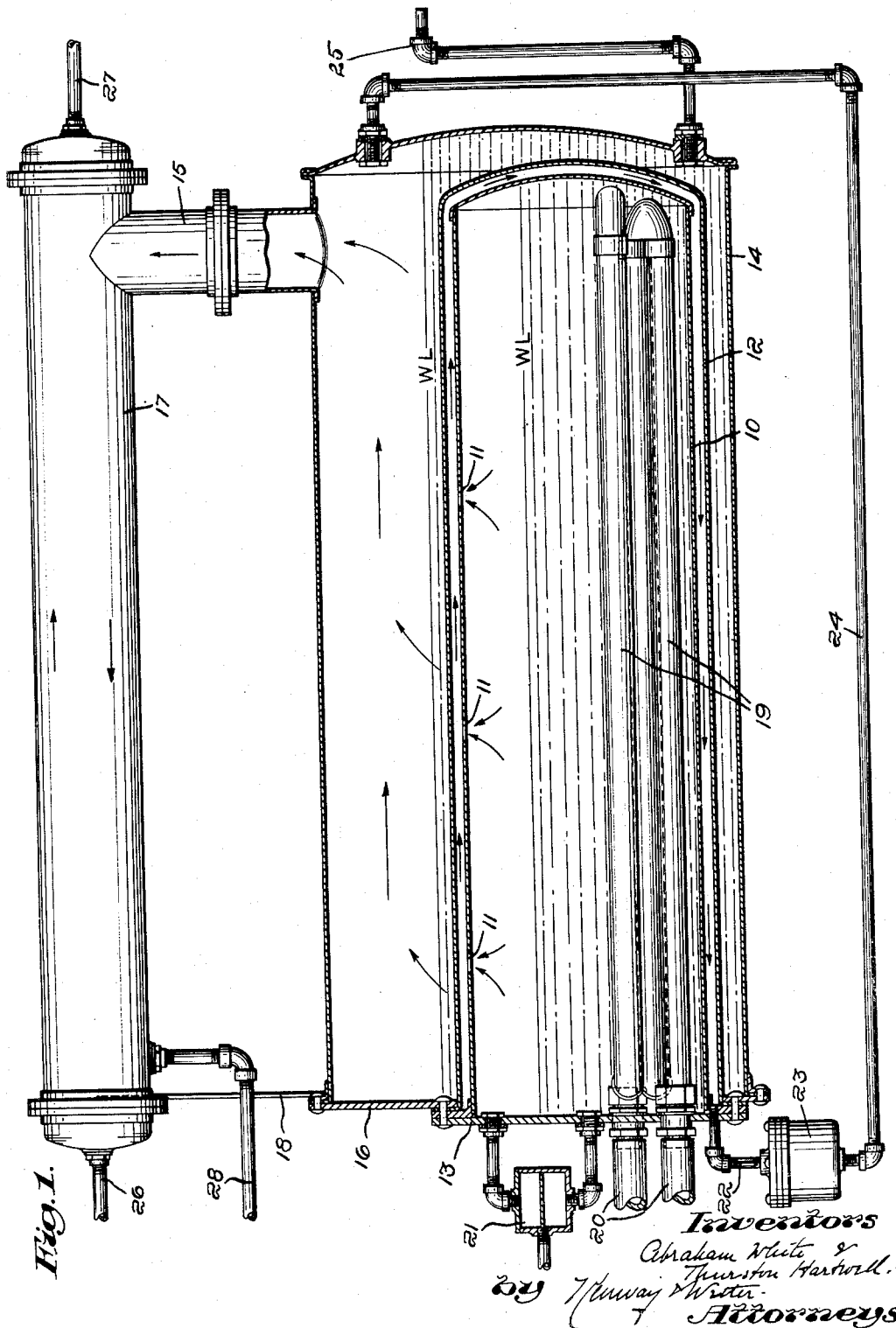
A. WHITE ET AL

2,301,835

DISTILLING APPARATUS AND PROCESS

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2 Sheets-Sheet 1



Nov. 10, 1942.

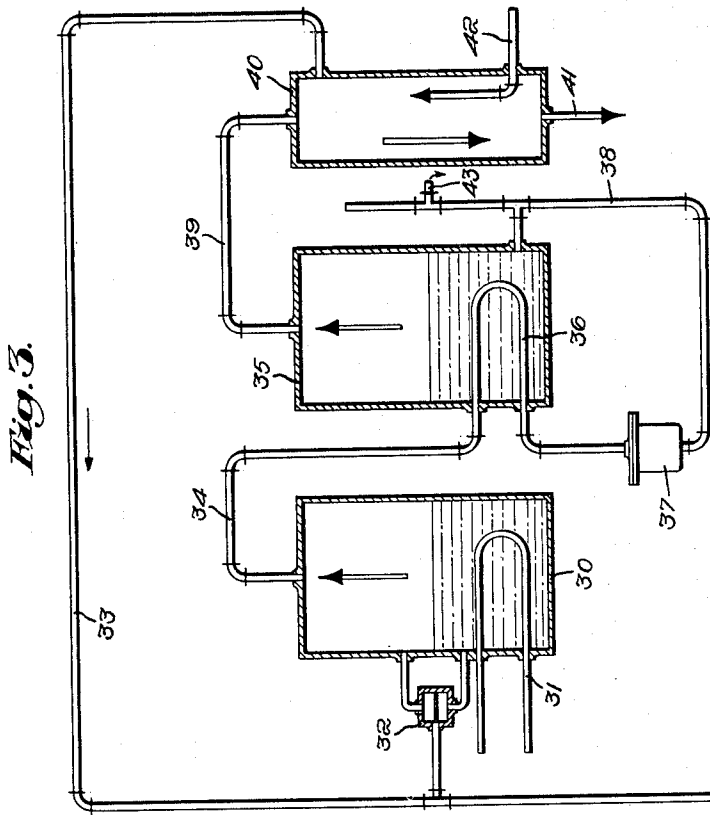
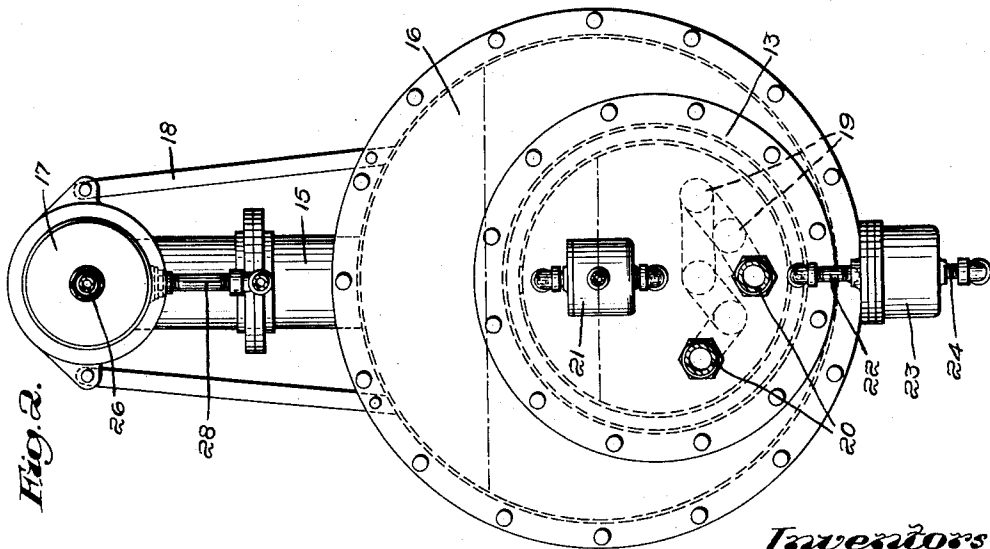
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Inventors
Abraham White and
Thurston Mansfield -
by Penway & Witter.
Attorneys

UNITED STATES PATENT OFFICE

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DISTILLING APPARATUS AND PROCESS

Abraham White, Newton, and Thurston Hartwell, Needham, Mass., assignors to Barnstead Still & Sterilizer Co., Inc., Forest Hills, Mass., a corporation of Massachusetts

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This invention consists in improved distilling apparatus for carrying out multiple effect distillation. It includes within its scope a novel process of double distillation or multiple redistillation for which the novel apparatus of our invention may be advantageously employed.

An important field of use of our invention is in the distillation of water for use in hospitals, laboratories and in the pharmaceutical, food, and beverage industries. Our invention will be accordingly described in its application to this field, although it will be understood that it is in no sense limited thereto, but has general application wherever it is desired to distill liquids under controlled and economical conditions.

In one aspect our invention consists in distilling apparatus having one effect or stage built within another. This type of construction offers three major advantages, (1) a saving in space over the conventional arrangement of multiple effect apparatus wherein the evaporators are arranged as separate units, (2) a saving in cost by eliminating the necessity of using a Calandria or other apparatus for transferring heat to the second-effect evaporator or subsequent evaporators in the series, and (3) the constructional and operating advantage of wasting or losing no heat from the pressure effect drum. As herein shown a pressure effect evaporator shell is used as a condenser for the vapors generated at that pressure and also as a heating means for the subsequent low pressure effect evaporator. Where two stages only are to be considered this shell, which is immersed in the liquid of the second-effect evaporator, takes the place of the Calandria or steam coil that would be needed in the conventional type of construction. Further, the necessity of interconnecting vapor piping is eliminated by immersing the pressure or first-effect evaporator in the second-effect liquid. In one aspect, therefore, our invention consists in inserting a pressure effect unit within an atmospheric or low pressure effect unit, thereby utilizing the shell area of the pressure effect unit as a condenser for the vapors of the pressure effect and also as a heater for the liquid of the second or low pressure effect. As herein shown the pressure effect includes an inner drum or liner which serves as a baffle to separate the pressure vapors and condensate from the boiling liquid in the pressure effect. This liner may be made of light construction since the pressure is equal on both sides and may be perforated in its top to provide passages for the pressure vapors from the inside of the drum or liner to the an-

nular space thus provided between the liner and the shell, in which space the pressure vapors are condensed, transferring their heat through the shell to the liquid in the atmospheric or low pressure effect.

While the invention is illustrated as embodied in apparatus for double effect distillation it may be used for double or triple or quadruple effect distillation by employing three or four drums or cylinders one immersed in another.

One of the most useful applications of the apparatus above discussed is in carrying out our novel process for double distillation or multiple redistillation of water. For intravenous hospital work double or triple distilled water is now quite generally demanded. There is an advantage in carrying out one stage of multiple distillation for this purpose under substantial pressure since water distilled under pressure and at high temperature is more quickly purified and sterilized than when distilled at lower pressure and temperature, and pressure distillation is particularly valuable in that it insures destruction of certain detrimental elements in raw water known as pyrogens.

Broadly the process of our invention consists in a process of multiple distilling which is characterized by heating and vaporizing liquid in a closed vessel under substantial pressure, condensing the vapors thus produced under practically this same substantial pressure, and then discharging the condensate thus produced from this once-vaporized liquid to a second vessel where it is revaporized at a lower temperature, for example at substantially atmospheric pressure, by heat transferred to it in said condensing step. As already intimated our novel process may be extended to triple or quadruple distillation by arranging the condensation of vapors from one particular evaporation to take place at practically the same pressure as that of the particular evaporation itself, and that the next evaporation should be effected at a lower pressure and the condensation from that next evaporation take place at the same lower pressure.

In using the apparatus of our invention to redistill water the condensate made from the pressure vapors of the first effect is condensed in the heater of the second effect and the condensate is fed back to the second effect evaporator as feed water. This is a novel procedure, because in the multiple effect equipment heretofore known the once-distilled water has been collected and mingled with the distillate from the second effect to make up the total distilled

water production of the unit. In other words, instead of feeding raw water to our second effect evaporator as is conventional, we propose to feed back the once-distilled water produced in the first effect evaporator for a redistillation and thus produce double distilled water.

The process of our invention can be applied to the multiple distillation of any liquid, such as alcohol for example, where for any reason it may be desired to distill the liquid over several times. The advantages of our process over the usual process of preparing double or triple distilled liquids is the saving in steam consumption, in that boiler steam is supplied to the first effect only and it is therefore possible to prepare a double or a triple distilled product at substantially the same cost as once-distilled water in a single effect unit. While we have referred to the source of primary heat for first effect as boiler steam, it is contemplated that an electric or a gas heater may be utilized wherever more convenient and that a corresponding saving will be realized in such instances.

These and other features of the invention will be best understood and appreciated from the following description of a preferred embodiment of our apparatus and an illustrative description of one specific manner of carrying out our novel process, all as illustrated in the accompanying drawings, in which:

Fig. 1 is a view of a complete apparatus in longitudinal section partly in elevation,

Fig. 2 is a view in front elevation, and

Fig. 3 is a diagrammatic representation of another typical apparatus for carrying out the double distilling process of our invention.

Referring first to Figs. 1 and 2, the apparatus includes an inner drum or liner 10 disposed in horizontal position and having in its upper wall a series of circular openings 11 providing vapor passages for vapor generated within the drum. Surrounding the drum 10 is a closed shell 12 herein shown as arranged concentrically with respect to the drum 10 and spaced therefrom to provide an annular condensing chamber. The shell and inner drum are closed at their outer ends by a common head 13 and at their inner ends by rounded convex heads which are disposed concentrically and spaced apart substantially the same distances as the circumferential walls of the drum and shell.

The inner drum 10 and its shell 12 are enclosed within an outer drum 14, being arranged eccentrically therein as shown in Fig. 2 and with the lower wall of the shell 12 spaced from the lower wall of the outer drum 14. The outer drum is provided in its upper wall with an upright vapor duct 15 of substantial size and is closed at its left end by a flat head 16 in which the smaller head 13 of the inner drum 10 and shell 12 is eccentrically inserted and securely riveted or may be otherwise secured.

Within the inner drum 10 heating means is provided, and as herein shown, this may comprise a coil of steam pipes 19 which communicate through the head 13 with boiler connections 20. Adjacent to the head 13 is also provided an automatic feed water valve 21 by which in the normal operation of the apparatus the water level is maintained in the drum 10 at about the three-quarter mark as indicated in Fig. 1. In the lower part of the head 13 is provided an outlet pipe 22 through which the liquid vaporized in the drum 10 and condensed within the shell 12 is drawn from the shell and directed to a combined trap and reducing valve 23

from which it passes through a pipe 24 and, as herein shown, is returned to the outer drum 14. An overflow connection 25 is provided for the drum 14 which is effective to maintain the water level in the outer drum at the desired point, at least a sufficient level totally to immerse the shell 12. Liquid revaporized in the outer drum 14 by the heat supplied to it from the shell 12 passes upwardly through the vapor duct 15 to a condenser 17 which is here shown as maintained above and in parallel relation to the drum 14, being supported at its rear end by the vapor duct 15 and at its forward end by a pair of supports 18 secured at their lower ends with cooling water connections 26 and 27, and in its bottom wall with an outlet pipe 28 by which the vapor condensed in the condenser, i. e. the redistilled product, is drawn from the apparatus for whatever its intended purpose may be.

In operating the apparatus above described for producing double distilled water, the inner drum 10 should be maintained below boiler pressure, for example, at 60 pounds, and may be heated by steam supplied to the coil at above 60 pounds, for example at full boiler pressure. Water vapor generated in the drum 10 passes upwardly through openings 11 in the shell 12 where it heats the shell and is itself condensed in the annular condensing chamber between the drum and shell. The pressure within and without the cylindrical walls of the inner drum 10 is, of course, equalized by the openings 11. It may be drawn in liquid form from this chamber by the outlet pipe 22 and delivered through the reducing valve 23 and pipe 24 to the outer drum which should be at pressure less than full-effect pressure, for example at atmospheric pressure. Here the once-vaporized and now condensed water is again vaporized, this time by the heat of the shell 12. The vapor passes up through the vapor duct 15 and is condensed for the second time and drawn from the condenser by the outlet pipe 28.

The apparatus may be advantageously operated at the pressures suggested, but it is not in any sense limited to that range or an approximation of it since it is necessary only that there should be a pressure difference between the outer and inner drums. For example, the pressure in the outer drum may be above atmospheric or vaporization therein may even be conducted under conditions of partial vacuum.

The apparatus has been described as functioning for double distilling, but it may be employed advantageously in a system for triple distilling or quadruple distilling there being no limitation as to the number of distillations that can be carried out. For quadruple distilling, for example, two intermediate drums with their corresponding shells would be added to the equipment now shown in Fig. 1, and under such conditions the first distillation may be carried out at 100 pounds, the second at 60 pounds, and the third at atmospheric pressure and the fourth at sub-atmospheric pressure.

It should be further noted that the apparatus above described is not limited to processes of multiple distilling, but may be employed with good advantage for multiple stage single distilling. In that case liquid would be supplied independently to the inner and outer drums and the single distilled condensation from both drums collected for use.

As already stated the process of double distillation herein disclosed is not limited to apparatus of the type illustrated in Figs. 1 and 2, but

may be carried out in any apparatus where the once condensed liquid is revaporized at a lower pressure by heat transferred to it in the first condensation step. This will be best understood from consideration of the alternative arrangement of apparatus diagrammatically shown in Fig. 3. In this figure a high pressure drum 30 is shown as disposed vertically and heated by a steam coil 31 while liquid is maintained therein at a predetermined level by an automatic feed water valve 32 connected to a water supply pipe system 33. Vapor generated in the high pressure drum 30 passes upwardly through the outlet duct 34 which communicates with a coil 36 disposed in a low pressure drum 35 herein shown as separate from the high pressure drum 30 and standing beside it. Vapor is condensed in the coil 36 heating and vaporizing the liquid contained in the low pressure drum 35. The vapor condensed in the coil 36 passes downwardly through the reducing valve and trap 37 and is delivered through the pipe 38 to the low pressure drum, the water level being determined by an overflow outlet 43. When revaporized therein the vapor passes upwardly through the outlet pipe 39 to the condenser 40 where it is again condensed and drawn off through the outlet pipe 41. The condenser 40 is shown as supplied with cooling water through the inlet pipe 42 and as communicating with the pipe system 33 which leads to the high pressure drum 30. The water supplied to the drum 30 is therefore preliminarily heated by passing through the condenser 40.

It will be noted that the first condensation, that occurring in the coil 36, is carried out at substantially the same pressure as the first vaporization in the high pressure drum 30. In general, the condensation of vapors from one particular evaporation should take place at substantially the same pressure in which that particular evaporation occurred, and the next evaporation should be at a lower pressure, and the condensation from the next evaporation at substantially the same lowered pressure. The drum 35 is provided with an overflow connection 43 by which the water level is maintained therein at the desired height.

In the illustrated apparatus the condensing step has been described as being carried out at substantially the same pressure as that at which the evaporation for that particular effect or stage has taken place. It is possible, and may be advantageous in some cases in practicing our invention, to carry out the condensing step at a somewhat lower pressure than that of the vaporizing step for the same stage, provided the pressure of the condensing step is maintained above the pressure of the succeeding revaporizing step; that is to say, the condensation may take place at some intermediate pressure between the pressure of evaporation in the sequent stages.

In Figs. 1 and 2 the inner drum 10 is shown as arranged eccentrically with respect to the outer drum 14 and the shell 12 is shown as arranged concentrically with respect to the inner drum 10. It is noted, however, that it is within the scope of our invention to arrange the inner drum concentrically with respect to the outer drum if desired or to place two or even more inner drums in a single outer drum. Moreover, the relationship of the inner drum 10 and its shell 12 is not necessarily concentric but may be varied to suit the conditions of the work in hand. For multiple stage distillation the employment of two

or more inner drums within a single outer drum presents many advantages.

Having thus disclosed our invention we claim as new and desire to secure by Letters Patent:

1. Apparatus for double distilling comprising an inner drum having heating means therein and connections for feeding liquid thereto, a concentric shell in communication with the inner drum through vapor passages in the upper side of the drum, an outer drum enclosing both the inner drum and its concentric shell, means for delivering liquid condensed from vapor within said shell to the outer drum, and a condenser connected to the outer drum for condensing vapor generated in the outer drum by heat from said concentric shell.

2. Apparatus for multiple effect distilling comprising an outer low-pressure drum, means for maintaining a constant water level therein, a high pressure closed shell having a spaced drum therein providing therewith an annular condensing chamber, said shell being located within the outer drum and below the water level thereof, heating means for the contents of said inner drum and passages therein leading to said shell, a feed-water connection to said drum, means for drawing from said annular condensing chamber water condensed therein and delivering it to said outer drum, and means for condensing vapor generated by the heat of said shell at low pressure in said outer drum.

3. Apparatus for multiple-effect distilling, comprising an inner drum having heating means therein, a spaced closed shell surrounding said inner drum, there being vapor passages in the drum which equalize pressure within and without the drum, said shell serving to condense vapor from the inner drum and being itself heated thereby, connections for removing condensate from the interior of the shell, an outer drum enclosing both the inner drum and its shell and having its contents heated by said shell, connections for delivering liquid to the inner and outer drums, condensing means in communication with said outer drum, and means for collecting condensed liquid from said condensing means.

4. Apparatus for multiple-effect distilling, comprising an outer drum having a flat head at one end, an inner drum apertured in its upper part and having a concentric closed shell disposed therewith as a unit eccentrically within the lower portion of the outer drum, the aperture in the inner drum serving to equalize pressure on both sides of its cylindrical walls, connections for delivering liquid to the inner and outer drums, connections for removing condensate from the interior of the shell, provision for maintaining a pressure difference between the inner and outer drums, and a head for the inner drum inserted in the head of the outer drum.

5. Apparatus for multiple-effect distilling, comprising an outer drum having outlet connections and means for maintaining a constant liquid level therein, an inner drum perforated in its upper part and having a closed spaced concentric shell located within the outer drum and below the liquid level therein, inlet supply connections to the inner drum, the perforations of the inner drum equalizing pressure within the drum and within said shell, means for vaporizing liquid in the inner drum, said vapor being condensed in contact with said shell and thereby heating the shell and vaporizing the liquid content of the outer drum in which the shell is immersed, connections for removing condensate from said shell, and pro-

vision for maintaining a pressure difference between the inner and outer drums.

6. Apparatus for multiple-effect distilling, comprising a liquid-containing inner drum having inlet connections and heating means and being maintained at below boiler pressure and perforated above the level of liquid therein to permit the escape of vapor generated therein and to equalize pressure within and without the drum, a closed shell enclosing said inner drum for collecting and condensing at below boiler pressure the vapor generated in the inner drum thereby becoming heated itself, connections for removing condensate from said shell, an outer drum enclosing the inner drum and shell and containing liquid at substantially atmospheric pressure to be vaporized by the heat of said shell, and provision for maintaining a pressure difference between the inner and outer drums.

7. Apparatus for multiple-effect distilling, comprising an outer drum having outlet connection and means for maintaining a constant liquid level therein, an inner drum perforated in its upper part and having a closed spaced concentric shell located within the outer drum and below the liquid level therein, inlet connections for the inner drum, means for vaporizing liquid in the inner drum, provisions for maintaining pressure difference between the inner and outer drums and connections for transferring condensate from said shell to the outer drum, said

vapor being condensed in contact with the shell, thereby heating the shell and vaporizing the liquid contents of the outer drum in which the shell is immersed.

8. Apparatus for multiple-effect distilling, comprising an outer horizontal drum having a flat head in one end, an inner drum fastened into said head, held thereby in horizontal position eccentrically spaced from the sides of said outer drum and having vapor outlets in its upper side wall, a closed shell concentrically surrounding said inner drum and spaced from the outer drum at its inner end, heating means in the inner drum, connections, including a steam trap, for removing condensate from the bottom of the shell and transferring it to the outer drum, and means for delivering liquid to the said inner drum.

9. The process of double distilling which consists in heating and vaporizing liquid in a drum under substantial pressure, condensing the vapor thus produced at substantially the same pressure in a closed annular space surrounding the drum wherein it has been produced, delivering the once-vaporized liquid to a second annular space surrounding the first, revaporizing the condensed liquid in said second annular space at substantially atmospheric pressure, by heat transferred to it in the said condensing step, and finally condensing the revaporized vapor.

ABRAHAM WHITE.

THURSTON HARTWELL.