June 26, 1945. K. C. D. HICKMAN 2,379,151

HIGH VACUUM PUMPS AND SELF-PUMPING STILLS

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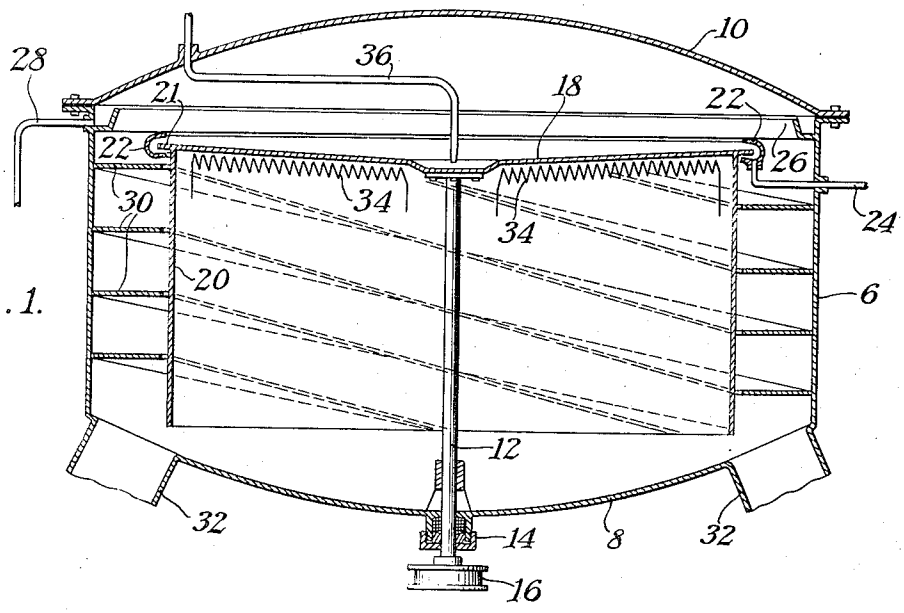


FIG. 1.

FIG. 2.

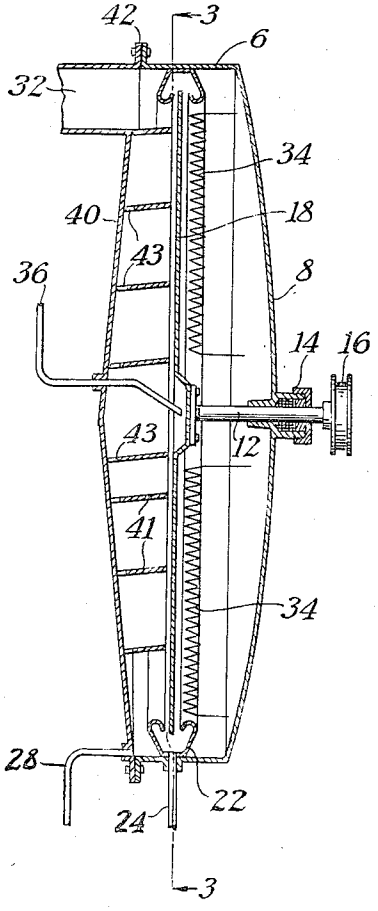
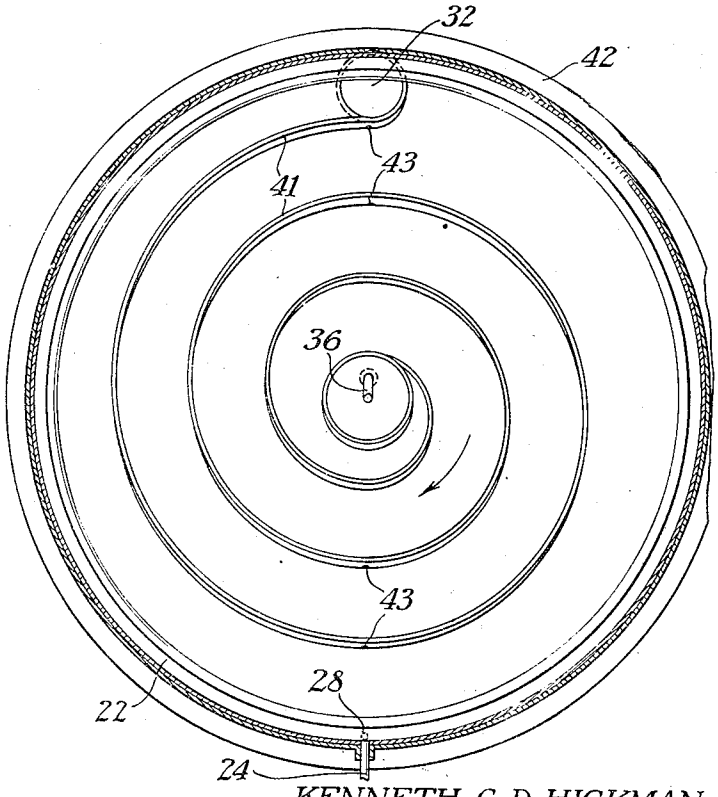


FIG. 3.



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HIGH VACUUM PUMP AND SELF-PUMPING STILL

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6 Claims. (Cl. 202—205)

This invention relates to improved high vacuum pumps of the type known as molecular pumps and improved self-pumping high vacuum stills.

Molecular pumps are well known in the high vacuum art. They are described in "Vacuum Practice" by Dunoyer, pages 30 to 40 (edition of 1926), published by D. Van Nostrand Company, Inc., New York city; see also Friesen, "The Review of Scientific Instruments," 11 (1940), p. 362. High vacuum stills provided with rotating vaporizing and/or condensing surfaces are also known. See, for instance, my Patent 2,210,926, August 13, 1940.

This invention has for its object to provide improved molecular pumps having high pumping capacity. Another object is to provide high vacuum centrifugal stills which are self-pumping. A further object is to provide a centrifugal still in which the rotation of the centrifugal surface causes evacuation of the still. Other objects will appear hereinafter.

These and other objects are accomplished by my invention which includes a centrifugal high vacuum unobstructed path still provided with a rotating vaporizing and/or condensing surface and a stator cooperating therewith to form a molecular pumping unit. Rotation of the vaporizing and/or condensing surface is thus caused to evacuate the still or distilling space in the manner of the molecular pump. My invention also includes a molecular pump in which vapors are generated on the rotor of the molecular pump and these vapors are caused to assist in the pumping action.

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

In the accompanying drawing wherein like numbers refer to like parts,

Fig. 1 is a vertical section of an improved centrifugal still embodying the principles of my invention;

Fig. 2 is a vertical section of a modification of the apparatus shown in Fig. 1, and

Fig. 3 is a vertical section taken on line 3—3 of Fig. 2.

Referring to Fig. 1, numeral 6 designates a cylindrical casing provided with a gas tight base plate 8 and a removable top plate 10. Numeral 12 designates a shaft mounted in a rigid manner in packed gland 14, the lower end of which is provided with a pulley 16 and the upper end of which is integral with circular plate 18. Numeral 20 designates a cylindrical collar rigidly attached to plate 18 which has a somewhat smaller diameter than plate 18 so that the periphery of 18 forms a lip therewith designated as 21. Lip 21 extends into an annular gutter 22 to which is connected a withdrawal conduit 24. Numeral 26 designates an annular gutter mounted upon the top inside wall of casing 6 to which is connected a withdrawal conduit 28. Numeral 30 designates a plurality of spiral shelves which are mounted upon the inside wall of casing 6, the inside diameter of each spiral being slightly greater in diameter than the cylindrical collar 20. Numeral 32 designates withdrawal or evacuating conduits which connect to evaporating pumps (not shown). Numeral 34 designates electrical heating units which heat vaporizing plate 18 to distillation temperature. Numeral 36 designates a conduit for introducing distilland on to the approximate center of vaporizing plate 18.

Referring to Figs. 2 and 3 numeral 40 designates a removable plate attached to the casing in a gas tight manner by flange 42 as indicated. Upon the inside surface of plate 40 is mounted a spiral 41 which extends into close proximity to vaporizing plate 18 the spiral being cut on the bias so that the element thereof slope slightly down hill as plate 40 is approached. The lower part of each baffle is provided with an opening at the point where the spiral is connected to plate 40. This opening is indicated by the numeral 43.

In operating the apparatus illustrated in Fig. 1, the system is evacuated by backing pumps connected to conduits 32. Vaporizing plate 18 and integral collar 20 are rotated clockwise by force applied to pulley 16, and heating units 34 are put into operation. Liquid to be distilled is introduced through conduit 36. Centrifugal force causes this liquid to pass in the form of a thin film to the periphery where it is flung into gutter 22 and is withdrawn therefrom by way of conduit 24. During passage over plate 18 in the form of a very thin film vaporization takes place and vapors are condensed upon the inside surface of top plate 10 which is air cooled. The condensate flows by gravity into gutter 26 and is withdrawn from the still by way of conduit 28. During rotation gases collide with the surface of collar 20 and vaporizing plate 18. They are thence forced into the spiral passages formed by spirals 30 and the walls of collar 20 and casing 6. These collisions are repeated numerous times and the gases are thus eventually forced

to the bottom of the casing by the same action which takes place in the conventional molecular pump. The gases are removed from the lower part of the casing by the backing pumps (not shown) connected to conduits 32.

In operating the apparatus illustrated in Figs. 2 and 3, the system is evacuated by backing pumps connected to conduit 32; vaporizing plate 18 is rotated in a clockwise direction and heating element 24 is put into operation. Distilland is introduced through conduit 36 and is thrown by centrifugal force in a thin film over vaporizing plate 18. Undistilled residue collects in gutter 22. This residue is withdrawn through conduit 24. Vapors pass to plate 40 and impinge upon spiral baffle 41. Liquid condensate flows downward through the series of openings 43 and eventually is withdrawn through conduit 28.

Because of the rotation of vaporizing plate 18, of Fig. 2 gases in the distilling space are given an impressed motion in the direction of the rotation. In this figure the plate would rotate in the direction shown by the arrow. The gases are then caused to pass through the spiral and eventually are forced into conduit 32 from which they are withdrawn by the backing pump.

As indicated above, my invention is preferably applied to high vacuum stills. However, I have found that the vapor produced on the rotating surface increases the pumping effect of the molecular pump and I, therefore, include as an important feature of my invention molecular pumps in which the rotor is provided with heating means and means for introducing a low vapor pressure liquid thereon so that it is distributed thereover in a thin film during operation. The vapors thus formed have a directional component which is imparted to them by the rotation of the surface and the force of these vapors causes them to sweep gases toward the exhaust side of the pump. Low vapor pressure fluids such as are used in conventional condensation pumps can be used. Examples are phthalic acid esters such as dimethyl, dibutyl, dioctyl phthalates, sebacic acid esters such as dioctyl sebacate, and low vapor pressure hydrocarbon fractions, etc. According to this modification the low vapor pressure fluid may be introduced in such amount that it is entirely vaporized so that a gutter at the periphery to catch undistilled residue is unnecessary. In any event, it is desirable, but not necessary, to collect the vapors and/or undistilled residue and reuse them in the pumping process by again introducing them on to the center of the rotor. According to conventional terminology the stationary part of such a pump is called the stator and indicates the stationary spiral shelf or passageway and such terminology will be used herein.

The apparatus illustrated in Fig. 2 can be used as a molecular pump instead of a still with little or no modification. However, if the system to be evacuated is not the casing or still itself, an intake conduit should be connected at the approximate center of plate 40. This intake conduit would then be connected to the system to be evacuated; gases would be drawn into the center through this conduit and would be forced through the spiral passage to the exhaust conduit 32. Similar modification of Fig. 1 could be made but this apparatus is designed primarily for distillation and the effect of the distilling vapors would not be taken advantage of. However, in the apparatus shown in Fig. 2, the vapors as well as the rotation of the surface perform a pumping action. When this device is operating as a pump there are really two distinct modes of operation that combine to produce the final result, the first is the purely molecular pumping action which does not need or depend upon the heating and vaporization, and the second is, in effect, an entraining action resulting from the centrifugal action and/or velocity imparted to the rapidly moving heated vapors.

It will be noted that Fig. 1 illustrates the use of a plurality of spiral pumping passages of short length while Fig. 2 utilizes one spiral passage of long length. The number and length of the passages can be varied to suit the circumstances. A large number of short passages will have a high pumping volume but will not reduce the pressure as much as a single long passage which in turn will not have as high capacity. Also the longer the passage the higher the forepressure against which the pump or still will operate.

The construction and method of operating molecular pumps is well known and detailed description is unnecessary. As a general rule the rotor should rotate at above 1500 R. P. M. and preferably 3000 to 10,000 R. P. M. The clearance between the spiral of the stator and the rotor is preferably small. However, the pumping effect of the vapors enables much wider clearances than are usual in a molecular pump. With large apparatus the clearance may be as much as one inch.

One of the factors which has limited the pumping capacity of molecular pumps is the small clearance between the stator and the rotor. Since such clearances can be greatly increased by my invention because of the effect of the distilling vapors, a corresponding increase in pumping capacity results. A further advantage is that the still becomes self-evacuating without the expenditure of any additional energy.

What I claim is:

1. A pump combining the action of a molecular pump with the pumping effect of an entraining vapor comprising a stator member, a rotor member spaced from the stator, means between said stator and rotor so positioned as to form a confined passageway of substantial length and terminating at an outlet and so positioned relative to the direction of rotation of said rotor that rotation thereof will convey gases along said passageway to said outlet, the rotor and stator co-operating to form a molecular pumping unit, means for heating the rotor and means for introducing a low vapor pressure liquid on to the central part of the surface of the rotor nearest to the stator.

2. A pump combining the action of a molecular pump with the pumping effect of an entraining vapor comprising a stator member, a rotor member, spaced from the stator, means between said stator and rotor so positioned as to form a confined passageway of substantial length and terminating at an outlet and so positioned relative to the direction of rotation of said rotor that rotation thereof will convey gases along said passageway to said outlet, the rotor and stator cooperating to form a molecular pumping unit, means for heating the rotor, means for introducing a low vapor pressure liquid on to the central part of the surface of the rotor nearest to the stator, means for condensing vapors produced on the stator and means for recycling condensate through the pump.

3. A pump combining the action of a molec-

ular pump with the pumping effect of an entraining vapor comprising a stator member, a rotor member spaced from the stator, means between said stator and rotor so positioned as to form a confined passageway of substantial length and terminating at an outlet and so positioned relative to the direction of rotation of said rotor that rotation thereof will convey gases along said passageway to said outlet, the rotor and stator cooperating to form a molecular pumping unit, means for heating the rotor, means for introducing a low vapor pressure liquid onto the central part of the surface of the rotor nearest to the stator and means positioned at the periphery of the rotor for collecting unvaporized low vapor pressure liquid.

4. High-vacuum, centrifugal distillation apparatus comprising a rotor at least part of which serves as a vaporizing surface, means for heating the part of the rotor serving as a vaporizing surface, means for introducing distilland onto and removing undistilled residue from the part of the rotor serving as a vaporizing surface, a condensing surface separated by substantially unobstructed space from the part of the rotor serving as a vaporizing surface, a stator, means between said stator and rotor so positioned as to form a confined passageway of substantial length and terminating at an outlet and so positioned relative to the direction of rotation of said rotor that rotation thereof will convey gases along said passageway to said outlet and thus cooperate with the rotatable element to form a pump whereby during operation the gases in the space between the condensing surface and that part of the rotor serving as a vaporizing surface are removed.

5. High-vacuum, centrifugal distillation apparatus comprising a rotor serving as a vaporizing surface, means for heating the rotor, means for introducing distilland onto and removing undistilled residue from the rotor, a condensing surface separated by substantially unobstructed space from the rotor, means for removing distillate from the condensing surface, a stator, means between said stator and rotor so positioned as to form a confined passageway of substantial length and terminating at an outlet and so positioned relative to the direction of rotation of said rotor that rotation thereof will convey gases along said passageway to said outlet and thus cooperate with the rotor or vaporizing surface to form a combined molecular and vapor entrainment pump whereby during operation gases in the space between the condensing and vaporizing surfaces are removed by the combined action of the distilling vapors and the rotation of the rotor surface.

6. High-vacuum, centrifugal distillation apparatus comprising a rotor at least part of which serves as a vaporizing surface, means for heating the part of the rotor serving as a vaporizing surface, means for introducing distilland onto and removing undistilled residue from the part of the rotor serving as a vaporizing surface, a condensing surface separated by substantially unobstructed space from the part of the rotor serving as a vaporizing surface, means for removing distillate from the condensing surface, a spiral shaped stator, said spiral shaped stator forming a confined passageway of substantial length terminating at an outlet and so positioned relative to the direction of rotation of said rotor that rotation thereof will cause gases to pass along said passageway to said outlet and thus cooperate with the rotor to form a combined molecular and vapor-entrainment pump whereby during operation the gases in the space between the condensing surface and that part of the rotor serving as a vaporizing surface are removed by the combined action of the distilling vapors and the rotation of the rotor.

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