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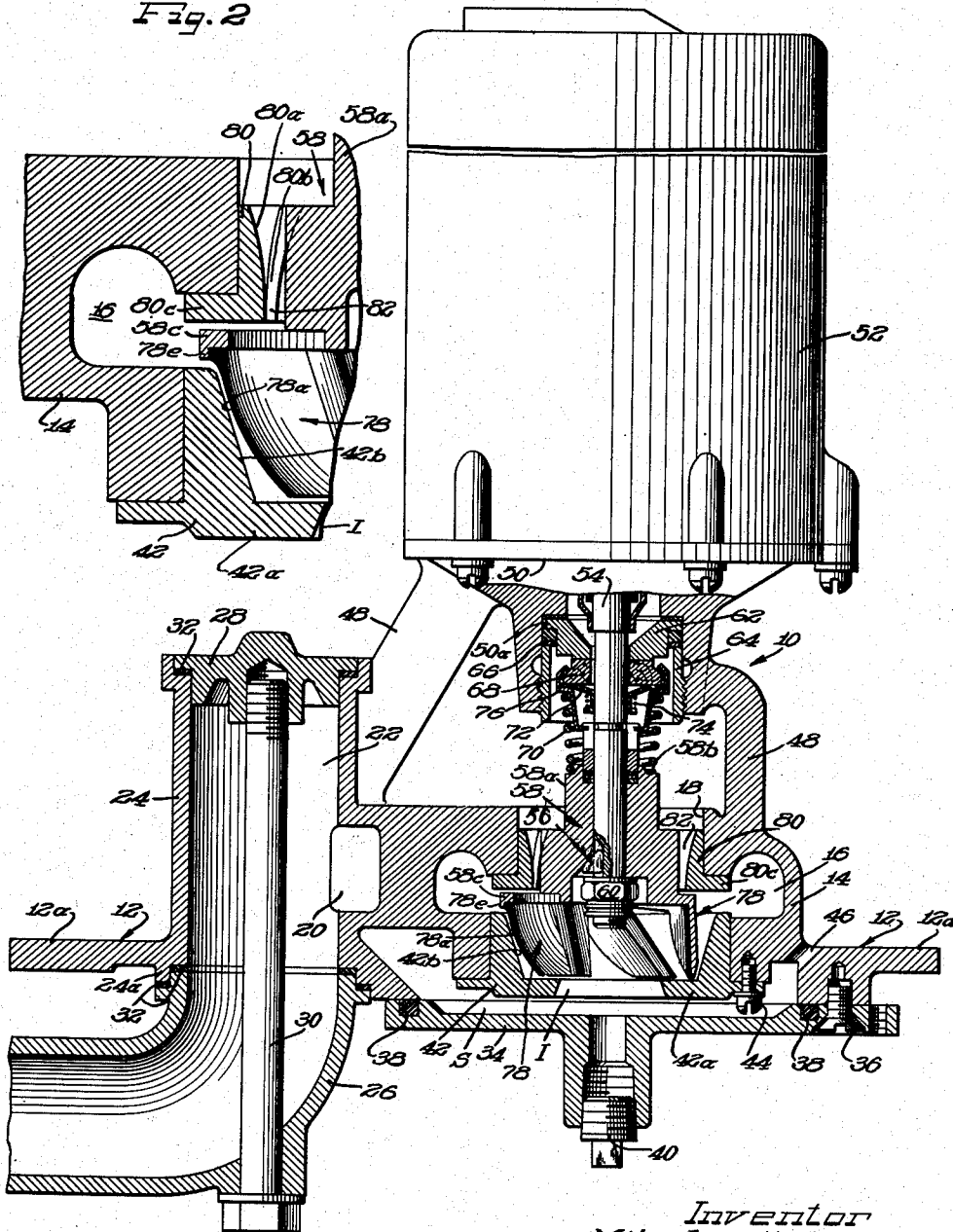
2,660,120

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2 Sheets-Sheet 1

Fig. 1

Fig. 2



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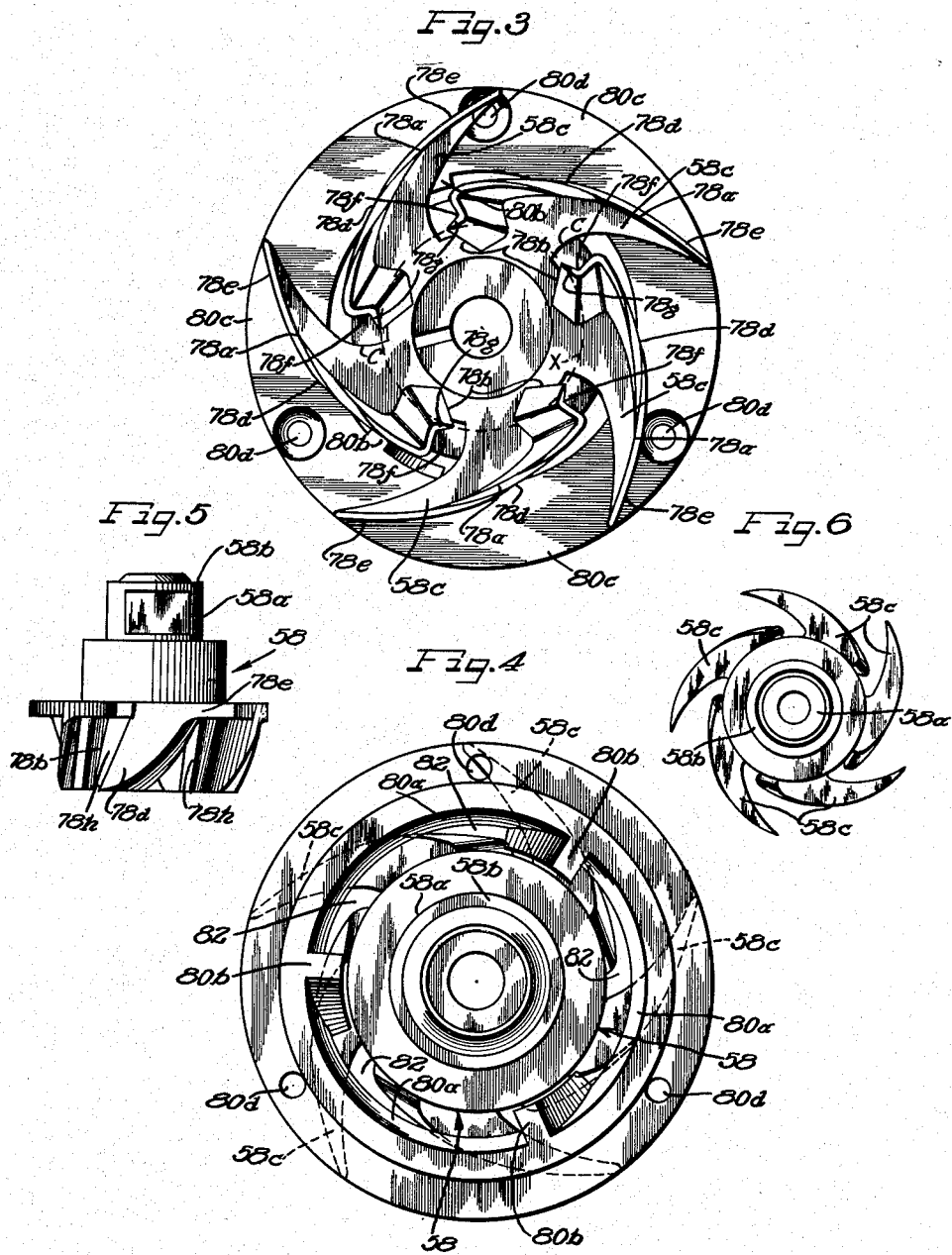
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## UNITED STATES PATENT OFFICE

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## VAPOR SEPARATING PUMP

Miles Lowell Edwards, Longview, Wash.

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15 Claims. (Cl. 103—88)

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This invention relates to devices for separating vapors from liquids, and for pressuring vapor-free liquid.

Specifically, the invention relates to a centrifugal pump with a separating chamber, a pumping chamber, and a vapor diffuser chamber wherein an impeller having a ring of circumferentially spaced blades is rotatably mounted in the separating chamber and arranged to create vortexes in the chamber for separating liquids and gases and for pumping the liquids to a pumping chamber while inducing flow of the gases to the diffuser chamber.

A feature of this invention is the provision of a stationary diffusion ring having inner spiral vanes which cooperate with the vapor separating impeller blades so that vapor rich fluid is discharged in separated relation from the liquid rich material discharged by the blades.

Another feature of this invention is to provide a stationary vapor take-off in a separating type pump which is positioned to cooperate with a rotatable centrifugal pump impeller to receive vapors under positive pressure therefrom.

The pumps of this invention are especially adapted for submersion in ponds of liquid material, and function to pump only fully liquid material from the pond while flowing vapors in the liquid back to the pond or to a separate receptacle or vent. It is, of course, highly desirable in pumps of this nature to diffuse the vapors back into the pond or completely out of the pond before they can be trapped in the pump or fed back to the pump.

While the pumps and impellers of this invention are especially adapted for use in aircraft fuel cells wherein the highly volatile fuel has a tendency to vaporize under the low pressure conditions of high altitude flight, they are also useful in other fields where separation of liquids and vapors or gases is desirable, such as, for example, in oil refineries to pump only fully liquid fractions of hydrocarbons; in steam condensation systems to pump only water; and in various food industries to pump only deaerated milk and fruit juices. The invention, however, will hereinafter be specifically described in an aircraft booster pump, but it should be understood that the devices are generally applicable in other installations requiring vapor separation and the pressuring of fully liquid material.

It is, therefore, an object of this invention to provide a pump and motor unit adapted for submersion in a pond of fluid material having an impeller which creates free vortexes in the

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pump to separate liquids and gases and efficiently discharge the separated components into separate chambers while pressurizing the liquids sufficiently to prevent further liberation of volatiles therefrom.

An important object of this invention is to provide a vapor vent arrangement for a separating pump whereby the pump impeller, in developing centrifugal pump pressure, will also pressure the vapors to the vent.

Another object of this invention is to provide an impeller for a liquid and vapor separating pump which has a ring of centrifugal pumping vanes with axially elongated inclined Z-shaped inner ends to create vapor separating vortex chambers therebetween and to scoop fluid into the vapor separating chambers.

Another object of this invention is to provide a pump having a stationary vapor diffusion ring with inner spiral vanes cooperating with the rotating pump impeller to effectively remove gaseous material from the area adjacent the pump inlet.

A further specific object of this invention is to provide a pump having a rotating pumping impeller which also separates vapor-rich fluid from liquid fuel and having a stationary diffusion ring surrounding the impeller and equipped with internal vanes for ejecting the vapor-rich fluid from the pump.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description of the annexed sheets of drawings which, by way of preferred example only, illustrate one embodiment of the invention.

On the drawings:

Figure 1 is a vertical cross-sectional view, with parts in elevation, of a vapor separating pump and motor unit according to this invention, which unit is suitable for mounting in an aircraft fuel cell or the like;

Figure 2 is an enlarged fragmentary vertical cross-sectional view of the pump impeller and vapor diffusion ring for the pump shown in Figure 1;

Figure 3 is an enlarged bottom plan view of the assembled pump impeller and diffusion ring for the pump shown in Figure 1;

Figure 4 is an enlarged top plan view of the assembled diffusion ring and impeller for the pump shown in Figure 1;

Figure 5 is a side elevational view of the impeller; and

Figure 6 is a top plan view of the impeller.

As shown on the drawings:

In Figure 1, the reference numeral 10 designates generally a pump and motor unit having the features of this invention, the unit being adapted particularly for use in aircraft fuel systems. The unit 10 has a base 12 with a peripheral mounting flange 12a thereon for underlying the bottom wall of a fuel cell to be secured thereto as by cap screws or the like (not shown).

The mounting base 12 is integral with a pump casing 14 defining an annular volute chamber 16 around and in communication with a central open-ended passageway 18. The volute chamber 16 discharges through a peripheral outlet passageway 20 into an upstanding passageway 22 defined by a tubular member 24 which is integral with the base 12 in spaced lateral relation from the casing 14. The tubular member 24 has a lower boss 24a which extends beyond the bottom of the base 12 and receives a conduit fitting 26. A cap 28 closes the top end of the member 24, and a single bolt 30 is passed through the conduit fitting 26 and threaded into the cap 28 to clamp the fitting 26 and the cap 28 on the opposite ends of the tubular member 24. Gaskets 32 are provided between the ends of the member 26 and the cap and conduit fitting.

Liquids from the volute chamber 16 are propelled through the passageway 20 into the passageway 22 and then through the passageway provided by the conduit fitting 26 to the fuel line (not shown) of the aircraft. The fuel line is connected customarily to an engine-driven main fuel pump.

The base 12 has a separate closure plate 34 secured thereto as by cap screws 36 and maintained in sealed relation with the base by a gasket 38. The closure plate 34 is beneath the lower wall of the fuel cell and provides a sump S for the cell. A drain plug 40 is threaded into the closure plate 34.

A throat ring 42 is secured to the bottom face of the casing 14 as by cap screws 44. The throat ring 42 defines an inlet I for the pump, the inlet communicating with the sump S. The sump S, in turn, communicates with the interior of the cell or tank through a plurality of circumferentially spaced openings such as 46.

The casing 14 has a plurality of upstanding legs 48 carrying a base 50 for a motor casing 52. An electric motor in the casing 52 has a drive shaft 54 depending through the base 50 which is keyed as by the key 56 to the hub 58a of an impeller 58. The lower end of the drive shaft 54 is threaded to receive a nut 60 for securing the impeller 58 from axial movement thereon.

An open-bottom well 50a in the base 50 receives a seal ring 62 loosely embracing the shaft 54 and is fixedly held in the bottom of the well by a threaded sleeve 64 which is threaded into the well 50a and presses against a washer 66 acting on the seal ring 62. A rotating seal ring 68 rides on the stationary ring 62 and is spring-urged against the ring 62 by means of a coil spring 70 surrounding the shaft 54 and bottomed on a shoulder 58b of the impeller hub 58a. A rubber sleeve 72 is sealingly engaged on the shaft 54 by means of a locking wire 74 and has a diaphragm portion extending over the seal ring 68 and clamped around the periphery of the ring 68 by the cap 76. Leakage along the shaft 54 is thereby effectively stopped by the diaphragm member 72 and by the riding contact of the seal rings 62 and 68.

The impeller 58 may be generally described as having a plurality of circumferentially spaced flat teeth 58c radiating somewhat tangentially from the bottom end of the hub 58a and converging to points lying in a circle which closely overlie the throat ring 42 in the entrance to the volute chamber. Each tooth provides a flat web and a blade or vane 78 depends from the leading edge of each tooth. Each blade or vane 78 has relatively deep or elongated broad faced portions overlying a flange 42a of the throat ring 42 with inclined inner and outer ends. The outer ends 78a terminate at about the middle of the teeth and are relatively sharp to ride in close-running clearance relation with the diverging side wall 42b of the throat ring 42. The inner ends 78b of the blades are also sharp and extend in a backward sloping direction from the inner edge of throat ring flange 42a to the teeth 58c.

As best shown in Figure 3, the flat teeth 58c of the impeller 58 provide a reinforcing backing for the top end of the vanes 78.

The vanes 78 are of a configuration having a substantially Z-shaped horizontal cross section at their leading portions, and have curved outer faces 78d increasing in width along the diverging edges 78a to extended shallow faces 78e adjacent the teeth 58c. These faces 78d and 78e provide a discharge surface for centrifugal discharge of liquids from the central passage 18 of the pump into the volute 16.

The inner end portions of the vanes 78 are offset at 78f and have forwardly projecting inner legs or ends 78g. The forwardly projecting portions 78g cooperate with the offset portions 78f to provide, between the inner ends of adjacent vanes, vapor separating chambers C having enlarged areas.

The contour of the radial portions 78f and forwardly projecting leg portions 78g, which form the leading edges for the vanes 78 is such as to provide a scoop-like leading face 78h (Figure 5). This scoop-like leading face 78h has a positive pitch with the lower end thereof having an angular lead over the upper end and creating a propeller-like action on the fluid to push it from the bottom to the top of the impeller as the impeller is rotated. The leading edges 78b of the vanes are sharp and form the innermost ends of the vanes to cut into and slice off the fluid to be acted upon by the scoop faces 78h.

In operation of the pump, fluid enters the inlet I which has a diameter substantially the same as a circle X (Figure 3) about which the bottoms of the leading vane edges 78b rotate. The rotating impeller vanes 78 induce rotation of this fluid in the passage 18 of the pump. Liquid in the peripheral portion of this passage is sliced off by the edges 78b and scooped up by the legs 78g of the vanes 78 and directed by the leading faces 78h of these inner ends to form localized circulating pools or vortexes in the separating chambers C between the scoop-like inner ends of the vanes. Due to the tapered leading edges of the vanes, these circulating pools or vortexes of liquid and vapor are being continually pushed upwardly towards the root of the vanes 78 or towards the teeth 58c of the impeller where the liquid-rich material is pressured by the faces 78d and 78e of the impeller into the volute 16.

In order that the vapor-rich fluid which has been scooped up by the vanes may be freed from the casing 14 of the pump assembly, a diffusion

ring 80 is provided which has an outwardly tapering inner surface 80a about which are a plurality of vanes 80b which may be cut by a straight machining or helical process to slope in the opposite direction to the scoop-like inner ends of the blades 73. The diffusion ring 80 has a lower annular flange 80c which is secured to the housing or casing 14 as by cap screws inserted through the openings 80d (Fig. 3) adjacent and above the teeth 53c of the impeller 53 and the inner faces of the vanes 80b loosely embrace the impeller hub at its greatest diameter.

An annular gap 82 is provided through which the vapor-rich fluid from the chambers C is drawn into the diffusion ring 80. The rotation of the impeller 53 causes a similar rotation of the fluid in the central pump passage 18; therefore the fluids entering the diffusion ring 80 are being rotated at a relatively high rate of speed. In addition, the rearwardly sloping Z-shaped inner ends of the vanes push the rotating fluid axially through the gap 82 and the trailing flat teeth 53c then close the gap to force the fluid against the vanes 80b which then effectively slice off this vapor-rich material and direct it axially upward in the ring 80 where it is given an opportunity to expand in the enlarged area between the upper edge of the diffusion ring 80 and the impeller 53, creating a low pressure area therein. This low pressure aids in drawing the vapors through the ring.

The entrance end of the gap 82 has a diameter greater than the diameter of the inlet I and circle X on which the bottoms of the vane edges lie so that the gap will receive rotating fluid from the upper ends of the vanes at a point where this fluid is somewhat pressurized due to centrifugal action in addition to the pressures created by the scoop or plow-like action produced by the inclined leading ends of the vanes. These two factors cooperate to place the fluid under positive pressure at the vapor take-off. This positive pressure, upon being released into the low pressure area of the diffuser ring insures efficient vapor removal.

From the foregoing it is to be understood that the invention provides a booster pump and electric motor unit adapted to be submerged in a fuel cell or pond of liquid wherein the pump impeller acts in a central separating chamber to separate the heavier liquid-rich fluids from the lighter vapor-rich fluids, discharging the liquid rich fluids centrifugally into a volute chamber. The impeller vanes which accomplish the separating have leading edges which are tapered and contoured to rotate and push the vapor-rich fluid axially while centrifugally throwing the liquid-rich fluid outwardly. The rotating pushed vapor-rich fluid is pressurized due to centrifugal and pushing action and is released to the stationary diffusion ring which slices and scoops the vapor-rich fluids into a low pressure chamber so that the vapor particles may expand and be discharged to the interior of the cell or tank. The liquid-rich fluid is centrifugally discharged radially outwardly and at a lower level than the vapor take-off point to be pumped through the volute chamber.

It will, of course, be further understood that various details of construction may be varied, through different adaptations, without departing from the principles of this invention and it is, therefore, not the purpose to limit the patent granted hereon otherwise than necessitated by the scope of the appended claims.

I claim as my invention:

1. A pump comprising a casing having an open ended passage therethrough, an impeller disposed in said passage, means on said casing defining a pumping chamber about said impeller, a plurality of circumferentially spaced vanes on said impeller surrounding the inlet end of said passage and providing flow passageways therebetween to said pumping chamber, a vapor diffusion ring secured to said casing within said passage adjacent and above said vanes, a plurality of vanes circumferentially spaced about the inner face of said ring, and means on said impeller vanes for rotating material in said passage and separating vapor-rich material from liquid-rich material and for inducing said vapor-rich material to rise to a position adjacent said diffusion ring whereby said rotating vapor-rich material is scooped up by said diffusion ring vanes and diffused to a material reservoir.

2. A pump comprising an impeller having a hub, a plurality of spaced outturned teeth on said hub, a plurality of circumferentially spaced vanes each depending from one of said teeth, a vapor diffusion ring surrounding said hub, a plurality of vanes on the inner surface of said ring, and means on said impeller vanes extending radially inwardly and forwardly to provide scoop-like faces for defining vapor separating chambers between said impeller vanes whereby vapor-rich material may be separated from liquid-rich material and discharged into said vapor diffusion ring.

3. A pump comprising a casing having an open-ended passage therethrough, an impeller having a hub disposed in the discharge end of said passage and having a depending ring of radial flow vanes extending to the inlet end of said passage, a diffusion ring surrounding said hub in spaced relation thereto, a plurality of vanes on the inner surface of said ring, and radially inwardly and forwardly extending portions on said impeller vanes providing scoop-like faces for said vanes whereby said impeller when rotated in a body of fluid material will separate vapor-rich material from liquid-rich material and will discharge the liquid-rich material laterally and project the vapor rich material upwardly to a position where it will be scooped up by said diffusion ring vane and discharged from said pump.

4. A pump comprising a casing having an open ended passage therethrough, a diffusion ring disposed in said passage and secured to said casing adjacent and below the discharge end of said passage, a plurality of spiral vanes circumferentially spaced integral to the inner surface of said ring, an impeller disposed for rotation in said passage having its hub in the center of said ring, and means on said impeller for separating vapor-rich from liquid-rich material and for discharging said liquid-rich material laterally while projecting said vapor-rich material upwardly to a position adjacent said ring whereby said spiral vanes scoop said vapor-rich material for discharge from said pump.

5. A pump comprising a casing having an open-ended passage therethrough, an impeller disposed in said passage having an outturned flange, pumping vanes depending from said flange adjacent the inlet end of said passage, said vanes having inner edges extending inwardly beyond the inner portion of said flange and providing scoop-like leading faces disposed outwardly from the axis of the impeller, a hub for said impeller, means on said casing defining a plurality of spiral

vanes circumferentially spaced about the discharge end of said passage, said impeller vanes being constructed and arranged to induce axial flow of material and to sweep bubbles of gas and vapor from the chambers between the scoop-like faces of the impeller vanes to a position where the bubbles of gas and vapor are scooped up by said spiral vanes and discharged from said pump.

6. A pump comprising a casing having an open-ended passage therethrough, an impeller disposed in said passage having a ring of circumferentially spaced vapor separating and liquid pumping vanes, each of said vanes being constructed and arranged to discharge liquid-rich material laterally and to induce axial flow of vapor-rich material as said impeller is rotated in said passage, and means on said casing defining a plurality of spiral vanes circumferentially spaced about the discharge end of said passage whereby said vapor-rich material may be discharged from said pump by said spiral vanes scooping up the rotating and axially flowing vapor-rich material.

7. A pump comprising a casing having an open-ended passage therethrough, means on said casing defining a liquid pumping chamber, means on said casing defining a plurality of circumferentially spaced spiral vanes in the discharge end of said passage, an impeller in said passage having a ring of vapor separating and pumping vanes thereon surrounding a central inlet passageway in said open-ended passage and providing channels therebetween discharging into the pumping chamber, said vanes having relatively deep inner end portions and relatively shallow outer end portions, and substantially Z-shaped leading ends on said inner end portions of the vanes projecting into said passage and defining therebetween separating chambers of relatively large areas communicating with said chambers through restricted throats, said Z-shaped inner ends having legs projecting forwardly to slice off material in said passageway, said legs extending up to said spiral vanes and overhanging the spaces between said spiral vanes, and said Z-shaped inner ends having front faces for directing the sliced-off material to create vortexes in said separating chamber communicating freely with said spiral vanes.

8. In a vapor separating and liquid pressuring pump, a casing having an open-ended passage therethrough, means on said casing defining a plurality of spiral vanes circumferentially spaced about the discharge end of said passage, an impeller disposed in said passage having a plurality of flat radiating teeth, each of said teeth supporting a depending centrifugal pumping vane, the inner ends of said vanes defining an axial flow passage and the outer ends of said vanes defining centrifugal pumping channels therebetween, said inner vane ends having portions projecting radially inwardly and forwardly to an increasing degree along said passage in the direction of fluid flow, thereby defining vapor separating chambers between said inner ends, said vapor separating chambers being in communication with said spiral vanes.

9. In combination in a vapor separating and fluid pressuring pump, a casing having an open-ended passage therethrough, a ring member secured to said casing adjacent the discharge end of said passage, said ring having spiral vanes circumferentially spaced about its inner face and having its inner face radially outwardly tapered, an impeller disposed in said passage having a hub loosely embraced by the inner faces of said spiral vanes and having a ring of centrifugal

pumping vanes spaced from the spiral vanes, and said pumping vanes having forwardly and inwardly projecting legs on their inner ends extending to the spiral vanes for defining rotating vapor-separating chambers between the pumping vanes joined with the spiral vanes.

10. In a vapor separating and liquid pressuring centrifugal pump, the improvement of a vapors diffusion ring communicating with the vapor separating chamber of the pump and the exterior of the pump, said ring being secured to the pump casing and having a plurality of spiral vanes circumferentially spaced along its inner surface.

11. In a centrifugal vapor separating and liquid pressuring pump, the improvement of a diffusion ring secured to the pump casing to loosely embrace the pump impeller hub, said ring having an outwardly tapered inner surface and a plurality of spiral vanes circumferentially spaced along its inner surface so as to scoop up vapor-rich material from the rotating material within the separating chamber of the pump.

12. In a liquids pressuring and vapor separating pump of the centrifugal type having a rotating impeller, the improvements of a vapors diffusion ring having an outwardly tapered inner surface communicating with the exterior of the pump, said ring being secured to the pump casing to loosely embrace the impeller hub, and a plurality of circumferentially spaced spiral vanes disposed in the gap between said ring and said hub and integral to one of said members for scooping vapor-rich material from the interior of the pump and discharging the same to a reservoir.

13. A vapor separating pump which comprises a pump casing having an inlet, an impeller chamber receiving fluids from the inlet, a pumping chamber receiving fluids from the impeller chamber and a vapor discharge passageway receiving vapors from the impeller chamber, an impeller in the impeller chamber having circumferentially spaced pumping vanes defining vapor-separating chambers discharging into the vapor passageway and pumping passages discharging into the pumping chamber, and stationary vanes in the vapor discharge passageway having ends terminating at the impeller chamber to receive fluid from the vapor separating chambers and angularly deflect the fluid for free discharge out of the passageway.

14. In a pump, an impeller rotatable about a vertical axis and having a hub and a plurality of circumferentially spaced vanes projecting axially downwardly from one end of said hub and also projecting radially outwardly with respect to said hub, means spaced downwardly from said one end of said hub and defining therewith a fluid inlet chamber communicating with inner portions of said vanes, means defining a liquid outlet chamber around outer portions of said vanes, each of said vanes including an inner centrifugal discharge surface having an upper end portion adjacent said hub and a lower end portion axially spaced downwardly from said hub, said lower end portion being angularly displaced in the direction of rotation of said impeller from said upper end portion so as to project vapor axially upwardly toward said hub, and means fixed in spaced surrounding relation to said hub and defining therewith a vapor passage receiving vapor flow from said discharge surface.

15. In a pump, an impeller rotatable about a vertical axis and having a hub and a plurality of circumferentially spaced vanes projecting

axially downwardly from one end of said hub and also projecting radially outwardly with respect to said hub, means spaced downwardly from said one end of said hub and defining therewith a fluid inlet chamber communicating with inner portions of said vanes, means defining a liquid outlet chamber around outer portions of said vanes, each of said vanes including an inner centrifugal discharge surface having an upper end portion adjacent said hub and a lower end portion axially spaced downwardly from said hub, said lower end portion being angularly displaced in the direction of rotation of said impeller from said upper end portion and said lower end portion also being displaced radially inwardly from said upper end portion so that the vapor is forced axially upwardly toward said hub and

also radially outwardly past the periphery of said hub, and means fixed in spaced surrounding relation to said hub and defining therewith a vapor passage receiving vapor flow from said discharge surface.

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