

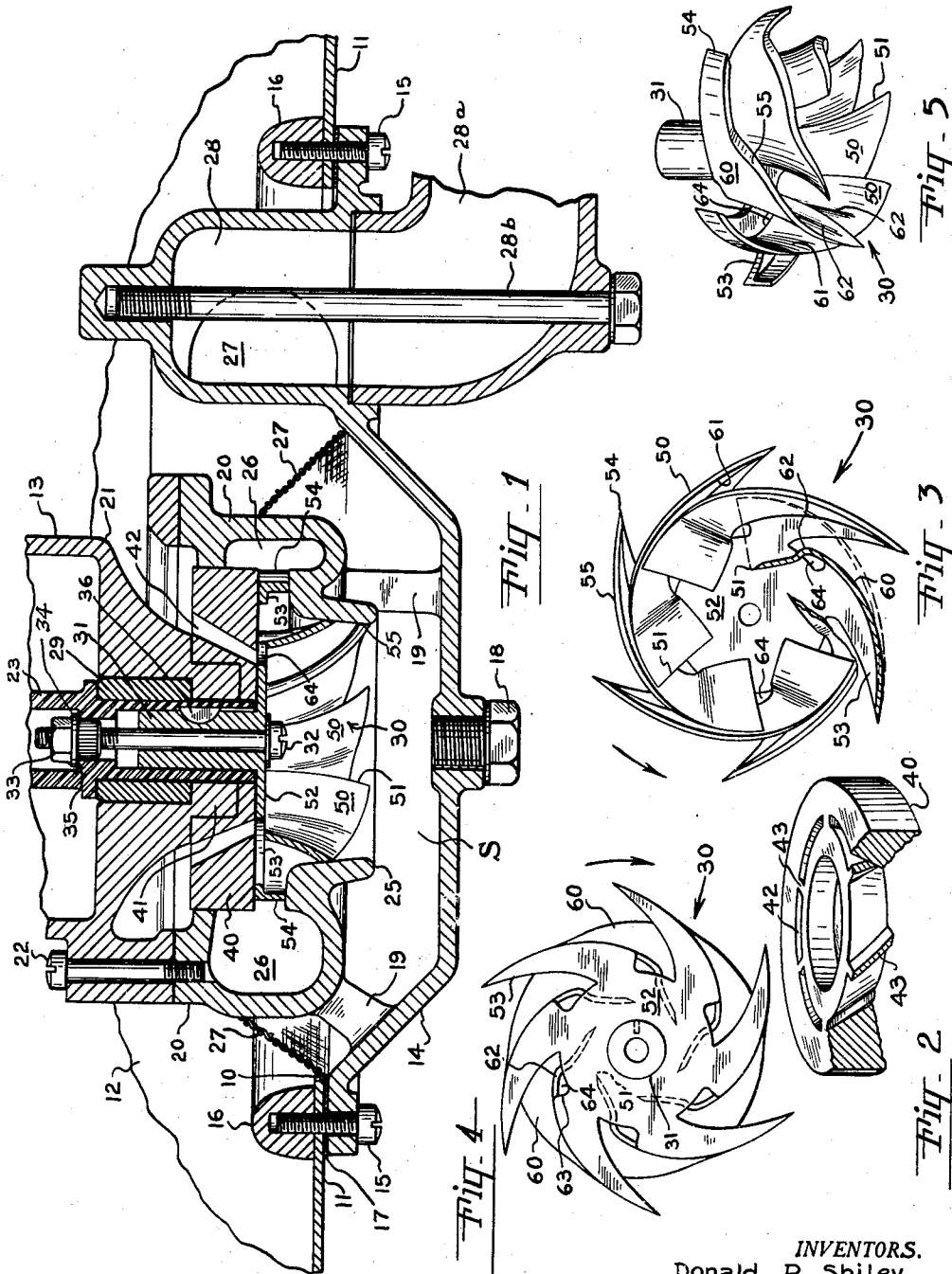
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D. P. SHILEY ET AL

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VAPOR EXPELLING PUMP

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INVENTORS.
Donald P. Shiley
Miles Lowell Edwards
BY

Will, Sherman, Merwin, Gross & Simpson
Attorneys

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VAPOR EXPELLING PUMP

Donald P. Shiley, Portland, Oreg., and Miles Lowell Edwards, Santa Ana, Calif., said Shiley assignor to said Edwards

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This invention relates to a centrifugal type liquid pump having improved means for expelling vapors to prevent vapor lock.

The principles of the invention are illustrated in an aircraft fuel pump where there is an acute problem of eliminating vapors from volatile liquid fuel so that gases and vapors reaching the pump, and also vapors liberated in the pump itself, will not be retained in the pump to create a vapor lock or gas bound condition impairing the performance of the pump. The invention is particularly applicable to the type of fuel pump known as booster pumps which are incorporated in an assembly with an electric motor, the whole assembly being mounted as a unit through an opening in the bottom of a fuel tank or cell. When a vapor lock or gas bound condition occurs, the discharge pressure and flow are reduced, causing the pump to fail to meet its delivery requirements. In an aggravated condition of excessive vapor accumulation in a centrifugal pump, failure of the pump pressure may occur to such degree that the pump is incapable of delivering fuel against the head in the system. Various devices have heretofore been devised to overcome this difficulty, and it is the general object of the present invention to achieve greater effectiveness in the vapor expelling or vapor swallowing function and improved pump efficiency through the application of a new principle in centrifugal pumps.

A particular object is to provide a centrifugal liquid pump having incorporated therein jet pump means for removing gases and vapors from the pump impeller chamber.

A more particular object is to provide a centrifugal liquid pump impeller with novel means utilizing a small portion of the pumped liquid to form a jet for sweeping gases and vapors from pumping passages between the impeller blades to prevent vapor lock in the pump and to prevent failure of pump discharge pressure and flow.

Another object is to provide a centrifugal pump impeller utilizing liquid from one pumping passage in the impeller as a driver liquid for ejecting gases and vapors from another pumping passage in the impeller.

Another object is to provide a centrifugal pump impeller having vapor orifices arranged in operative relation to jets of liquid from one side of the blades for removing gas and vapor from the impeller.

When the curved leading edge of a high speed centrifugal impeller blade cuts into a stationary or slowly rotating body of liquid in the eye of the impeller, the increasing radius of the spiral blade as it rotates relative to the liquid produces an acceleration in the particles of liquid in a direction having radial and circumferential components. The advancing convex surface of the blade, which may be referred to as the working surface, crowds the liquid radially outwardly and forwardly in the direction of rotation, producing accelerating forces as imparted by a wall moving rapidly against the relatively motionless body. These accelerating forces increase the rotating velocity of the relatively dense liquid and cause

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the dense liquid to be concentrated against the convex working surface of the blade. Any less dense gas or vapor bubbles that may be present are forced in a forward and outward direction against the concave trailing surface of the preceding blade which forms the opposite side of a pumping passage between the pair of blades.

According to the present invention, an aperture is formed in the impeller at the trailing edge of each blade in a suitable position to expose the accumulated gases and vapors to contact with jets of liquid from the working surface of the blades and cause the accumulated fluids to be swept from the pumping passages. Thus, some dense liquid hugging the working face of a blade is allowed to discharge into a diffuser port under lower pressure and pulls with it the vapor at the trailing or concave side of the blade. As a result, the vapor at the trailing blade side is aspirated out of its pumping channel by the liquid jetted from the previous pumping channel on the leading side of the blade. As a result, liquid is utilized from one pumping chamber to remove gas and vapor from the next following pumping chamber, whereby all the gas and vapor are removed from the impeller. The invention also includes means for removal and disposal of the mixture of liquid and separated gas and vapor in an axial direction while the pumped liquid is delivered centrifugally into a volute casing from which it is discharged tangentially in the usual manner.

The invention will be better understood and additional objects and advantages will become apparent as the description proceeds in connection with the preferred embodiment illustrated on the accompanying drawing. Various changes in the construction and arrangement of parts may be made, and all such modifications within the scope of the appended claims are included in the invention.

On the drawing:

Figure 1 is a fragmentary sectional view showing the pump and motor unit of the invention;

Figure 2 is a perspective view of the vapor diffuser ring shown in Figure 1 with parts broken away;

Figure 3 is a front end view of the impeller from the suction side;

Figure 4 is a back end view of the impeller; and

Figure 5 is a perspective view of the impeller.

As shown on the drawing:

Figure 1 illustrates a typical installation in an opening 10 in the bottom wall 11 of an aircraft fuel tank 12. The motor and pump unit 13 is supported inside the tank by a closure plate 14 secured by screws 15 having threaded engagement with a mounting ring 16. The joint between the closure plate and tank wall is sealed by means of a gasket 17. Closure plate 14 is depressed to form a sump S which may be drained by removing the drain plug 18.

A plurality of upstanding legs 19 on closure plate 14 are integral with a pump housing 20, which in turn carries a motor housing 21 secured thereto by screws 22. A hollow shaft 23 extends from the motor housing for driving an impeller in the pump. A bottom inlet opening in the pump housing is formed by an integral throat ring 25 which provides the desired contour of pump inlet a short distance above the bottom of sump S. Fuel from the tank must pass through screen 27 before entering the sump.

Pump housing 20 contains a conventional volute discharge passage 26 surrounding the impeller on the motor shaft. Volute passage 26 terminates in an outlet 27 communicating with a vertical discharge passage 28. A discharge conduit connection 28a is secured in communication with passage 28 by means of a bolt 28b.

In the foregoing installation, it is desired that all gas and vapor finding its way to the pump, or liberated in

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the pump by the action of the impeller, be separated from the pumped liquid and expelled back into the tank at some point remote from the pump inlet.

The pump impeller is designated generally by the numeral 30. In order to keep the motor shaft as short as possible and obviate the necessity for a additional bearing, the impeller 30 is equipped with a projecting hub 31 to fit a bore in the end of the hollow shaft 23 extending within the motor bearing 29. The hub is secured in said bore by a bolt 32 having a nut 33 equipped with a flange 34. When the bolt is tightened, the impeller is drawn against the outer end of the shaft and flange 34 is seated against an internal circular shoulder 35 in the shaft, as shown. Nut 33 also preferably has a serrated lower end snugly engaging the interior of the shaft to lock it to the shaft. The impeller hub is rotatively locked to the shaft by means of a key 36.

Surrounding the impeller hub immediately behind the impeller and forming a closure for the top end of the impeller chamber is a vapor diffuser ring 40 which is pressed or shrunk on a circular end boss 41 on motor housing 21. The periphery of diffuser ring 40 has a close fit within a central opening in the upper wall of pump housing 20. Diffuser ring 40 is provided with an upwardly and outwardly flaring annular vapor expelling port 42 having spiral vanes 43 therein, as shown in Figure 2. Throat ring 25 and diffuser ring 40 form the impeller chamber.

The impeller 30 has a plurality of centrifugal pumping blades 50 with leading edges 51 extending from a back plate 52 in radially outward and axially forward directions with reference to the direction of rotation to exert an initial screw action on the mass of liquid in the eye of the impeller. The back plate 52 joins the back or upper edges of the blades with the hub 31, this plate closing the eye of the impeller at its upper side, as shown in Figure 1. Back plate 52 assumes the form of a sprocket having crescent shaped projections 53 trailing from the upper edge of each blade to leave spaces therebetween in communication with the fragmental annular vapor expelling ports 42 between helically pitched diffuser vanes 43 of the diffuser ring 40. Thus, the circumferentially continuous portion of back plate 52 is of smaller diameter than the lower or inlet end of annular port 42. The blades 50 are of spiral shape and diminish in axial width or depth toward their trailing ends 54 which have surfaces substantially tangential to the circle of revolution of said ends. The forward or bottom edges 55 of the blades are beveled to correspond to the interior contour of throat ring 25 and have a close running fit therein. Back plate 52 has a close running fit against the face of diffuser ring 40 and the vanes 43 between the parts assist in imparting upward axial ejecting motion to rotating fluid fed to the bottom of the ring.

The impeller blades have sufficient length to overlap each other circumferentially and form pumping passages therebetween. Each pumping passage is bounded on one side by the convexly curved working surface 60 of one blade and the concavely curved surface 61 of an adjacent blade. Each blade is preferably kinked or offset at 62 to provide a narrow generally radially extending face to between a trailing or outer end blade portion which is circumferentially advanced or upstream in the direction of rotation and a retracted or downstream radially shorter inner end blade portion acting as a scoop. The kink fades out as it approaches the bottom edge 55 of the blade so that the blade has a smoothly curved contour at its bottom edge as shown in Figure 3. As the liquid is sliced off from the column in the eye of the pump inlet by the leading edges 51 of the blades and crowded radially outwardly and forwardly in the direction of rotation by the scoop or offset inner ends of the blades, it rides over the kinks and is centrifugally accelerated and discharged over the blade working sur-

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faces 60. The heavier fully liquid material hugs the surfaces 60 and crowds the lighter vapor rich fluid forwardly toward the concave back face 61 of the preceding blade. The kink 62 aids this forward crowding by providing somewhat of a pushing wall. As the forwardly pushed vapor rich liquid approaches the back face of the inner scoop portion of the blade, it jets over the ledge-like back face of the kink and some of it escapes upwardly through the open top of the pumping channel into the ports 42 of the diffuser ring 40. Since the back faces of the blades converge toward the back wall 52 of the impeller, this upwardly escaping action is accelerated axially toward the ports 42.

When the impeller rotates, the leading end 51 of each blade cuts into the mass of liquid in the eye of the impeller and starts crowding it radially outwardly toward the kink and forcing it forwardly in the direction of rotation as the blade rotates relative to the liquid. The increasing radius of the blade rotating with respect to each particle of liquid produces a radially outward and forward accelerating force on the liquid, causing the liquid to hug and bear against the working surface 60. When gas or vapor is present in the pumping passages between the blades, a degree of stratification results, with the fluid of greater density hugging the working surface 60 and crowding the fluid of lesser density outward against the concave surface 61 of the opposite blade.

The main liquid flow thus developed by the rotation of the blades is delivered into the volute discharge passage 26, but a minor flow also escapes upwardly in the form of a jet off the top or upper edges of the blades at the kink or offset point 62 shown best in Figure 4 where it is free to pass between the crescent shaped portions 53 of the back plate 52 into the annular vapor expelling port 42. The crescent shaped portions of the back plate are notched at 63 in the region of point 62 to provide a vapor orifice 64 communicating with the concave side of each blade immediately behind the offset or kink 62. Liquid jetting over the blade edge at 62 into the annular ports 42 acts as a driving liquid to sweep past orifice 64 and in so doing to entrain and remove through each port 42 any gas or vapor collected on the concave side of the blade and available to the orifice 64. An aspiration of the vapor is thereby obtained. Liquid from the convex side 60 of the blade jets over the blade edge at 62 in a slightly curved sheet to blanket and entrap any gas or vapor at the orifice 64 and insure the complete entrainment thereof in the liquid. The constant removal of such gas and vapor while the pump is operating keeps the pumping passages between the blades free of gas and vapor by preventing its accumulation, and insures against vapor lock and pressure failure. The gas and vapor thus expelled through annular port 42 escapes into the tank at a level sufficiently above the intake screen 27 that it is not recirculated through the pump.

While the kink or offset 62 appears to enhance vapor removing efficiency of the pump, the jet driver force and vapor aspiration can be obtained without the kink and the invention therefore is not limited to the preferred illustrated embodiment.

The jet flow described is enhanced by the inclination of the leading end 51 of the blade relative to the axis of rotation. The blade portion between leading edge 51 and point 62 assumes a propeller shape which in rotation crowds the liquid on working surface 60 back, or upwardly, axially against back plate 52 until it is released from the trailing edge of plate portion 53 at the point 62.

In the operation of the pump as described above, the pressure built up by accelerating forces expels a small quantity of liquid over the top blade edge at 62 where it frictionally engages fluids which are present in orifice 64. The fluids present in orifice 64 may be gases or vapors or a mixture of gases, vapors and liquids. This union of driver liquid and fluids to be eliminated occurs within

the rotating body of the impeller at the entrance to ports 42 where the united fluids rotate at considerable velocity owing to the motion of the impeller. The rotating united fluids thus impinge against stationary pitched vanes 43 and are propelled axially upwardly thereby away from the pump.

Pumps equipped with impellers having the jet drivers for aspirating or sweeping out vapors according to this invention have increased pumping efficiency about 40% over the heretofore best known vapor separating pumps.

It will be understood that variations and modifications may be effected without departing from the scope of the novel concepts of this invention.

We claim as our invention:

1. A vapor expelling impeller for a centrifugal liquid pump, comprising a radial back plate perpendicular to the axis of the impeller, centrifugal pumping blades projecting forwardly from said back plate, and means defining orifices in said plate on the trailing sides of said blades at a distance from their leading edges, portions of said plate forming a back wall between said blades from the leading edges of the blades to points on the leading sides of the blades adjacent said orifices.

2. A centrifugal liquid pump comprising a pump housing having a volute liquid discharge passage, an impeller in said housing having centrifugal pumping blades extending forwardly from a back plate, said back plate having a sprocket form with crescent shaped projections extending from the trailing sides of said blades, an annular vapor port in said housing communicating with spaces between said crescent shaped portions of said back plate, and orifices in said back plate in register with said annular port and communicating with the trailing sides of said blades.

3. A vapor separating pump which comprises a pump casing having a central pumping chamber with a liquid inlet at one end and a vapor outlet at the other end, an annular volute chamber surrounding the pumping chamber in communication therewith and having a liquid outlet, an impeller rotatably mounted in said pumping chamber having a ring of circumferentially spaced spiral blades surrounding the center of the pumping chamber and defining pumping channels therebetween discharging into the volute chamber, said blades having kinked intermediate portions separating circumferentially retracted leading inner blade end portions effective to slice liquid from the central portion of the pumping chamber and circumferentially advanced trailing outer end portions effective to centrifugally discharge the liquid and crowd lighter vapor rich liquid toward the back faces of the preceding blades, said kinked blade portions providing back ledges receiving the thus crowded liquid thereover, ports joining the back ledges with the vapor outlet, and said blades being pitched to form jets of liquid from the pumping channels to aspirate vapors through the ports into the vapor outlet.

4. A vapor separating pump comprising a casing having a central pumping chamber, a volute chamber surrounding the pumping chamber in annular communication therewith, an inlet at one end of the pumping chamber and a vapor diffuser outlet at the other end of the pumping chamber, an impeller rotatably mounted in the pumping chamber having a ring of circumferentially spaced spiral pumping vanes defining pumping channels therebetween for impelling liquid from the inlet to the volute chamber, each of said vanes having kinked intermediate portions, and ports on the impeller connecting the back faces of the vanes at the kinked intermediate portions with the diffuser outlet.

5. A vapor expelling impeller for a centrifugal liquid pump, comprising a shaft, a series of spaced centrifugal pumping blades around said shaft, integral annular means

connecting the upper edges of said blades with said shaft, said blades curving outwardly and downwardly from said means, and said annular means being imperforate immediately adjacent said shaft and formed radially beyond the imperforate portion to provide a vapor orifice for each blade communicating with the trailing side of the blade, through which orifice fluid may be carried off with a jet of liquid centrifugally forced over the trailing side of the blade by the leading, downwardly curved face of the next succeeding blade.

6. A combined centrifugally pumping and vapor expelling impeller, comprising a drive shaft, blades attached to said shaft, each of said blades extending generally at an obtuse angle to the driven end of said drive shaft, each blade having a screw-type impeller surface on its side adjacent the axis of said shaft and a centrifugal pumping surface on its radially outer side, a wall normal to said shaft connecting said blades and shaft, said wall and each of said blades being formed to provide an opening adjacent each blade through which liquid and vapor are expelled toward the driven end of said shaft by said screw-type impeller surface.

7. In a centrifugal liquid pump, a pump housing having an inlet and a volute liquid discharge passage, a vapor expelling impeller in said housing comprising a shaft, a series of spaced centrifugal pumping blades around said shaft, integral annular means connecting the upper edges of said blades with said shaft, said blades curving outwardly and downwardly from said means, and said annular means being imperforate immediately adjacent said shaft and formed radially beyond the imperforate portion to provide a vapor orifice for each blade communicating with the trailing side of the blade, through which orifice fluid may be carried off with a jet of liquid centrifugally forced over the trailing side of the blade by the leading, downwardly curved face of the next succeeding blade, and a diffuser plate in said housing above said annular means having an annular series of openings therein with side walls sloping upwardly in the direction of rotation of said impeller and in communication with said vapor orifices.

8. In a centrifugal liquid pump, a pump housing having an inlet and a volute liquid discharge passage, a combined centrifugally pumping and vapor expelling impeller in said housing, said impeller comprising a drive shaft, blades attached to said shaft, each of said blades extending generally at an obtuse angle to the driven end of said drive shaft, each blade having a screw-type impeller surface on its side adjacent the axis of said shaft and a centrifugal pumping surface on its radially outer side, a wall normal to said shaft connecting said blades and shaft, said wall and each of said blades being formed to provide an opening adjacent each blade through which liquid and vapor are expelled toward the driven end of said shaft by said screw-type impeller surface, and a diffuser plate in said housing above said impeller, said plate having an annular series of openings therein defined by walls sloping upwardly in the direction of rotation of said impeller, and said openings being in communication with said openings adjacent each blade in the impeller.

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