

Feb. 28, 1956

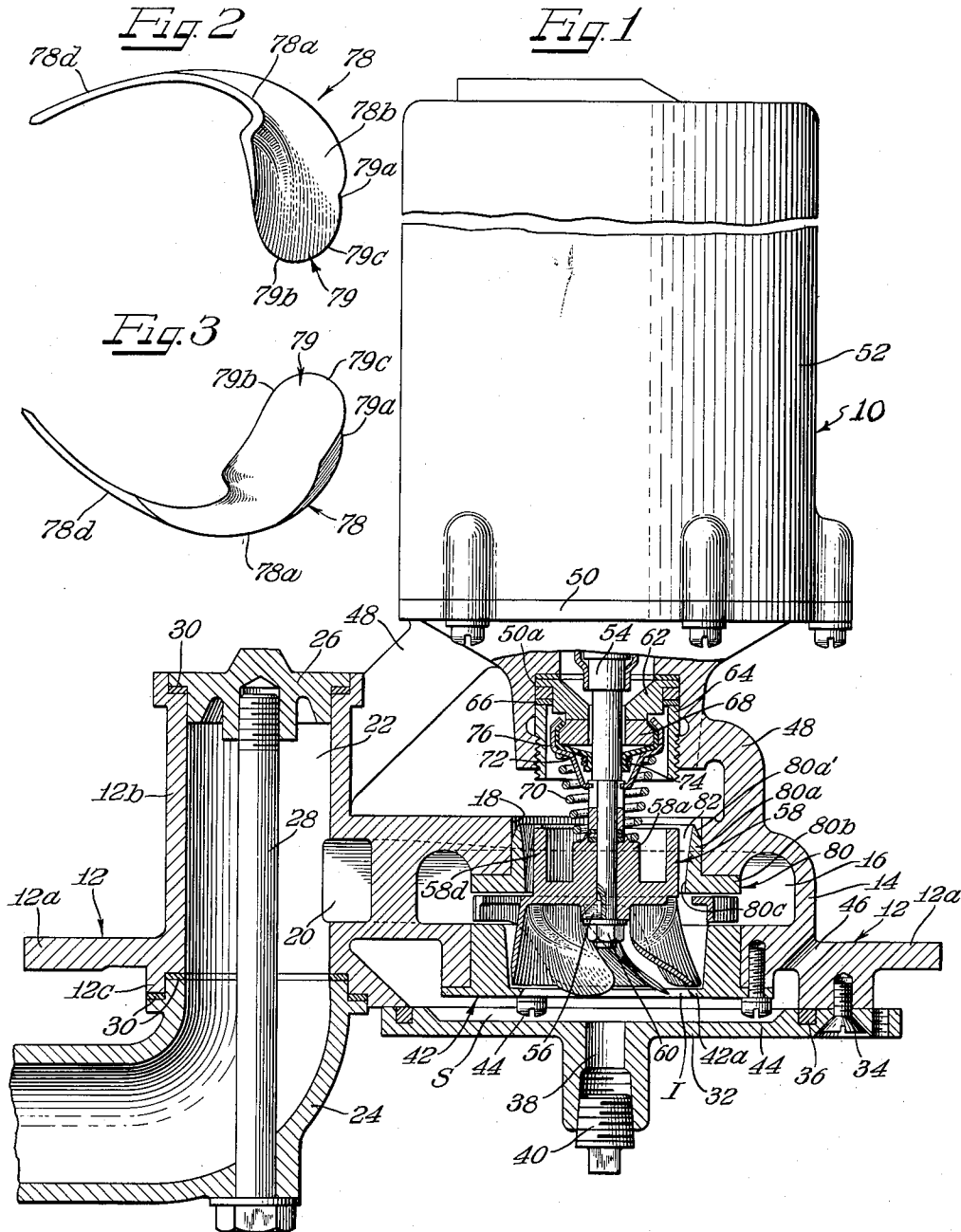
W. H. EISELE

2,736,266

PUMP IMPELLER CONSTRUCTION

Filed May 5, 1950

2 Sheets-Sheet 1



Inventor
William H. Eisele

by *The Dixie of Charlesville* Attys

Feb. 28, 1956

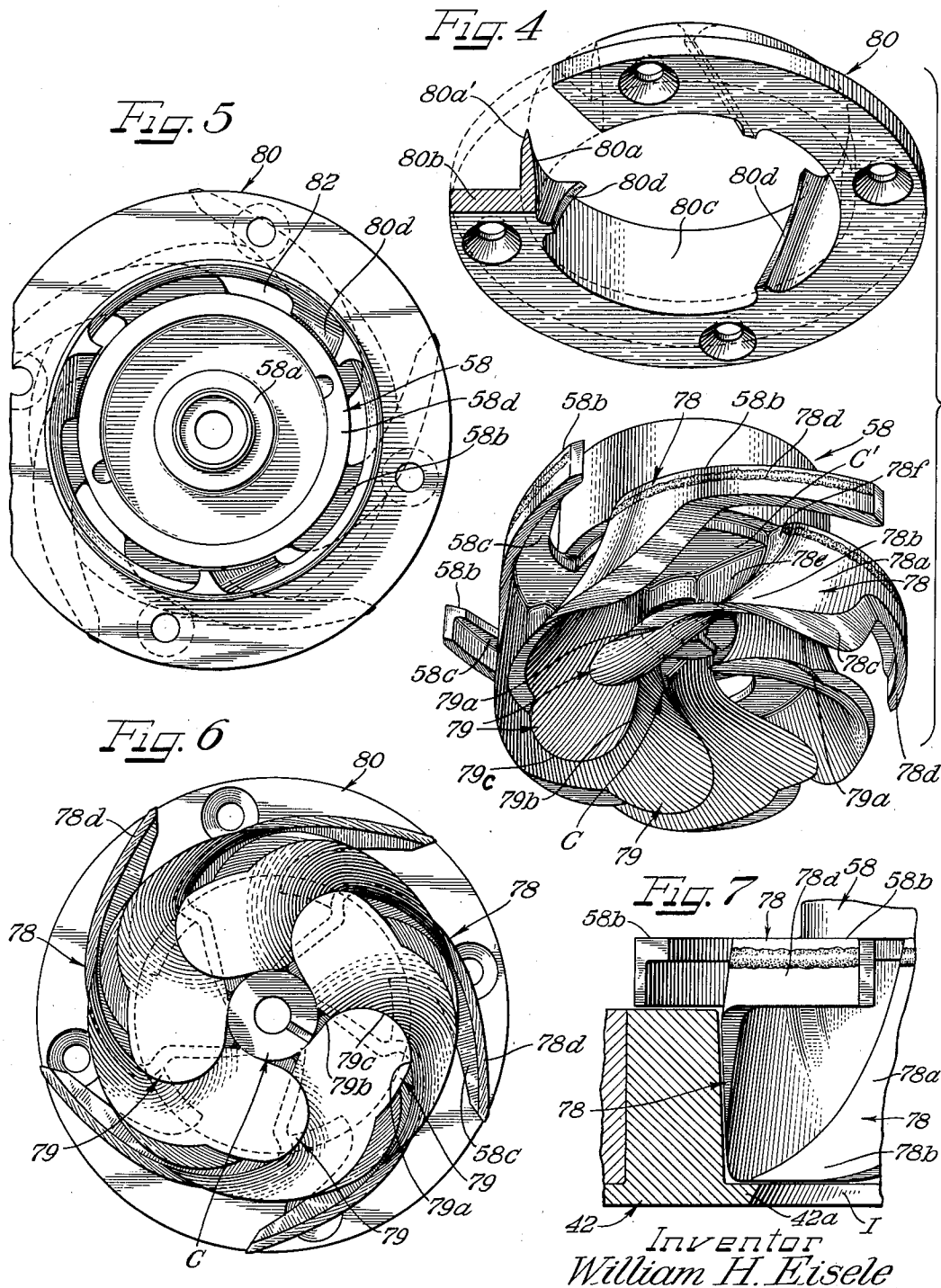
W. H. EISELE

2,736,266

PUMP IMPELLER CONSTRUCTION

Filed May 5, 1950

2 Sheets-Sheet 2



Inventor
William H. Eisele

by *The Firm of Charles H. Eisele* Attys

1

2,736,266

PUMP IMPELLER CONSTRUCTION

William H. Eisele, Cleveland, Ohio, assignor to Thompson Products, Inc., Cleveland, Ohio, a corporation of Ohio

Application May 5, 1950, Serial No. 160,343

3 Claims. (Cl. 103—115)

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

Specifically, the invention relates to a centrifugal pump having a separating chamber, a pumping chamber, a vapor diffusing chamber, and an impeller having a ring of circumferentially spaced blades rotatably mounted in the separating chamber and arranged to create vertices 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 diffusing chamber.

A feature of this invention is the provision of an axial flow inducer, integrally formed on each of the impeller blades, to project into the inlet end of the pump and thereby reduce power and efficiency losses at the inlet end while assisting in creating a greater pressure head at the discharge end of the pump.

Another feature of this invention is to provide a vapor separating pump impeller with a ring of plow-like vanes around a central eye or vortex space that have inner edges conforming with the shape of a vortex formed in the eye when the impeller is rotated.

Pumps constructed in accordance with this invention are especially adapted for submersion in ponds of liquid and function to pressure the liquid material from the pond while discharging vapors removed from the liquid material back to the pond or to a separate receptacle or vent.

While such pumps find particular utility in aircraft fuel systems, wherein they are submerged in the aircraft fuel cells containing the highly volatile fuel which has a tendency to vaporize under the low pressure conditions of high altitude flight, they are also useful in other fields of endeavor, such as, for example, steam condensation systems to pump only water; oil refineries to pump liquid fractions; and in the food industries for separating fractions of liquid foods having different specific gravities. The invention, however, will hereinafter be specifically described as incorporated in an aircraft fuel system, as in a booster pump, but it should be understood that the devices are generally applicable to other installations requiring gas-liquid separation and pumping.

It is, therefore, an object of this invention to provide a pump and driving unit adapted for submersion in a pond of fluid and having an impeller which induces and creates the necessary vertices in the pump so as to separate liquids and gases for discharge from the pump under pressure.

It is another important object of this invention to provide an axial flow inducer on a centrifugal impeller whereby axial flow is induced at an early stage of the pumping process and a desired vortex action is created to separate gases from liquids.

Another object of this invention is to provide a gas vent arrangement for a vapor separating pump positioned so as to receive vapors or gases under pressure from the impeller and to propel said vapors or gases away from the pump.

Another object of this invention is to provide an im-

2

PELLER for a liquid and vapor separating pump which has a ring of peripherally spaced pumping vanes having axially elongated inner sections with inner edges contoured to follow the shape of a vortex formed in the space surrounded by the ring of vanes and with Z-shaped inclined surfaces outwardly from the inner edges to create vapor-separating chambers around the vortex.

Another object of this invention is to provide an impeller construction for a centrifugal pump wherein the impeller blades may be separately cast and machined before being fixed to the impeller.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed description and from 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 broken 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 a top plan view of one of the blades of the impeller shown in the pump of Figure 1 before it is secured to the impeller;

Figure 3 is a bottom plan view of the detached impeller blade from the impeller in the pump of Figure 2;

Figure 4 is an exploded perspective view of the diffusion ring and impeller as detached from the pump assembly with a section of the diffusion ring removed so as to show the diffusion ring in cross-section;

Figure 5 is a top plan view of the diffusion ring with the impeller disposed as in assembly within the pump;

Figure 6 is a bottom plan view of the diffusion ring with the impeller disposed as in assembly on the pump; and

Figure 7 is an enlarged fragmentary vertical cross-sectional view of the pump impeller and vapor diffusion ring for the pump shown in Figure 1.

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 the fuel cell so as to be secured thereto by cap screws or the like (not shown). The mounting base 12 is integral with a pump casing 14 which defines an annular volute chamber 16 which surrounds and communicates with an open-ended passageway 18. The volute 16 discharges through a peripheral outlet passageway 20 into a discharge passageway 22 defined by a hollow, substantially vertical portion 12b of the base 12 in spaced lateral relation to the casing 14. The base 12 has a depending boss 12c extending below the portion 12b which receives a conduit 24. A cap 26 closes the top end of the upright portion 12b, and a single bolt 28 is passed through the conduit fitting 24 and threaded into the cap 26 to clamp the fitting 24 and the cap 26 on the opposite ends of the tubular portion 12b. Gaskets 30 are provided between the ends of the member 24 and the cap and conduit fitting.

Liquids from the volute chamber 16 are propelled through the passageway 20 into the discharge chamber 22 and then through the passageway provided by the conduit fitting 24 to fuel line (not shown) of the aircraft. The fuel line may be connected to an engine-driven main fuel pump.

The base 12 has a separate closure plate 32 secured thereto as by cap screws 34 and maintained in sealed relation with the base by a gasket 36. The closure plate 32 is beneath the lower wall of the fuel cell and provides a sump S for the cell. The sump S may be drained through

the communicating passage 38 which is ordinarily closed by a drain plug 40.

A throat ring 42 is secured to the bottom face of the casing 14 as by the screws 44. The throat ring 42 defines an inlet I for the pump in communication with the sump S. The sump S, in turn, communicates with the interior of the fuel cell through a plurality of circumferentially spaced openings 46. The pump 10, when disposed within a pond of fluid as in the fuel cell, is thus supplied fluid through the opening 46 and the sump S to the inlet I and then, by means of an impeller construction, to be described in detail hereinafter, raises the gaseous particles from the liquid, pressures the liquid material into the volute 16 and sends the gaseous material back into the pond of fluid.

The casing 14 has a plurality of upstanding legs 48 carrying a base 50 for a motor casing 52. An electric motor disposed in the casing 52 has a drive shaft 54 projecting 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 from axial movement along the shaft 54.

An open bottomed well 50a in the base 50 receives a seal ring 62 which loosely embraces the shaft 54 and which is fixedly held in the bottom of the well by a threaded sleeve 64 threaded into the well 50a and pressing against the 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 against 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 to be clamped therearound by the cap 76. Leakage along the shaft 54 is eliminated by the diaphragm 72 and by the seal rings 62 and 68.

The impeller 58 may best be described with reference to Figures 4 to 7, inclusive, wherein it will be noted that the impeller 58 comprises a plurality of circumferentially spaced flat teeth 58b spiraling outwardly and rearwardly from the bottom end of the hub 58a. Each tooth 58b converges to a sharp edge at its outer end, and these edges lie in a circle which closely overlies the throat ring 42 when assembled in the pump 10. Each tooth provides a flat web-like top portion 58c, and a plow-shaped blade or vane 78 is secured as by welding to the underside of the web 58c so as to depend from the forward face of each tooth. Each vane 78 has relatively deep outer face 78a having an outwardly and downwardly projecting leading portion 78b which overlies the inlet defining flange 42a of the throat ring 42 in assembly and has a sharpened trailing portion 78c to ride in close-running clearance relation with the diverging side wall 42b of the throat ring 42. The trailing portion 78d of the vane 78 follows the contour of the teeth 58b to converge in points lying in a cylindrical path at the entrance to the volute 16 adjacent and below the terminating points of the teeth 58b.

Projecting forwardly and inwardly from the outer face 78a of the blade 78 there is disposed the leading face 78e, which is substantially normal to the outer face 78a and which slopes downwardly and forwardly to terminate into a tongue-like axial flow inducer portion 79. The flow inducer projects forwardly of the forward portion 78b of the outer face of the vane and projects downwardly into the inlet I of the pump when assembled. The flow inducer portion 79 has a machined outer edge 79a to ride in close-running clearance relation with the inner surface of throat ring flange 42a. The inner edge 79b of the axial flow inducer runs smoothly into the inner edge of the leading face 78e of the impeller blade 78 to terminate at the hub 58a of the impeller 58.

The impeller thus has a ring of teeth each with a depending vane and these vanes surround a central chamber C in full open communication at one end with the pump inlet I. This chamber, in operation of the pump, has liquid flowing therethrough at a high rate and a draining

vortex shape may be assumed by the liquid. The inner edges of the vanes are contoured to follow the shape of such a vortex so as not to project into the gas area of the vortex.

In other words, the inner edges of the vanes lie on a vortex line. The term "vortex line" is recognized in the art as a line in a fluid whose tangent at every point has the direction curl of the velocity vector at that point.

It will be noted that the leading face 78a of the blade 78 and the integrally formed flow inducer 79 while sloping downwardly are pitched forwardly from a substantially vertical to a substantially horizontal position so that the axial flow inducer 79 when rotated in the inlet I by the impeller effectively scoops fluid in a screw-like movement from the inlet I in a plane approaching the horizontal. The horizontal scooping can be accentuated by sharpening the leading edge 79c of the axial flow inducer on the top surface of the inducer.

The scooping action of the inducer portion 79 causes axial flow of the fluid back along the leading face 78e of the blade 78, and a vapor separating swirl or secondary vortex chamber C' is formed forwardly of each leading face 78e and recirculation of the fluid in these chambers C' is induced by an indented or offset portion 78f formed at the intersection of the leading face 78e and the outer face 78a so that a cross-section taken at the joiner of the faces 78e and 78f, particularly near the hub 58a, will closely resemble a Z. Thus, liquid surrounding the central vortex chamber C is sliced off by the vanes into the secondary vortex chambers C' for separation of entrained gases.

The flow inducers 79 are relatively broad and flat to induce a substantial volume of the fluid to move axially upwardly by a slicing or scooping motion which does not beat the fluid or stir it up to a great extent. In that manner, the fluid may flow smoothly upwardly into the vortex action so that vapor and liquid separation takes place in the chambers C' between each of the blades. By so doing it has been found that a greater pressure differential occurs between the inlet I and the discharge of the liquid portions of the fluid at the entrance of the volute 16. As the fluid undergoes the vortex action in the separating chambers C', the heavier liquid particles are centrifugally discharged and pressured into the volute 16 by the outer face of the trailing portion 78d of the impeller blade 78. The lighter vapors or gaseous particles of the fluid are discharged axially upwardly along the indented or offset portions 78f of the blades 78.

When the impeller 58 is assembled (as in Figures 5 and 7), with a vapor diffusion ring 80, the vaporous or gaseous particles of the fluid are discharge through an annular vent 82 defined between an upstanding cylindrical portion 80b of the ring 80 and an upstanding cylindrical shroud 58d on the impeller 58 surrounding the hub 58a. The diffusion ring 80 has a peripheral flange portion 80b having a plurality of circumferentially spaced holes for receiving screws which are threaded into the casing 14 for securing the ring 80. The cylindrical portion 80a of the diffusion ring 80 has an inwardly tapered outer surface adjacent its upper end so that the diffusion ring 80 may be easily guided into the open-ended channel 18 within the casing 14. The inner wall 80c of the cylindrical portion 80a is upwardly diverging for purposes of venting the gaseous particles. A plurality of vanes 80d are circumferentially spaced about the wall 80c and may be cut by a straight machining or helical process along the inner wall 80c so as to scoop the vapors upon discharge from the impeller blades 78 within the vent passageway 82.

Thus, it can be seen with reference to Figure 1, that the liquid portions of the fluid from the separating chambers C' are discharged into the volute 16 along the blade surface 78d, the impeller teeth 58 and associated blade section 78d operating in close running clearance within the opening defined by the lower surface of the flange portions 80b of the diffusion ring 80 and the top

5

surface of the throat ring 42. The vapors and gases separated from the fluid are axially discharged upwardly in a vapor-rich stream into the annular vent.

It should be understood that the invention thus provides a booster pump and an electric motor unit adapted to be submerged in a fuel cell or other pond of fluid wherein the centrifugal pump impeller acts in a central separating chamber to separate liquid-rich portions from vapor-rich portions in a body of fluid, which is induced to flow axially upwardly into the impeller by means of flow inducers projecting from the impeller blades into the pump inlet.

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

I claim as my invention:

1. A rotatable centrifugal pump impeller comprising a hub having a ring of circumferentially spaced radially curved outwardly extending centrifugal pumping vanes, each vane having a blade portion extending in axial direction, said blade portions having an inner axially extending edge spaced outwardly of the axis of the impeller, each said inner edge constituting the generatrix of a vorticeform surface of revolution upon rotation of the impeller, said blade portions terminating in a tongue-like axial flow inducer, whereby upon rotation of said impeller a vortex gas chamber is formed at the axis thereof and liquid fluid is advanced axially and impelled radially outwardly by said pumping vanes.

2. A rotatable centrifugal pump impeller as defined

6

in claim 1, said axial flow inducers having leading ends of relatively low pitch adapted to scoop up liquid with minimum agitation, together with plow-shaped faces extending from said leading ends in axial and radial directions to centrifugally discharge the liquid scooped up by said leading ends, said faces having radially offset portions at the ends thereof remote from the leading ends and said offset portions being shaped to axially flow gases and vapors inwardly from the outer ends of the vanes.

3. A rotatable centrifugal pump impeller as defined in claim 1, said blade portions having outer edges extending radially outwardly and forward faces pitched from substantially parallel relation with the axis of the impeller to right angle relation with said axis to provide therebetween channels having swirl chambers which will feed fully liquid material radially outwardly and will trap gaseous vapor in said liquid in the vortex gas chamber.

References Cited in the file of this patent

UNITED STATES PATENTS

897,397	Pirkl	Sept. 1, 1908
2,046,226	Weightman	June 30, 1936
2,422,956	Edwards	June 24, 1947
2,660,120	Edwards	Nov. 24, 1953

FOREIGN PATENTS

295,152	Germany	Nov. 10, 1916
414,518	Germany	June 1, 1925
607,830	Great Britain	Sept. 6, 1948