

Jan. 30, 1945.

M. L. EDWARDS

2,368,529

PUMP

Filed Sept. 8, 1942

2 Sheets-Sheet 1

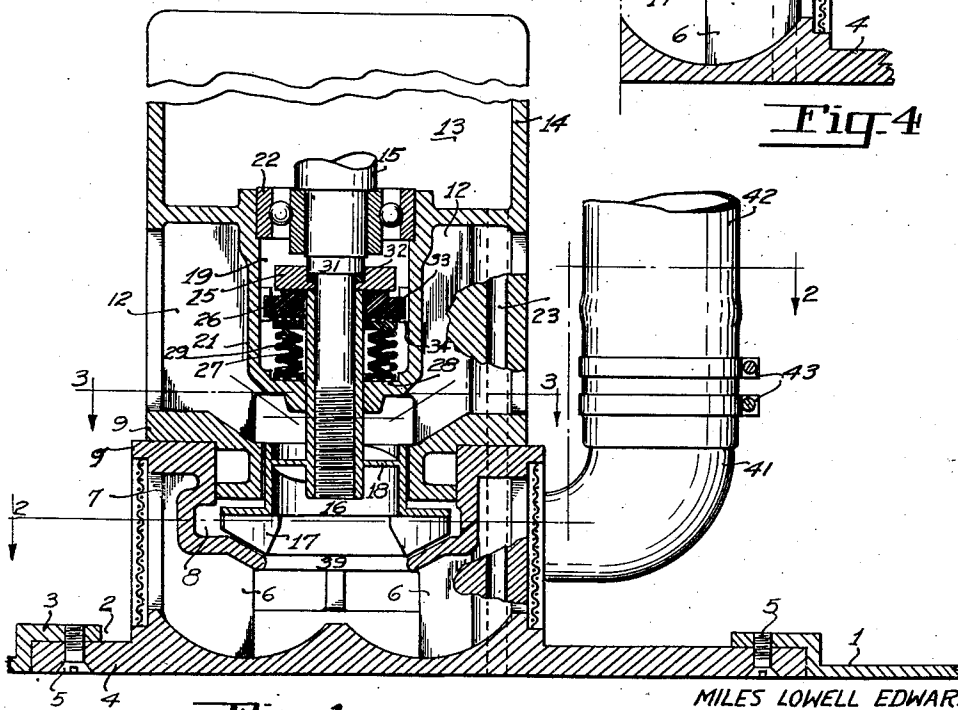
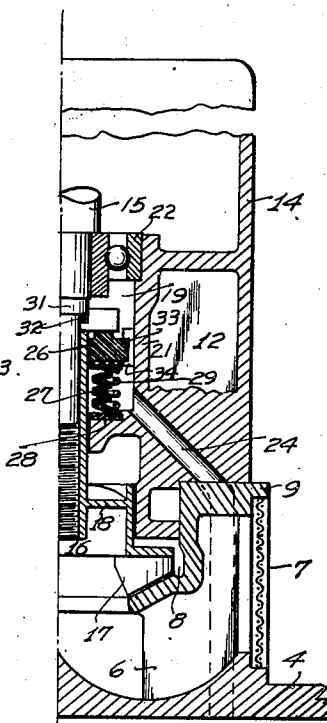
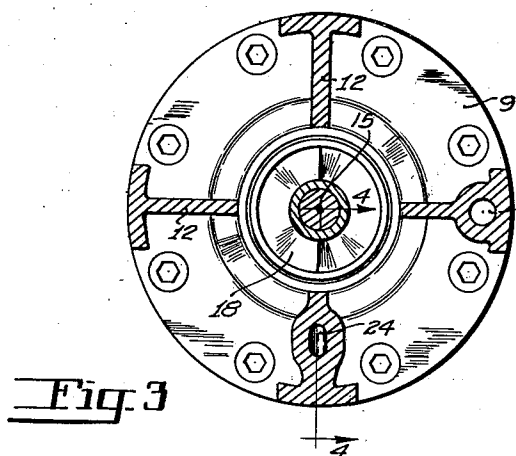


Fig. 1

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2 Sheets-Sheet 2

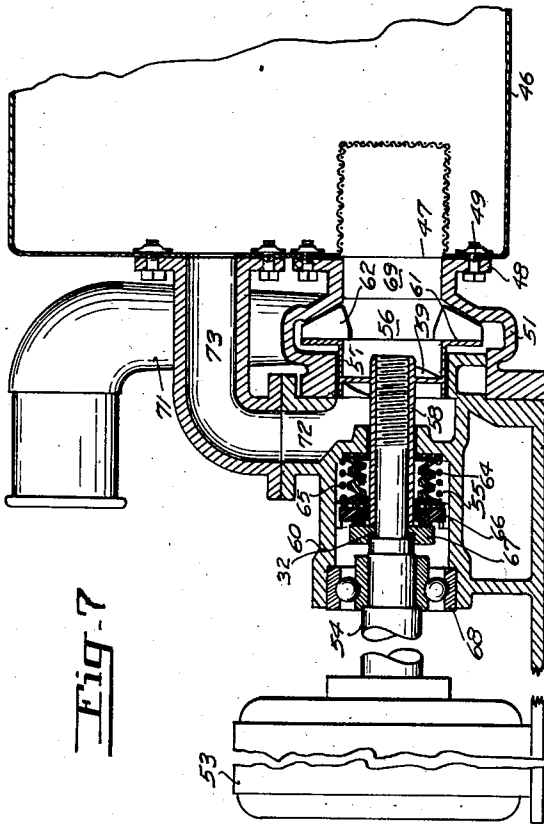


Fig. 7

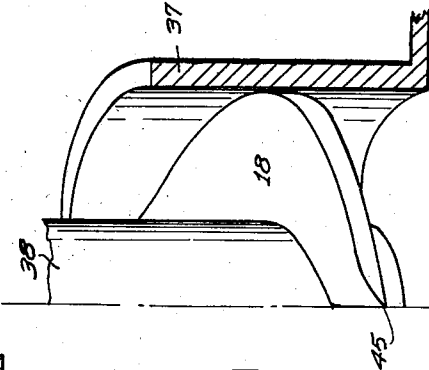


Fig. 6

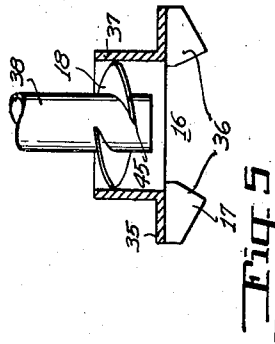


Fig. 5

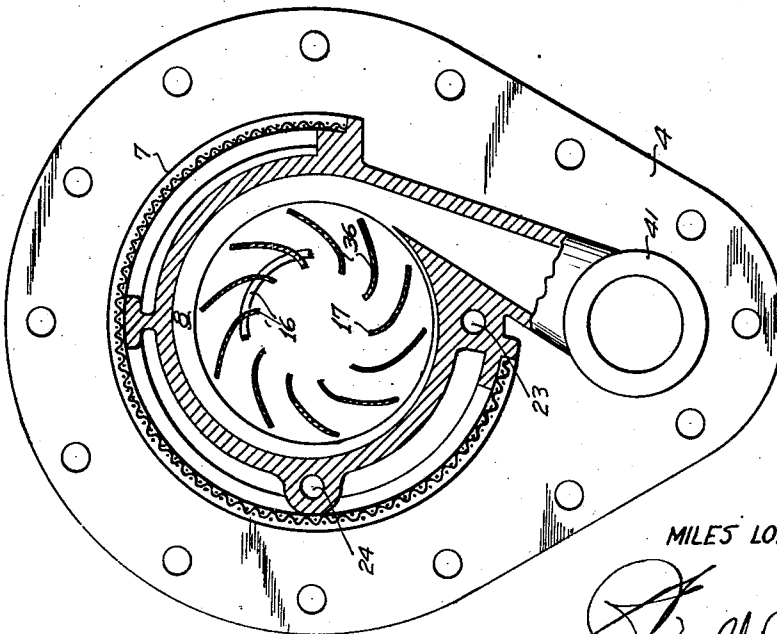


Fig. 2

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UNITED STATES PATENT OFFICE

2,368,529

PUMP

Miles Lowell Edwards, Longview, Wash.

Application September 8, 1942, Serial No. 457,641

16 Claims. (Cl. 103-113)

This invention relates to pumps, and more particularly to centrifugal pumps designed to handle liquids at temperatures at the flashing point of the liquid. Such temperatures may be occasioned either by the application of heat to the liquid, or by a reduction of pressure of the liquid, or where the fluid is being reduced to a liquid state from a gaseous state by removal of heat, as in a distilling process.

In a tank which contains liquid at the boiling point, the actual evolution of gas is more inclined to take place near the surface of the liquid due to the lower pressure of that area. As the pressure increases with the depth of the liquid, the boiling action is lessened and boiling is less inclined to take place at the bottom of the tank. However, in a tank containing boiling liquid, in the area adjacent the bottom where gas is not freely forming, a hydraulic disturbance, such as occurs when the liquid enters a centrifugal pump, will cause the formation of gas. For this reason, in pumping liquids at boiling temperatures a pump of the centrifugal type will become gas bound due to the accumulation of gas from the flashing liquid. In order, therefore, to handle boiling liquids in a centrifugal pump, it has been necessary heretofore either to locate the centrifugal impeller closely adjacent the intake from the tank and in such position that the gas which forms in the impeller passages may free itself from the revolving impeller and flow in a counter-gravity direction back into the tank away from the pump, or to locate the pump by pipe connection at an appreciable distance below the tank whereby the additional gravity head will provide a pressure sufficient to prevent the formation of gas at the impeller.

An example of a construction where the centrifugal impeller is mounted closely adjacent the tank is to be found in pumps employed to deliver fuel to the engines of aircraft designed to fly at high altitudes. In this case the reduced atmospheric pressure due to the high altitude causes the liquid to boil. Because of the restricted space, it is obvious that the fuel pump cannot be located at any appreciable distance below the fuel tank. It has been found necessary to locate these pumps in a horizontal position with the intake flanged directly to a vertical wall of the tank so that gas which forms at the entrance to the impeller passages may free itself therefrom and return to the tank. In a construction heretofore in use, the pump is located within an inverted well in the bottom of the tank with the pump mounted in a horizontal position and with the

pump intake in a side wall of the well. Obviously, the well must be of sufficient size to admit not only the pump but provide room also for the manipulation of tools for effecting replacement and repair. The primary disadvantages of such an installation reside in the weight and cost inherent in the construction of the well and in the structure of the tank made necessary by the relatively large arm hole opening to the well.

10 An example of a construction embodying the location of the pump by pipe connection at an appreciable distance below the surface of the liquid in a tank is to be found in the oil refining industry where distillate is collected in condens-
15 ing tanks which are mounted at relatively high elevations in order that the pump may be submerged a sufficient depth below the surface of the liquid to utilize the pressure of the liquid for avoiding the excessive formation of gas by the
20 hydraulic disturbance created by the impeller vanes.

In the present invention applicant has provided a centrifugal pump comprising the usual intake communicating with the eye of the impeller and a volute casing communicating with the discharge
25 port, and in combination therewith a new and novel arrangement of elements comprising a radial flow or centrifugal pump having a discharge therefrom to the volute casing, and an
30 axial flow pump having a discharge therefrom back to the liquid supply, i. e., the tank. In this pump there are two components of flow, one of which is radial due to the function of the centrifugal impeller and the other of which is axial
35 due to the function of the axial flow impeller. Applicant has found that a simple axial flow pump, when working at very low differential pressures, will function to pass quantities of gas along with the pumped liquid without becoming
40 gas bound. The centrifugal impeller is so constructed that the vanes extend to within the area of axial flow and the gases which collect in the inner ends of the passages of the centrifugal impeller are withdrawn therefrom by the axial flow
45 impeller and removed from the path of radial flow.

This combination of elements permits the location of the pump unit at a distance away from the tank for pipe connection to the tank or, if
50 desired, the pump may be located within the tank in a vertical position with the motor above the pump for withdrawal of liquid from the tank into the bottom of the pump. Pumps embodying constructions heretofore in use have been
55 inoperative in vertical positions for bottom suc-

tion arrangement for the reason that when operated in this vertical position gases which collect in the pump are trapped therein by the position of the pump with respect to gravity. Applicant's construction enables the installation of a centrifugal pump in a vertical position in the floor of a tank with the motor above the pump, the motor being immersed in and tightly sealed from the liquid in the tank. Suitable passages vent the motor chamber to the atmosphere.

It is a principal object of the invention to provide a pump of the centrifugal type for pumping liquids at temperatures at the flashing point of the liquid.

It is a further object of the invention to provide a pump wherein a centrifugal impeller functions to create a radial flow and a screw impeller functions to create an axial flow, and wherein gases which may collect in the centrifugal impeller are conducted to within the area of the axial flow and withdrawn thereby from the area of radial flow.

It is a further object of the invention to provide a pump which will operate under conditions of minimum submergence in a condensing liquid as when pumping the condensed liquid in a distilling process.

It is a further object of the invention to provide a pump which may be installed in a vertical position for bottom suction and which will operate in this position without becoming gas bound.

It is a further object of the invention to provide a pump for use as an aircraft fuel booster pump and which will maintain the delivery of fuel under conditions accompanying the ascent of the aircraft to stratosphere altitudes, and to enable such ascent within an absolute minimum period of time.

With these and other objects and advantages in mind, the invention resides in the novel construction and combination of parts hereinafter described, illustrated in the accompanying drawings, and set forth in the appended claims; it being understood that various changes in form, proportion, size and details of construction within the scope of the claims may be resorted to without departing from the spirit or sacrificing any of the advantages of the invention.

In the drawings: Figure 1 is a sectional elevation of a vertically positioned bottom suction pump embodying the principles of the invention; Figure 2 is a sectional view taken on the line 2—2 of Figure 1, showing the configuration of the impeller unit and volute casing; Figure 3 is a sectional view taken on the line 3—3 of Figure 1, showing the configuration of the axial impeller and disposition of the passages for venting the motor chamber and seal; Figure 4 is a fragmentary sectional elevation of the pump shown in Figure 1, showing the passages for venting the seal; Figure 5 is a sectional elevation of the impeller unit; Figure 6 is a perspective view of a detail showing the leading edge of an axial impeller blade; and Figure 7 is a sectional elevation of a horizontally positioned side suction pump illustrating a modification of the invention.

The pump illustrated in Figure 1 of the drawings is shown as mounted in a vertical position within a tank, with the pump arranged for bottom suction and with the motor above the pump. In such an installation the pump may preferably be mounted on a removable portion of the floor of the tank and to which the struts of the pump are integrally connected. In such a construction the tank, of which a fragmentary portion is indicated by the reference numeral 1, is provided with an

opening 2 through the floor through which the pump unit may be inserted or withdrawn. The opening 2 is defined by a recessed flange 3 to which the plate 4 which supports the pump may be attached as by suitable fastening means 5. The construction just described provides a flush outer surface of the tank wall, which is of importance in installations where the outer surface of the tank wall is the wing surface of an aircraft. In the construction illustrated in the drawings the pump structure is supported upon four struts 6. These struts support that portion of the pump casing 7 which forms the volute 8 and to which is bolted, at meeting flanges 9 and 9, the upper side plate 11.

Supported by means of struts 12 in a vertical axial position above the pump is the motor chamber 13 within which is mounted the motor (not shown) for driving the pump. The housing 14 which encloses the motor chamber 13 may be separable at meeting flanges (not shown) to permit access to the motor. The motor is directly connected to a vertical shaft 15 to the lower end of which is threaded an impeller unit 16 comprising a centrifugal impeller 17 and a screw impeller 18. The shaft 15 extends through a chamber 19 within the housing 21 and within which is contained the sealing means for sealing the motor chamber from the liquid which may follow upwardly along the shaft. The shaft is supported by bearing 22 mounted in the bottom wall of the motor housing 14.

Air is admitted to the motor chamber 13 and to the chamber 19 in the housing 21 by way of passages 23 and 24 extending through selected ones of the struts 12, through the meeting flanges 9 and 9, through complementary ones of the struts 6 and through the plate 4. Surrounding the shaft 15 in the housing 21 is a seal comprising a steel washer 25 closely fitting the shaft, a carbon sealing washer 26 keyed to the wall of the housing 21 and having seating engagement with the steel washer 25, and a bellows seal 27 the ends of which are compressed against a machined surface 28 of the housing 21 and against the lower surface of the sealing washer 26, respectively, by means of a helical spring 29. The upper surface of the steel washer 25 is recessed to receive a shouldered portion 31 of the shaft 15, a gasket 32 being inserted between the washer 25 and the shoulder 31 to prevent the leakage of fluid therepast. The sealing washer 26 is provided with ears 33 which engage in niches 34 provided in the wall of the housing 21 to prevent rotation of the washer relative to the bellows seal. By this construction, while fluid being acted upon by the pump may enter that portion of the chamber 19 within the bellows seal, entrance of such fluid into that portion of the chamber 19 surrounding the bellows seal and through the bearing 22 into the motor chamber 13 is precluded.

In the illustrated embodiment of the invention, the impeller unit, comprising both the radial or centrifugal impeller 17 and the axial or screw impeller 18, is machined from a homogeneous solid block of metal. The impeller unit comprises a cylindrical element 37 open at both ends and receiving through one end thereof an internally threaded sleeve 38 by which the impeller unit is fastened to the shaft 15. Mounted within the cylindrical element 37 is the axial flow impeller 18 consisting of complementary screw-like flanges of approximately one-half turn. The inner edges of the screw-like flanges are secured to the sleeve 38, while the outer edges are secured to the wall

of the cylindrical element 37, so that the blades of the impeller 18 furnish driving connection between the shaft 15 and the impeller unit. An annular flange 35 at the lower end of the cylindrical element 37 forms the shroud plate for a radial flow impeller of the centrifugal type having vanes 36 extending generally outwardly from the eye of the impeller. A detail of the construction of the axial impeller is illustrated in Figure 6 where the sharp leading edge 45 of each screw-like flange is shown as leading from the lower surface of the flange. Any tendency toward cavitation around the impeller will occur on the pressure side of the blade rather than on the vacuum side of the blade due to this leading edge 45, and, since the flow of liquid is approximately parallel to the surfaces of the blade, the tendency towards cavitation and consequent loss of efficiency will be reduced to a minimum.

The cylindrical element 37 forms an opening through the impeller unit of somewhat greater diameter than the eye of the centrifugal impeller and yet of somewhat smaller diameter than the intake port 39 through the volute casing 7. It is important that the intake port be large enough to prevent excessive velocities of the liquid entering the pump. Fluid acted upon by the screw impeller 18 is discharged therefrom into the area surrounding the housing 21 and may flow from thence between the struts 12 into the tank 1. The liquid pumped by the centrifugal impeller 17 flows through the volute 8 and is delivered by suitable pipe connection as may be desired. The drawings illustrate a thimble 41 to which a flexible hose 42 may be fastened by couplings 43. By loosening the couplings 43 the hose 42 may be disconnected from the pump to permit withdrawal of the entire pump unit through the opening 2 in the floor of the tank.

The struts 6 support the pump a short distance above the floor of the tank to provide for the flow of liquid from the tank to the intake port 39. A screen 44 is positioned peripherally of the pump and extends between the floor of the tank and the volute casing 7 so as to screen liquid flowing from the tank to the intake port.

In the event the liquid being pumped is at the boiling point, the moment the liquid moves to within the area of rotation of the centrifugal impeller 17 the hydraulic disturbance created by rotation of the impeller causes the formation of gas bubbles which, if permitted to accumulate in the inner ends of the impeller passages, would cause the pump to become gas bound. Gas bubbles from any source whatsoever appearing within the area of rotative influence of the centrifugal impeller vanes are forced by the separating effect of centrifugal force to flow to the area of smallest diameter within rotative effect of the centrifugal vanes, i. e., to within the inner ends of the passages between the impeller vanes. The centrifugal impeller 17 is so constructed that the inner ends of the impeller vanes 36 extend to within the radial area defined by the cylindrical element 37 and so to within the area of the axial flow induced by the screw impeller 18, and the gases which may collect within the inner ends of the impeller passages are acted upon by the axial flow and withdrawn from the centrifugal impeller by the action of the screw impeller. The axial impeller discharges the admixture of liquid and gases into the space surrounding the housing 21 from whence it may flow back into the tank 1.

In Figure 7 is illustrated an installation of a pump mounted in a horizontal position exteriorly

of the tank with the intake through a vertical wall of the tank. While in this view the pump intake is flanged more or less directly to the wall of the tank, it is a feature of the invention that the pump may be positioned at some distance from the tank for pipe connection therewith, as may be necessitated in constructions where supporting girders and other similar framework would prevent the pump being mounted closely adjacent the tank in the manner shown. Figure 7 shows a tank 46 having an outlet opening 47 adjacent the bottom of the tank to which is connected by means of a meeting flange 48 and suitable fastening devices 49 the volute casing 51 of a centrifugal pump. A bracket 52 is bolted to the volute casing 51 for supporting a motor 53. In this construction, since the motor is not immersed in the liquid within the tank, it need not be contained within a sealed chamber as described in connection with the device shown in Figure 1. The motor 53 is directly connected to the drive shaft 54 which extends through a sealing chamber 55 and into the volute casing 51 for driving connection with the impeller unit 56. Impeller unit 56 comprises a cylindrical element 57 mounted upon the shaft 54 by means of an internally threaded sleeve 58 in the manner as described in connection with the disclosure of Figure 1. Within the cylindrical element 57 is mounted the screw vanes of an axial impeller 59, these vanes merging with both the sleeve 58 and the walls of the cylindrical element 57 to impart driving force to the impeller unit. The flanged portion 61 of the cylindrical element forms a shroud plate for a centrifugal impeller 62.

The bracket 52 carries thereupon a housing 60 enclosing a sealing chamber 55 containing therein a bellows seal 64, helical spring 65, carbon washer 66 and steel washer 67, the arrangement thereof being as described in connection with the disclosure of Figure 1. This combination of elements functions to prevent liquid from following along the shaft 54 and leaking into the sealing chamber and from thence past the bearing 68.

In operation, liquid is withdrawn from the tank 46 through the opening 47 and into the impeller unit 56 through the intake 69. Liquid is discharged from the centrifugal impeller by way of volute 51 through the discharge port 71 to suitable pipe connection. Fluid acted upon by the axial flow impeller 59 is discharged thereby into the passage 72 from whence it is conducted through pipe connection 73 back to the tank 46.

The impeller unit 56 produces both a radial and an axial flow, these being the normal functions, respectively, of the centrifugal impeller 62 and the axial flow impeller 59. The inner ends of the vanes of the centrifugal impeller extend to within the area of the cylindrical element 57 and so to within the area of the axial flow, and gases which collect in the inner ends of the centrifugal impeller passages are withdrawn therefrom by action of the axial impeller and discharged from the impeller unit back into the tank 46 by way of pipe connection 73.

Having now described my invention and in what manner the same may be used, what I claim as new and desire to protect by Letters Patent is:

1. A pump for handling liquids at temperatures at the flashing point of the liquid, comprising a casing defining a volute chamber having a peripheral discharge, a shaft mounted in vertical position and extending axially of said casing, an

impeller unit mounted on said shaft, a motor for driving said shaft mounted above said pump in vertical axial alignment with said impeller, an intake port in said casing below said impeller unit, a discharge port in said casing above said impeller unit, said impeller unit having vanes for discharging liquid from said inlet into said volute chamber, said impeller unit having vanes for inducing a flow of liquid axially of said first mentioned vanes and for discharging said axial flow of liquid from said pump.

2. A pump for handling liquids at temperatures at the flashing point of the liquid, comprising a casing defining a volute chamber having a peripheral discharge, a shaft, means for driving said shaft, an impeller unit mounted on said shaft, said impeller unit having vanes for centrifugally discharging liquid into said volute chamber, said impeller unit having vanes for creating a flow of liquid axially of said casing, said first mentioned vanes extending to within the area of flow created by said last mentioned vanes whereby gases collecting between said first mentioned vanes are acted upon by said last mentioned vanes and discharged from the pump, and means for conducting the admixture of liquid and gases discharged by said axial flow vanes to the source of liquid supply.

3. A pump comprising a casing having means defining an inlet and means defining an outlet in opposite end portions of said casing and having a peripheral discharge, an impeller mounted in said casing having vanes for creating a flow of liquid axially through said casing, and a second impeller mounted in said casing and having radial vanes extending outwardly to a point beyond the area of influence of axial flow created by said first impeller for centrifugally discharging a portion of the liquid entering said casing through said peripheral discharge, said outlet for said axial flow pump communicating with the source of liquid supply.

4. A pump comprising a shaft, an impeller unit mounted on said shaft, means for driving said shaft, said impeller unit comprising a centrifugal impeller having radially extending blades for creating a flow radially of said shaft, and an axial flow impeller having screw-like vanes for creating a flow axially of said shaft and said centrifugal impeller, said radial vanes extending outwardly to a point beyond the influence of axial flow for centrifugally discharging a portion of the liquid entering said pump and extending inwardly to within the area of axial flow whereby gases collecting in the passages between said radial vanes are withdrawn therefrom by said axial flow, and means for conducting said axial flow away from said pump.

5. A pump comprising a shaft, an impeller unit mounted on said shaft, said impeller unit comprising a cylindrical element open at both ends and having an annular flange extending laterally from one end thereof, a shaft engaging sleeve positioned axially of said cylindrical element, pump vanes secured at one side to said sleeve and at the other side to said cylindrical element and providing driving connection between the shaft and said impeller unit, pump vanes secured to said flange and extending inwardly to within the radial area of said cylindrical element, said first mentioned vanes comprising an axial flow pump and said last mentioned vanes comprising a radial flow pump.

6. A pump comprising a shaft, an impeller unit mounted on said shaft, said impeller unit

comprising a cylindrical element having an annular flange at one end thereof, a shaft engaging sleeve positioned axially of said cylindrical element, pump vanes secured to said sleeve and to said cylindrical element and providing driving connection between the shaft and the impeller unit, said pump vanes comprising an axial flow pump, and pump vanes secured to said flange and comprising a radial flow pump, the longitudinal axes of said pumps being in axial alignment whereby said axial flow pump induces an axial flow through said radial flow pump for expelling gaseous fluids from said radial flow pump.

7. A pump assembly comprising a casing defining a volute chamber having a peripheral discharge, means in said casing defining a central opening extending through said casing and defining at one end thereof an inlet and at the other end thereof a discharge, an impeller unit mounted in said casing comprising a cylindrical element mounted in one end of said opening, an annular flange extending from one end thereof, a shaft engaging sleeve positioned axially of said cylindrical element, pump vanes secured to said sleeve and to said cylindrical element and providing driving connection between the shaft and the impeller unit, said vanes being operable to create a flow of liquid axially through said casing, and pump vanes secured to said flange and extending to within the radial area of said cylindrical element for centrifugally discharging a portion of the liquid entering said casing into said volute chamber.

8. A device for pumping fully liquid material such as volatile fuel from a supply of such material, comprising a casing defining a volute chamber having a central inlet and a peripheral discharge, a cylindrical portion of said casing extending axially of said pump from said volute chamber and defining an axial discharge, a pump impeller in said casing for centrifugally discharging liquid from said inlet into the volute chamber, a pump impeller in said cylindrical extension for inducing a flow of liquid axially of said first pump impeller and discharging it through said axial discharge, and means for returning liquid from said axial discharge to the source of liquid supply.

9. A pump assembly comprising a casing defining a volute chamber having a central inlet and a peripheral discharge, an impeller unit mounted in said casing comprising an axial flow pump and a radial flow pump, the longitudinal axes of said pumps being in axial alignment, means defining a discharge for said axial flow pump, and means for returning liquid from said discharge to the source of liquid supply.

10. A pump assembly comprising a tank, a pump mounted within said tank comprising a casing defining a volute chamber having a peripheral discharge, means in said casing defining a central opening extending through said casing and defining at one end thereof a central inlet providing for the flow of liquid from said tank into said casing and providing at the other end thereof a central discharge from said casing into said tank, a pump impeller in said casing for centrifugally discharging liquid from said inlet into said volute chamber, and a pump impeller mounted in one end of said opening for inducing a flow of liquid axially through said casing and into said tank.

11. A pump assembly comprising a casing defining a volute chamber having a central inlet

and a peripheral discharge, an impeller unit mounted in said casing having vanes for centrifugally discharging liquid into said volute chamber, said impeller unit having vanes for creating a flow of liquid axially of said casing, and an outlet orifice in said casing for said axial flow disposed on the opposite side of said impeller unit with respect to said inlet.

12. A pump assembly comprising a casing defining a volute chamber having a central inlet and a peripheral discharge, means defining an axial discharge port in said casing on the opposite side of said volute chamber with respect to said inlet, a pump impeller in said casing for centrifugally discharging liquid into said volute chamber, and a pump impeller in said casing for inducing a flow of liquid axially of said first impeller and discharging it through said axial discharge.

13. A device for pressuring fully liquid material from a source of liquid which comprises a pump assembly having an open passage with an inlet and an outlet accommodating free flow of liquid therethrough and a peripheral pumping chamber having an annular inlet communicating with said passage, pumping means in said pump assembly for pressuring material through the pumping chamber from said passage together with agitating means extending into said passage for releasing bubbles of gas and vapor from the liquid being pumped, and means for inducing a flow of liquid through the passage for removal of bubbles liberated by said agitating means.

14. A device for pressuring fully liquid material from a source of liquid which comprises a pump assembly adapted to be submerged in the liquid

of said source and having a casing defining an annular pumping chamber with a central inlet and a peripheral outlet, an impeller having pumping vanes for pressuring liquid through the pumping chamber to the outlet, said assembly having an open passage in communication with the liquid of said source on opposite sides of the pumping vanes accommodating flow of bubbles released by the impeller back to said source, and means inducing a flow of liquid through the passage to sweep bubbles off of the inner edges of the pumping vanes and out of the passage.

15. A pump impeller construction comprising an open ended cylindrical member having an outturned flange at one end thereof, pumping vanes depending from said flange beyond the member, said vanes having inner edges extending inwardly beyond the inner end of the flange to provide agitators disposed outwardly from the axis of the impeller, an axial hub, and screw vanes connecting the cylindrical member and hub arranged to impell fluid axially of the agitators to sweep off bubbles developed thereon.

16. A pump impeller comprising circumferentially spaced pumping vanes having open inner ends defining a ring, said vanes extending outwardly from the ring to define pumping channels therebetween arranged to receive fluids from the space inside of the ring, said space inside of the ring providing a through axially extending channel, and means for inducing a substantial flow of fluids through said axially extending channel to circulate fluids along the inner open ends of said vanes to prevent the vanes from becoming gas bound.

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