

Jan. 30, 1945.

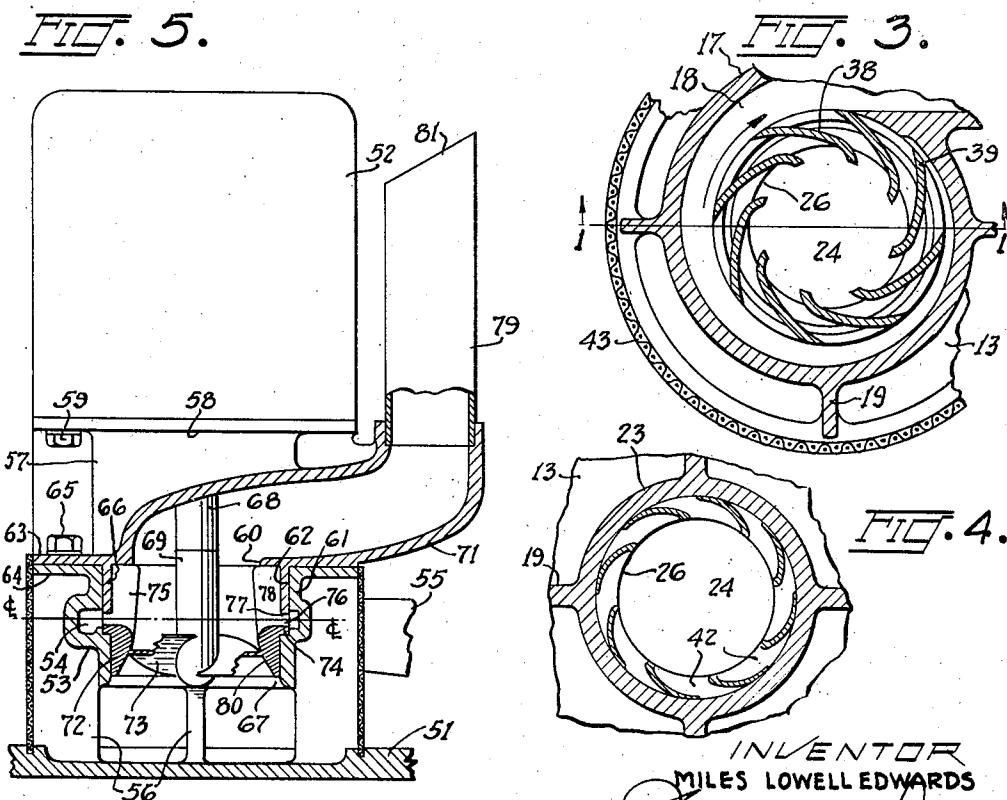
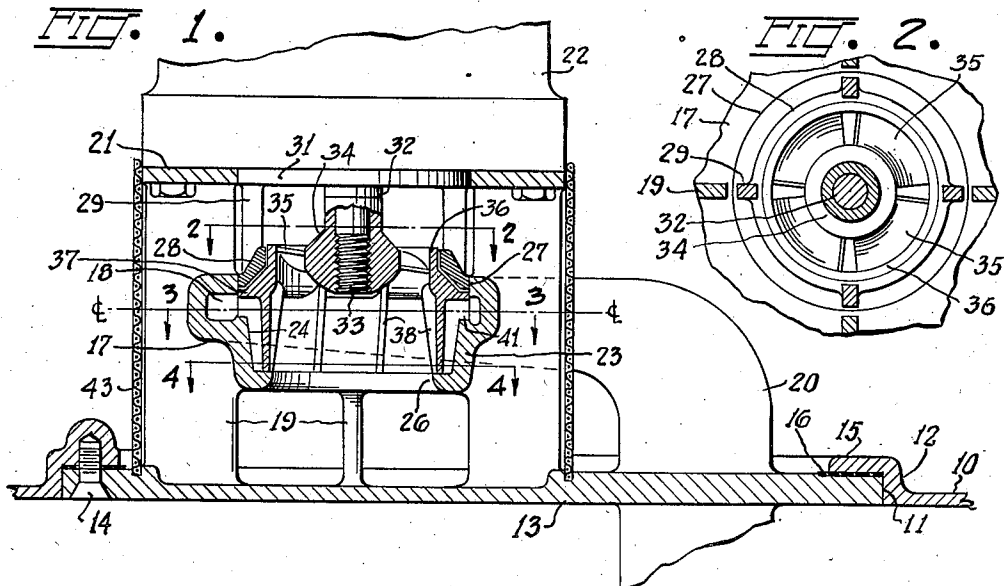
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2,368,530

VAPOR EXPELLING PUMP

Filed April 19, 1943

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 6.

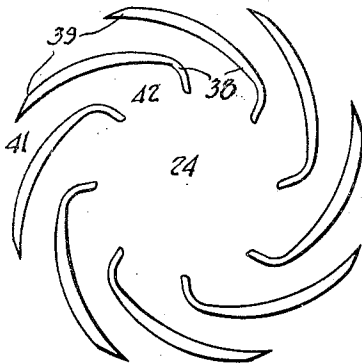


FIG. 7.

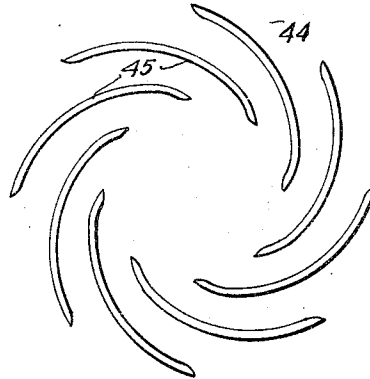


FIG. 8.

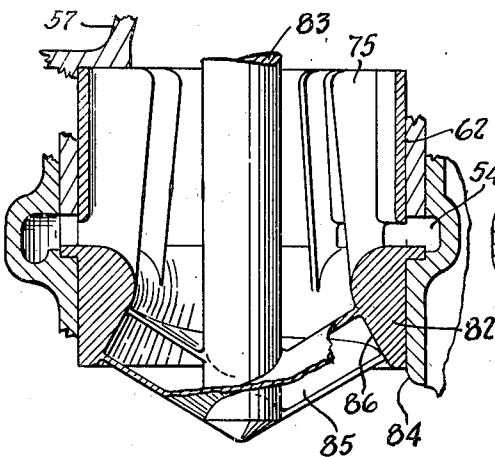


FIG. 9.

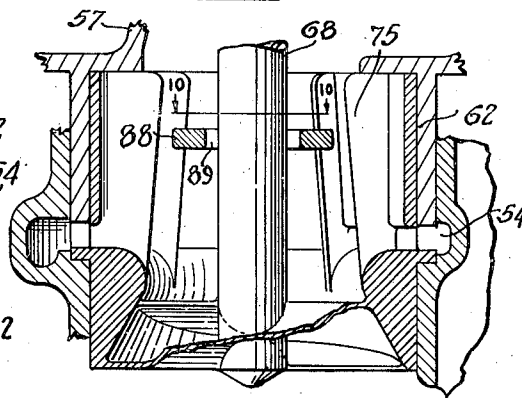


FIG. 11.

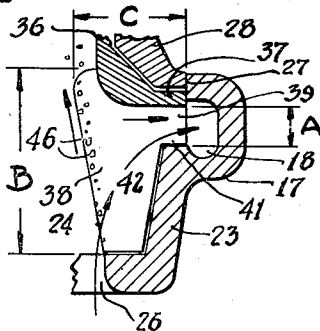
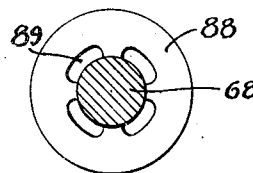


FIG. 10.



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VAPOR EXPELLING PUMP

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Application April 19, 1943, Serial No. 483,677

18 Claims. (Cl. 103—113)

This invention relates to pumps of the centrifugal type which continuously free themselves of accumulations of vapor which otherwise would cause the pump to become vapor locked, and has particular reference to a pump for delivering liquid fuel to internal combustion motors under conditions affecting stability of the liquid.

It is a primary object of the invention to provide a liquid pump of the type employing centrifugal force as its primary pumping agent, having means for inhibiting any tendency toward vapor locking of the pump even though great quantities of vapor may be present or may form in the liquid being pumped.

It is a further object of the invention to provide in a centrifugal pump an impeller unit having means for agitating the liquid entering the impeller passages for freeing gases and vapors dispersed in the liquid before it is pumped.

A further object of the invention is to provide in a centrifugal pump an impeller unit having separating chambers for centrifugally excluding gases and vapors from the liquid before it is pumped.

It is a further object of the invention to provide in a centrifugal pump an improved impeller unit having radially disposed separating chambers characterized by an inlet opening of considerable area facing the center of rotation of the pump.

It is a further object of the invention to provide in a centrifugal pump an improved impeller unit having separating chambers extending axially beyond the direct zone of influence of centrifugal flow.

It is a further object of the invention to provide a vapor expelling centrifugal pump having means providing for lower inlet velocities than would ordinarily be obtained in a pump of the same inlet impeller diameter.

It is a further object of the invention to provide a vapor expelling pump having an improved impeller unit comprising an axial flow impeller and a radial flow impeller, and having separating chambers formed by the impeller vanes of the radial flow impeller extending from the pump inlet to within the area of the radial flow impeller.

It is a further object of the invention to provide a vapor expelling pump having an improved impeller unit in which the radial depth of the impeller vanes is greater than the axial length of the impeller vanes at the place of discharge into the volute chamber, and in which the axial length of the vanes at the inlet to the impeller

passages is greater than the radial depth of the vanes.

With these and other objects and advantages in view, 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 vertical section of a pump embodying the instant invention, shown as being mounted within a tank for pumping liquid fuel therefrom; Figure 2 is a cross section of the pump, taken on the line 2—2 of Figure 1, and showing a plan view of the axial flow impeller; Figure 3 is a cross section of the centrifugal pump, taken on the line 3—3 of Figure 1; Figure 4 is a cross section, taken on the line 4—4 of Figure 1, showing the configuration of the separating chambers formed by the centrifugal impeller; Figure 5 is a vertical elevation, partly in section, of a pump employing a modification of the structure illustrated in Figure 1, and also embodying the invention; Figures 6 and 7 are plan views of centrifugal pump impellers illustrating certain important advantages of the invention; Figure 8 is a vertical section showing a detail of a pump of the type illustrated in Figure 5, and illustrating a modified construction of the axial flow impeller; Figure 9 is a vertical section showing a further detail of a pump of the type illustrated in Figure 5, and illustrating an attachment for restricting the axial flow; Figure 10 is a plan view taken on the line 10—10 of Figure 9; and Figure 11 is a sectional elevation of a detail of the pump shown in Figure 1, illustrating the flow induced by the impeller unit.

The pumps illustrated in the drawings are shown as mounted within fuel tanks for pumping volatile fuel such as gasoline from the tank to the fuel pump of an internal combustion engine as, for example, the motors of high altitude aircraft. These pumps serve the dual purpose of freeing gases and vapors from the liquid to eliminate vapor lock in the fuel system, and of delivering the fully liquid fuel to the motors. For this purpose, each of the pumps illustrated comprises a new and novel impeller having formed therewith: (1) means for agitating the liquid entering the impeller for the purpose of freeing gases and vapors dispersed therein; (2) means for centrifugally excluding said gases and vapors

from the pumped liquid; (3) means for forcefully expelling the gases and vapors from the impeller; and, (4) pumping means for delivering the gas free liquid to the aircraft engines.

Referring particularly to Figure 1 of the drawings, there is shown a fragmentary portion of the bottom wall of a fuel tank 10 having an opening 11 therethrough defined by a recessed flange 12. The opening 11 is closed by a plate 13 secured to the flange 12 at spaced intervals therearound by means of screws 14 threadedly engaging tapped wells in a mounting ring 15 mounted on the flange 12. A gasket 16 may be mounted between the plate 13 and the flange 12 to seal the opening 11.

Mounted upon the plate 13 is a pump assembly comprising a casing 17 defining the volute chamber 18 and the discharge outlet 20 of a centrifugal pump. The casing 17 is mounted upon struts 19 secured at one end to the plate 13. These struts extend upwardly from the casing 17 and terminate in a flange 21 to which is secured a motor housing 22. The struts 19 may be cast as an integral part of the casing 17 and welded or otherwise suitably secured to the plate 13, and provide the means whereby the pump assembly is firmly secured to the plate.

The casing 17 is provided with a wall portion 23 extending generally axially from the volute chamber 18 in the direction of the plate 13, this portion of the casing defining a circular chamber 24 within which is mounted an axial extension of the impeller unit. The wall 23 of the casing is curved inwardly under the lower end of the impeller unit defining the pump inlet 26. The struts 19 support the casing 17 at the requisite distance above the floor of the tank 10 to permit an ample flow of liquid in the tank to the pump inlet 26.

Above the volute chamber 18 the edge of the casing 17 defines an opening 27 through which the impeller unit is inserted into the casing 17 at the time of assembling the pump. Mounted in the opening 27 between the casing 17 and the impeller unit is a clearance ring 28 closely fitting the opening 27 for preventing loss of pressure from the volute chamber 18 therethrough. The clearance ring is supported by struts 29 depending from the end plate 31 of the motor housing 22 of which they may form an integral part.

Within the motor housing 22 is mounted an electric motor (not shown) which drives the shaft 32. The shaft 32 extends downwardly to within the impeller chamber 24, the end of the shaft being provided with threads 33 for threadedly engaging the hub 34 of the impeller unit. The pitch of the threads is in such direction that the normal torque of the motor prevents disengagement of the impeller unit from the shaft.

Mounted on the drive shaft 32 is an impeller assembly comprising the internally threaded hub 34 affixed to which are spirally shaped blades 35 forming an axial flow pump impeller. The outer edges of the blades 35 are made integral with a cylindrical shroud 36 which forms one side of the passages of the axial flow impeller. The cylindrical shroud 36 is provided with an annular flange 37 which forms the shroud plate of a radial flow impeller of the centrifugal type having impeller vanes 38. The vanes 38 are greatly elongated in the axial direction, extending from the pump inlet 26 to a point within the area of the cylindrical shroud 36, the greater proportion of each vane being disposed between the center line of the volute chamber 18 and the inlet end of the casing. In the radial direction each impeller vane

38 extends inwardly to a point within the area defined by the cylindrical shroud 36 and outwardly to engagement with the wall 23 of the casing 17. At the point where the casing wall 23 flares outwardly to form the volute chamber 18 the impeller vanes 38 are elongated to form tangentially inclined pumping vanes 39. The pumping vanes define with the shroud 37 and the wall 23 impeller passages 41 communicating at their outer ends with the volute chamber 18 and at their inner ends with separating chambers 42 presently to be described. It will be noted that the inner ends of the impeller vanes 38 extend axially to points both below and above the pump vanes 39 which lead the impeller passages into the volute chamber 18.

In Figure 11, by means of lines indicated by reference characters A, B and C, are shown the structural proportions of the impeller vanes 38. It will be noted that the radial depth of the vanes 38, as indicated by the distance C, is considerably greater than the axial length of the pumping vanes 39 at the point of discharge into the volute chamber 18, as indicated by the distance A. Also that the axial length of the vanes 38 at the entrance to the impeller passages, as indicated by the distance B, is considerably greater than the radial depth of the vanes, indicated by the distance C. The ratio of radial depth of the impeller vanes to axial length of the pumping vanes at the point of discharge into the volute chamber is determined by the volume of vapor likely to be present in the liquid acted upon by the pump. If the ratio is greater than necessary, the power required to drive the pump may be excessive.

It will be noted that the diameter of the pump inlet 26 coincides with the inside diameter of the cylindrical shroud 36 of the axial flow impeller. Adjacent the pump inlet 26 the inside diameter of the impeller vanes 38 coincides with the diameter of the pump inlet. From the pump inlet the impeller vanes 38 are tapered upwardly to a point within the area of the axial flow impeller so that the inner ends of the impeller vanes 38 describe a slightly conical chamber cut off at the top adjacent the lower edge of the axial flow impeller vanes 35.

The impeller vanes 38 extend first generally radially and then curve abruptly in a more tangential direction, so that the inner ends of adjacent vanes are separated by a distance greatly exceeding the distance between the vanes at the point where the outer end of the one vane overlies the inner end of the next adjacent vane. This may more clearly be understood by reference to Figure 4 of the drawings. Thus there is formed between the inner ends of adjacent vanes separating chambers 42. It is an important feature of the instant invention that the length of the separating chambers 42 in an axial direction is three or more times the axial length of the impeller passages 41. In other words the axial length of the passages between the impeller vanes 38 at the entrance of flow exceeds the axial length of the same passages at the point of discharge by an amount equal to at least three times. Due to the fact that the inner ends of the impeller vanes 38 extend first in a generally radial direction, the shape of the separating chambers 42 is such that each is provided with an inlet opening facing the center of rotation of the pump, and in which the path of vapor return is so direct as to constitute the shortest possible distance. Thus the impeller unit is characterized by the provision of separating chambers of relatively great width and axial

length, wherein liquid velocities in a radial direction are relatively low as compared with radial liquid velocities occurring in the outer ends of the same passages between the pumping vanes 39. Below the volute chamber 18 the wall portion 23 of the casing 17 forms a closure member for the outer ends of the separating chambers 42 so that the flow through these chambers within the area of the wall portion 23 is in a generally axial direction, carrying both vapor and liquid to points of departure from the pump.

The drawings illustrate the discharge from the volute chamber as extending downwardly through the floor of the tank 10. From thence the liquid fuel delivered by the centrifugal pump may be led to the fuel pump of an internal combustion engine, wherever located. If the floor of the tank 10 is coincidental with the wing surface of an aircraft, the pump discharge 20 may communicate with a pressure line leading upwardly through a side wall of the tank in a manner clearly within the skill of a mechanic whose duty it is to install the pump in the tank. The discharge from the axial flow impeller is directed upwardly and outwardly between the struts 19 and 29 into the tank. A cylindrical screen 43 is disposed between the motor housing 22 and the plate 13 for screening the liquid flowing to the pump inlet.

In operation, liquid fuel from the tank 10 flows through the screen 43 and enters the chamber defined by the casing 17 through the pump inlet 26. As the liquid enters the impeller chamber 24 the inner ends of the impeller vanes 38 create a violent agitation of the liquid in the zone where it enters the separating chambers 42, causing the formation of bubbles either by the extraction or collection of dissolved and entrained gases, or by evaporation of the liquid.

A comparison of Figures 6 and 7 will illustrate advantages of a structure embodying the instant invention. In Figure 6 is illustrated a plan view of an impeller embodying the invention, and showing the inner edges of the impeller vanes as extending generally radially. Because of the relatively great area of the separating chambers 42 radial liquid velocities in these chambers are relatively low as compared to the radial velocities created by the pump vanes 39. These relatively low velocities, and the direct route for vapor return to the smallest diameter of the separating chambers, is productive of a complete centrifugal separation of gases and vapors from the liquid delivered into the volute chamber and from thence supplied to the motors. In Figure 7 is shown an impeller 44 illustrating the curvature of impeller vanes 45 generally in use in centrifugal pumps. The inner ends of the passages defined by the impeller vanes 45 are relatively narrow and for the same amount of flow the velocity of the liquid is relatively high, and vapor bubbles are carried by the liquid into the volute chamber of the pump and are discharged into the pressure line. Of considerable importance in this respect is the fact that in applicant's construction the path of return of the bubbles within the separating chambers, being generally radial, is so direct as to constitute the shortest possible measurable distance, whereas in the structure illustrated in Figure 7 the centrifugal separating force, being in a radial direction, and the flow being tangentially inclined, only that vector of the separating force parallel to the flow is effective in returning the bubbles to the smallest diameter of the im-

PELLER. This reduction in separating force, combined with the greater friction of liquid at higher velocities in these passages, clearly multiplies the advantages of the wider passages and more direct path of bubble return embodied in the instant structure.

Parenthetically, it may be stated that the rate of formation of vapor in a liquid such as gasoline, which is boiling due to reduction in pressure as in a rapidly climbing aircraft, is proportional to the rate of decrease in pressure. For example, assume that an aircraft is continuously gaining altitude at a point where the barometric pressure corresponds to the boiling point of the liquid in the fuel tank. At this altitude and under these conditions the rate of formation of vapor is proportional to the rate of altitude gained. Therefore, the ability of a pump to free itself of a continuously forming quantity of vapor is a measure of its ability to perform under conditions attending a rapid gain in altitude.

The theory of operation may better be understood by a study of the action as illustrated in Figure 11. As the liquid enters the impeller chamber 24 the impeller vanes 38 induce the formation of bubbles throughout the slightly conical zone generated by rotation of the inner ends of the impeller vanes. In Figure 11 this zone is indicated by the presence of bubbles 46. By thus forming vapor, heat is extracted from the liquid, and there momentarily exists in the separating chambers a mixture of vapor bubbles and liquid at a slightly lower temperature than the liquid in the stream entering the pump. After the temperature drop occurs the liquid is stabilized and does not further vaporize. This stabilization due to temperature drop occurs throughout the entire area of the conical zone, and avoids the later formation of vapor in an area concentrated at the entrance to the impeller passages 41. The distribution of vapor formation over a wide area within the pump and the presence of extended and well formed centrifugal separating chambers within the area of axial flow induces the orderly conduction of large quantities of vapor axially of the separating chambers and into the area of influence of the axial flow impeller, and allows a relatively large radial flow of vapor-free liquid to enter the volute chamber for delivery to the fuel discharge line.

Within the separating chamber 42 the flow is generally in the axial direction to the point where the vapor free liquid enters the impeller passages 41 and the vapor laden liquid is forcefully withdrawn from the impeller chamber by action of the axial flow impeller vanes 35. For inducing the withdrawal of the vapor bubbles from the separating chambers by the action of the axial flow impeller, the inner ends of the impeller vanes 38 are sloped inwardly to a point within the area of the cylindrical shroud 36 of the axial flow impeller. Thus the separating chambers 42 open at their upper ends directly into the passages of the axial flow impeller. Due to the centripetal or inward flow tendency of vapor in a whirling mixture with liquid, the vapor tends to move upward toward the smallest diameter where rotation is induced by the rotating vanes. In the instant structure the inward slope of the vanes conducts the vapor to a point beyond the influence of the centrifugal pump and wholly within the influence of the axial flow pump which forcefully withdraws the vapor from the upper ends

of the separating chambers and returns the vapor laden liquid into the fuel tank.

In Figure 5 is illustrated a structure comprising a plate 51 forming a closure member for an opening in a fuel tank such as illustrated in Figure 1. Mounted in the tank is a pump assembly comprising a motor housing 52, and a casing 53 defining the volute chamber 54 and discharge outlet 55 of a centrifugal pump. The motor housing 52 and casing 53 are mounted in vertical relation, with the motor housing above the pump and with an impeller unit mounted in the casing and arranged for bottom suction. The casing 53 is mounted upon struts 56 secured at their lower ends to the floor of the fuel tank and at their upper ends to the casing 53. The motor housing 52 is supported above the pump casing 53 by means of a structure 57 cast integrally with the end plate 58 for the motor housing 52 and to which the motor housing is secured as by bolts 59. The structure 57 and the pump casing 53 are provided with meeting flanges 63 and 64, these parts being secured together by bolts 65. The annular flange 63 of the structure 57 defines the discharge outlet 60 of an axial pump. From the discharge outlet 60 the structure 57 defines a discharge passage 71 extending upwardly and communicating with a discharge pipe 79.

The pump casing 53 is provided with a wall portion 61 extending generally axially from the volute chamber 54 in the direction of the axial discharge 60, this portion of the casing 53 forming a circular chamber 62 for housing an axial extension of the impeller unit. The structure 57 is provided with a cylindrical portion 66 closely fitting the impeller chamber 62 and extending inwardly thereof to the point where the wall 61 flares outwardly to form the volute chamber 54. Below the volute chamber 54 the pump casing 53 extends generally axially in the direction of the floor of the tank 51 and forms the pump inlet 67. The struts 56 support the casing 53 at a sufficient elevation above the floor of the tank 51 to permit flow of liquid in the tank to the pump inlet 67.

Mounted within the motor housing 52 is an electric motor (not shown) for driving the shaft 68. The shaft 68 extends downwardly from the motor housing and axially of the impeller chamber 62. Mounted on the shaft 68 is an impeller assembly comprising an internally threaded hub 69 by which the impeller assembly is secured to the shaft. Mounted on the impeller hub and occupying that portion of the impeller chamber between the volute chamber 54 and the pump inlet 67 is an axial flow impeller comprising a cylindrical shroud 72 and spirally shaped blades 73 extending between the shroud 72 and the hub 69. The cylindrical shroud 72 is provided with an annular flange 74 which forms the shroud plate of a radial flow impeller of the centrifugal type having impeller vanes 75. The vanes 75 are elongated in the axial direction and extend axially from a point within the cylindrical shroud 72 to the axial discharge outlet 60, the greater proportion of each vane 75 being disposed between the center line of the volute chamber and the axial discharge end of the casing. In the radial direction each impeller vane 75 extends inwardly to a point within the area defined by the axial outlet 60 and outwardly to engagement with the cylindrical wall 66. In the area where the pump casing 53 forms the volute chamber 54 the impeller vanes 75 are elongated

to form tangentially inclined pumping vanes 76. The pumping vanes define with the shroud plate 74 and the edge of the cylindrical wall 66 impeller passages 77 communicating at their outer ends with the volute chamber 54 and at their inner ends with separating chambers 78.

The inner wall 80 of the cylindrical shroud 72 flares downwardly to a point coincident with the pump inlet 67. Thus the inlet to the axial flow impeller is made as large as possible for the purpose of obtaining low inlet velocities in the fluid being pumped. It will be noted that the diameter of the pump inlet 67 is approximately equal to the diameter of the centrifugal impeller. The diameter of the discharge of the axial pump corresponds to the inlet diameter of the centrifugal pump, the transition from the large inlet 67 to a small discharge from the axial flow impeller being entirely within the axial length of the spiral blades 73. This is done to provide a centrifugal impeller of small inlet diameter and thus obtain a high R. P. M. speed of the motor. Adjacent the discharge of the axial impeller the inside diameter of the impeller vanes 75 coincides with the inside diameter of the cylindrical shroud 72. From this point the impeller vanes are tapered upwardly to a point within the area of the axial discharge outlet 60.

The impeller vanes 75 extend first generally radially and then curve abruptly in a more tangential direction, and form between the inner ends of adjacent blades the separating chambers 78. The cylindrical portion 66 of the structure 57 forms a closure member for the outer ends of the separating chambers 78 so that above the level of the volute chamber 54 the flow through these chambers is generally in an axial direction.

In the pump illustrated in Figure 5 the axial flow impeller is designed to deliver a quantity of liquid in excess of the amount required by the centrifugal pump. The excess liquid delivered by the axial impeller flows upwardly through the impeller chamber 62 and through the separating chambers 78, carrying therewith the vapor bubbles generated by action of the impeller, causing these to be expelled from the pump through the axial discharge 60. The excess liquid delivered by the axial impeller is conducted upwardly through the pipe 79 to a point adjacent the upper end of the motor housing 52. At such times as the fuel level in the tank 51 is below the outlet orifice 81 of the pipe 79 the back pressure created by the elevated discharge places the centrifugal impeller in an area of greater pressure than that which would be created by the fuel in the tank. The greater pressure of the liquid in the center of the centrifugal impeller has the effect of placing the centrifugal impeller in a position of greater submergence below the liquid surface than would be the case if it were subject only to the liquid head of the fuel in the tank. The outlet orifice 81 of the pipe 79 is so formed as to throw the liquid discharged therethrough onto the motor housing 52 to aid in dissipating the heat created by operation of the motor.

It will be noted that in each of the constructions hereinbefore described the inner ends of the centrifugal impeller vanes are sloped upwardly to the point of smallest diameter at the end of the impeller where the vapor is induced to leave the separating chambers. In each of the pumps illustrated the tapered inner edges of the impeller vanes greatly augment the flow of vapor

bubbles into the area of axial flow by which these bubbles are carried away from the pump.

In Figure 8 is illustrated a modification of the pump illustrated in Figure 5. In the construction illustrated in this figure the drive shaft 83 extends to a point below the pump inlet 84 and the spiral blades 85 are curved inwardly to counteract any centrifugal action which may create a reverse flow along the downwardly flared inner wall 86 of the cylindrical shroud 87.

In Figure 9 is illustrated a further modification of the pump illustrated in Figure 5. In this view there is shown the use of a baffle 88 secured to the shaft 68 intermediate the axial length of the impeller chamber 62. The baffle 88 extends outwardly from the shaft to a point closely adjacent the inner edges of the impeller vanes 75. Adjacent the shaft the baffle is provided with apertures 89 for the escape of bubbles which may otherwise collect therebeneath and be held thereunder by action of centripetal force. The baffle 88 is provided for so restricting the axial flow of fluid through the pump as to create increased velocities along the inner tips of the impeller vanes 75 to sweep the vapor bubbles therefrom.

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 of the gas expelling type comprising an impeller having centrifugal impeller vanes as the primary pumping agent and axial flow impeller vanes as a means of expelling gas from said pump, a casing for said pump defining a volute chamber and a discharge outlet near the periphery of said impeller, a circular inlet port located concentric with and on one side of said impeller and a circular gas discharge port concentric with and on the other side of said impeller, said centrifugal impeller vanes extending axially of said casing from one end thereof to a point adjacent said axial flow vanes, said axial flow vanes being mounted adjacent the opposite end of said casing.

2. A device for pumping fully liquid material such as gasoline from a supply of such material, comprising a casing defining a volute chamber and discharge outlet, an impeller unit mounted in said casing comprising an axial flow impeller and a radial flow impeller, said axial flow impeller constituting the sole driving means for said radial flow impeller, said casing defining at one end thereof a pump inlet and at the opposite end thereof an outlet for said axial flow impeller, said radial flow impeller comprising impeller vanes extending axially from the inlet end of said casing to a point within said axial flow impeller.

3. A device for pumping fully liquid material such as gasoline from a supply of such material, comprising a casing defining a volute chamber and discharge outlet, said casing being open at both ends for permitting the flow of liquid axially therethrough, an impeller unit mounted in said casing and comprising at one end thereof an axial flow impeller for inducing the flow of said material axially of said casing, said impeller unit comprising impeller vanes for delivering said material to said volute chamber, said impeller vanes being greatly extended in an axial direction, the greater proportion of said vanes being disposed between the center line of said volute chamber and one end of said casing.

4. A device for pumping fully liquid material such as gasoline from a supply of such material, 75

comprising a casing defining a volute chamber and discharge outlet, said casing being open at both ends for permitting the flow of liquid axially therethrough, an impeller unit mounted in said casing and comprising at one end thereof an axial flow impeller for inducing the flow of said material axially of said casing, said impeller unit comprising impeller vanes for delivering said material to said volute chamber, said impeller vanes being greatly extended in an axial direction, the greater proportion of said vanes being disposed between the center line of said volute chamber and one end of said casing, separating chambers formed between the inner ends of said vanes, said separating chambers extending from a point adjacent said one end of said casing axially to a point beyond the zone of influence of flow into said volute chamber.

5. A pump of the type employing centrifugal force as the primary pumping agent, comprising a casing defining a pump chamber and a discharge outlet, a rotatable impeller unit mounted in said casing, said impeller unit having a ring of circumferentially spaced vanes with inner end portions terminating in outwardly spaced relation from the center of rotation of the unit and outer end portions discharging into the pump chamber, said inner end portions being axially elongated to provide between adjacent vanes deep liquid and gas separating channels, said outer end portions being axially foreshortened and extending outwardly from the outer ends of the inner end portions to provide between adjacent vanes shallow pumping channels receiving liquid from the separating channels, and means for circulating fluid axially through said separating channels to sweep out gases therefrom.

6. A pump of the type employing centrifugal force as the primary pumping agent, comprising a casing defining a pump chamber and a discharge outlet, a rotatable impeller mounted in the casing having vanes with deep inner ends terminating outwardly from the center of rotation of the unit and shallow outwardly extending outer ends discharging centrifugally into the pump chamber, and means for causing an appreciable flow of liquid along the length of said deep inner ends to sweep bubbles away from the vanes and thereby prevent the pump from becoming gas bound.

7. A pump of the type employing centrifugal force as the primary pumping agent, comprising a casing defining a volute chamber and a discharge outlet, a cylindrical portion of said casing extending axially of said pump from one side of said volute chamber and defining an intake port, means at the opposite end of said casing defining a discharge port, an impeller unit mounted in said casing and having impeller vanes, impeller passages between adjacent ones of said vanes, a portion of the outer ends of said vanes leading said passages into said volute chamber, the inner portions of said vanes being greatly extended in an axial direction, the greater proportion of said vanes being disposed within said cylindrical portion of said casing and wherein the outer ends of the impeller passages are closed by said casing wall, the inner ends of said vanes being tapered from one end of said pump to the other and defining a conical chamber extending axially of said casing.

8. A pump of the type employing centrifugal force as the primary pumping agent, comprising a casing defining a volute chamber and a discharge outlet, an impeller unit mounted in said

casing and having impeller vanes, impeller passages between adjacent ones of said vanes, a portion only of the outer ends of said vanes leading said passages into said volute chamber, the inner portions of said vanes being greatly extended in an axial direction, and defining inlet openings for said passages characterized by relatively great width and axial length facing the center of rotation of the pump, the greater proportion of said vanes being disposed between the center line of said volute chamber and one end of said casing, a wall portion of said casing forming a closure member for the outer ends of said impeller passages throughout the greater proportion of the length of said vanes, and means for inducing axial flow of liquid along the inner ends of the vanes.

9. A pump of the type employing centrifugal force as the primary pumping agent, comprising a casing defining a volute chamber and a discharge outlet, an impeller unit mounted in said casing and having impeller vanes with open inner ends spaced outwardly from the center of rotation of the impeller, said vanes extending first in a radial direction and then abruptly curving in a tangential direction, impeller passages between adjacent ones of said vanes, a portion only of the tangentially inclined outer ends of said vanes leading said passages into said volute chamber, a cylindrical wall portion of said casing closing the outer ends of said passages throughout the remaining portion of said vanes, and means for inducing an appreciable flow of liquid along the inner ends of said vanes.

10. A pump for pumping fully liquid material from a supply of such material, comprising a casing having at one end thereof an intake port and at the opposite end thereof a discharge port, said casing comprising also a volute chamber and a peripheral discharge port, an impeller mounted in said casing, said impeller comprising at one end thereof a plurality of spirally shaped blades forming an axial flow pump, said impeller further comprising a plurality of radially disposed vanes for pressuring liquid into said volute chamber, each said vane extending axially of said impeller from a point within the area of influence of said axial flow pump to a point adjacent the port in the opposite end of said casing, the greater proportion of each vane being disposed between the center line of said volute chamber and the end of said casing opposite said axial flow pump.

11. A pump for pumping a fully liquid material from a supply of such material, comprising a casing having a volute chamber and a peripheral discharge, a cylindrical wall portion of said casing disposed generally axially from said volute casing and comprising at the outer end of said wall portion an axial port in said casing, a second axial port in the opposite end of said casing, a plurality of spirally shaped blades mounted adjacent one of said axial ports and constituting an axial flow pump, a plurality of radial vanes mounted in said casing between the said axial flow pump and the opposite end of said casing and constituting therewith a radial flow pump, the greater proportion of said vanes being disposed between the center line of said volute chamber and the end of said casing opposite said axial flow pump.

12. A pump for pumping fully liquid material from a supply of such material, comprising a casing defining a volute chamber and a peripheral discharge, a portion of said casing extending

from one side of said volute chamber in a generally axial direction and defining an intake port, a second portion of said casing extending in a generally axial direction from the opposite side of said volute chamber and defining a discharge port, a plurality of spirally shaped blades mounted in said casing adjacent one end thereof and constituting therewith an axial flow pump, a plurality of radially disposed vanes mounted in said casing, each said vane extending from a point adjacent one of said axial ports in said casing to a point on the opposite side of said volute chamber with respect to said port.

13. A pump for pumping fully liquid material from a supply of such material, comprising a casing defining a volute chamber and a peripheral discharge, a portion of said casing extending from one side of said volute chamber in a generally axial direction and defining an intake port, a second portion of said casing extending in a generally axial direction from the opposite side of said volute chamber and defining a discharge port, a plurality of spirally shaped blades mounted in said casing adjacent one end thereof and constituting therewith an axial flow pump, a plurality of radially disposed vanes mounted in said casing, each said vane extending from a point adjacent one of said axial ports in said casing to a point on the opposite side of said volute chamber with respect to said port, said vanes and said casing together constituting a plurality of separating chambers characterized by inlet openings of relatively great width and axial length facing the center of rotation of the pump, said separating chambers opening directly into the passages of the axial flow pump, and impeller passages in said impeller providing communication between said separating chambers and said volute chamber.

14. A pump for pumping a fully liquid material from a supply of such material, comprising a casing defining a volute chamber and a peripheral discharge, a portion of said casing extending axially from one side of said volute chamber and defining an intake port, a second portion of said casing extending axially from the opposite side of said volute chamber and defining a discharge port, an impeller mounted in said casing comprising a plurality of radially disposed vanes for pressuring liquid into said volute chamber, said vanes adjacent said intake port coinciding with the diameter of said port, said vanes extending axially of said casing from said intake port to said discharge port, said vanes tapering from a point adjacent said intake port to a point within the area of said discharge port so that the inner ends of said vanes define a conical chamber extending axially of said casing.

15. A pump for pumping fully liquid material from a supply of such material, comprising a casing defining a volute chamber and a peripheral discharge, said casing extending generally axially from one side of said volute chamber and defining an intake port, an impeller mounted in said casing and comprising a plurality of vanes extending between said one side of said volute chamber and said intake port and being disposed generally radially to a point adjacent the wall of said axially extending casing and defining a plurality of separating chambers open only in a direction facing the center of rotation of the pump, said vanes in the plane of said volute chamber curving abruptly in a tangential direction, said tangentially curved vanes and said casing together defining impeller passages for delivering liquid to said volute cham-

ber, and means on said impeller for propelling liquid axially through the separating chambers.

16. A pump for pumping fully liquid material from a supply of such material, comprising a casing defining a volute chamber and a peripheral discharge, said casing extending generally axially from one side of said volute chamber and defining an intake port, said casing extending generally axially from the opposite side of said volute chamber and defining a discharge port, an impeller mounted in said casing and comprising a plurality of vanes extending first generally radially to a point adjacent the wall of said first axially extending portion of said casing and defining a plurality of separating chambers, said vanes in the plane of said volute chamber curving abruptly in a more tangential direction, said tangentially curved vanes and said casing together defining impeller passages for delivering liquid to said volute chamber, said separating chambers extending axially of said casing from a point adjacent said intake port to a point on the opposite side of said volute chamber with respect to said intake port, and means for inducing an axial flow of liquid through the separating chambers.

17. A pump impeller comprising a hub, spirally

shaped blades radiating from said hub forming an axial flow impeller, a cylindrical shroud connected rigidly to the outer edges of the blades, an annular outturned flange on said shroud forming a shroud plate for a centrifugal impeller, and a plurality of centrifugal impeller blades depending from the shroud and shroud plate having greatly elongated deep inner end portions spaced outwardly from the axial center of the impeller together with foreshortened shallow outer end portions extending outwardly from the outer ends of the deep portions.

18. A pump impeller comprising a unit having a ring of spaced vanes having axially elongated inner end portions and axially reduced outer end portions, the inner portions being at least three times as long as the outer portions, said elongated inner vane portions defining therebetween liquid and vapor separating channels open at their inner ends, said outer portions defining therebetween centrifugal pumping channels open at their outer ends and receiving liquid from the separating channels, and additional vanes for inducing a substantial axial flow of liquid through the separating channels to sweep out the vapors.

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