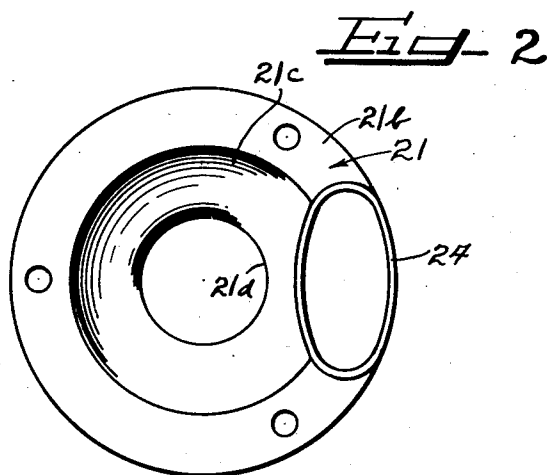
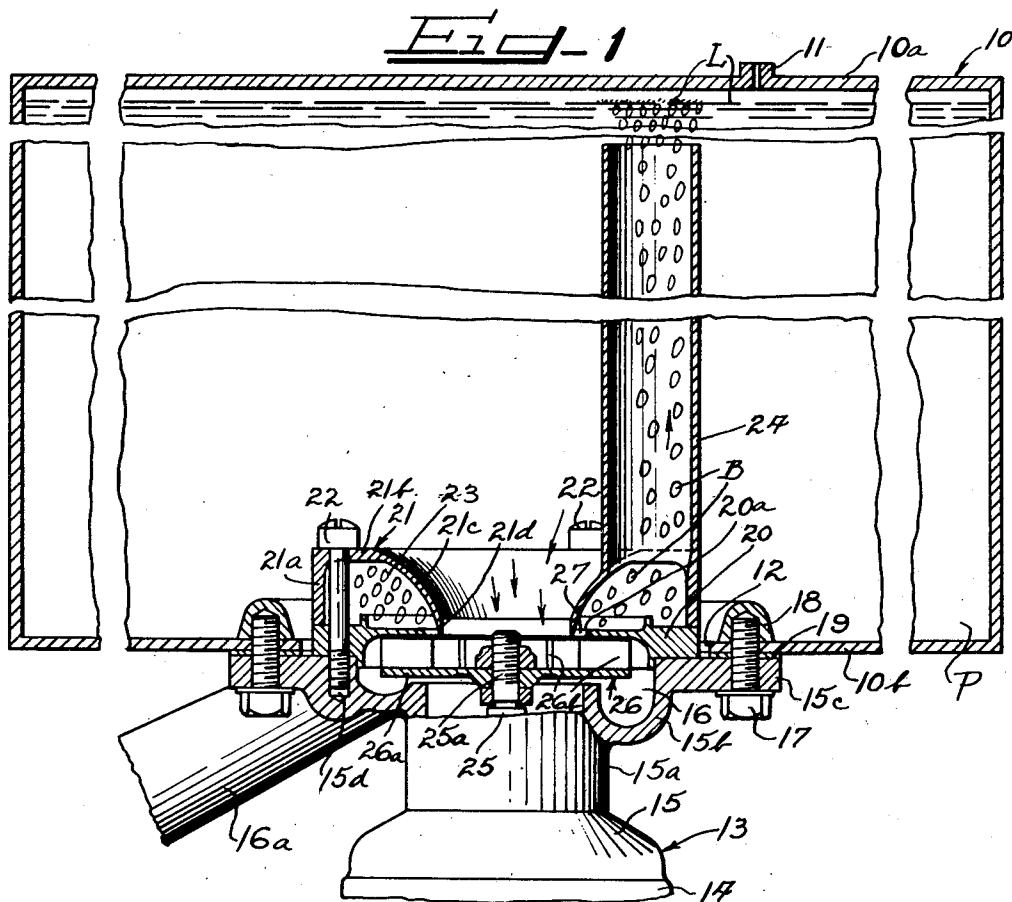


R. R. CURTIS
VAPOR EXPELLING PUMP

3 Sheets-Sheet 1

Filed Oct. 19, 1944



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March 1, 1949.

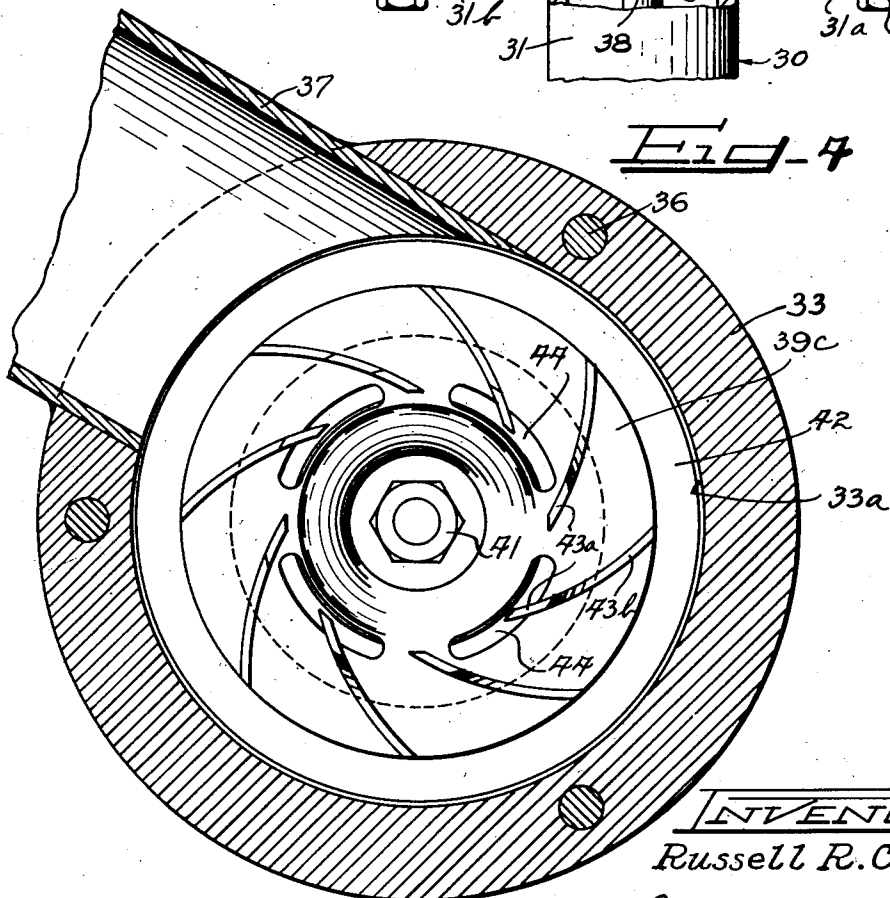
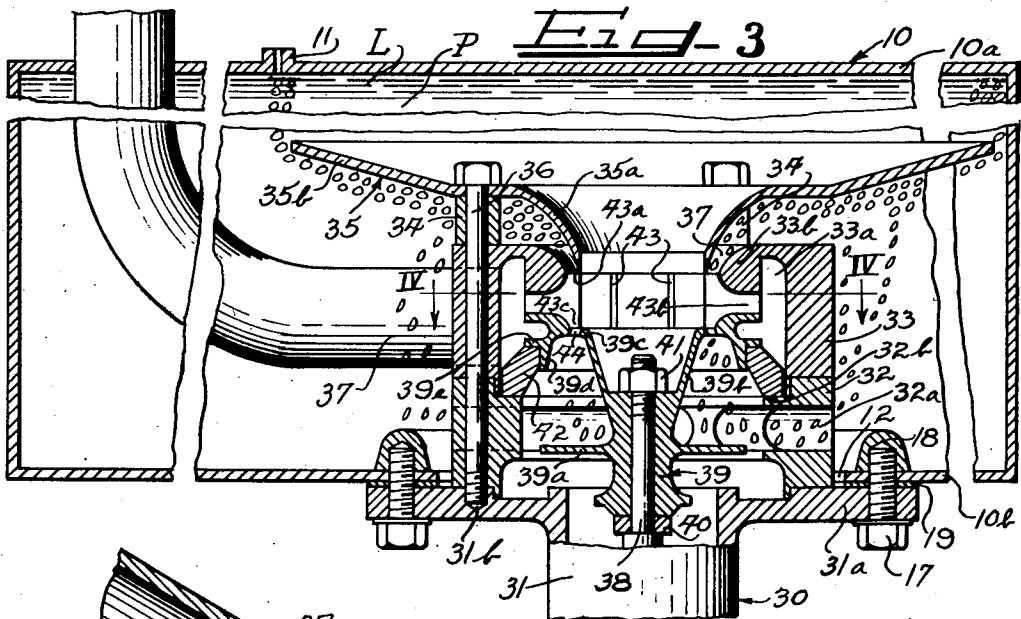
R. R. CURTIS

2,463,251

VAPOR EXPELLING PUMP

Filed Oct. 19, 1944

3 Sheets-Sheet 2



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R. R. CURTIS

2,463,251

VAPOR EXPELLING PUMP

Filed Oct. 19, 1944

3 Sheets-Sheet 3

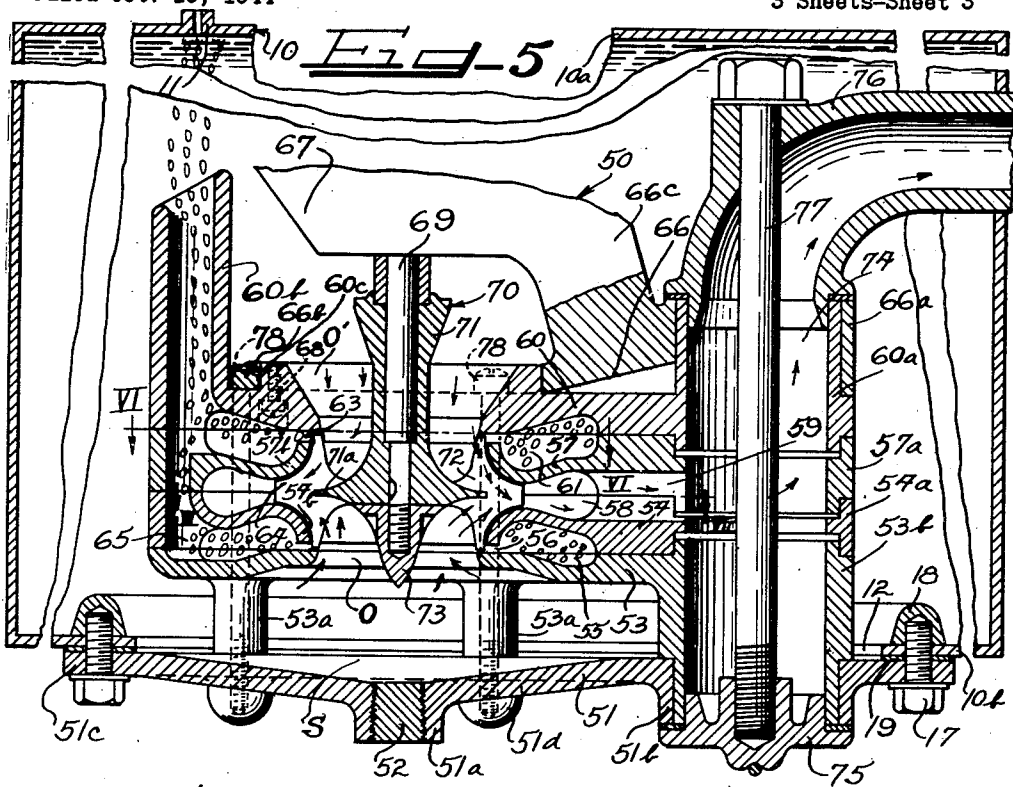
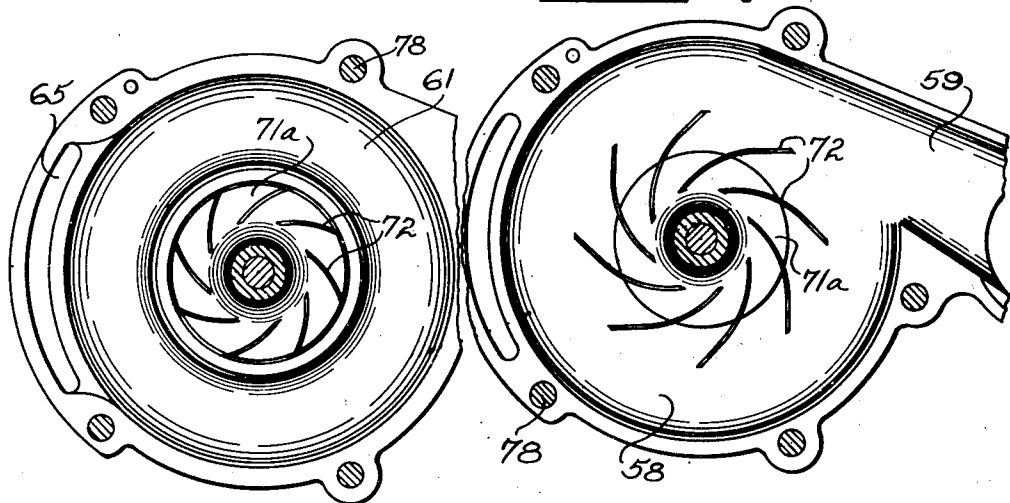


Fig-6

Fig-7



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UNITED STATES PATENT OFFICE

2,463,251

VAPOR EXPELLING PUMP

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Application October 19, 1944, Serial No. 559,432

11 Claims. (Cl. 103—113)

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This invention relates to devices for separating gases and vapors from liquids.

Particularly, the invention relates to booster pumps for aircraft fuel systems which efficiently separate gaseous materials from liquid fuel so that the fuel pumped to the fuel line will be in fully liquid condition, thereby avoiding a vapor lock in the fuel system.

In accordance with this invention pumps are equipped with vents for liberation of gaseous material. The vents are so arranged that the gaseous material cannot commingle with the liquid material being pumped. An efficient trapping off and venting of gaseous material is thereby maintained.

The invention will hereinafter be specifically described as embodied in booster pumps for airplane fuel systems. These pumps are suspended on or submerged in airplane fuel tanks. It should be understood, however, that the invention is not limited for such usage since the vapor and liquid-separating devices of the invention have general usage in the art.

A feature of the invention deals with the provision of collecting chambers for gas and vapor-rich liquid stripped from fully liquid material being pumped.

Another feature of the invention deals with the agitation of liquid being pumped and the immediate separation of the agitated liquid into separate chambers.

An object of the invention is to provide a booster pump for aircraft fuel systems which efficiently separates gases and vapor from liquid fuel being pumped from a fuel tank and simultaneously collects the vapor and gas-rich fuel in a separate chamber vented to the interior of the fuel tank at a point remote from the inlet of the pump.

A still further object of the invention is to equip aircraft booster pumps with vented chambers for receiving gas and vapor-rich liquid to deliver this liquid back to the source of liquid at a point remote from the inlet to the pump.

A further object of the invention is to provide vapor and liquid-separating devices having chambers for receiving separated vapor-rich liquid and for discharging this liquid in such a manner that it will not commingle with the incoming liquid to the devices without first discharging the vapors and gases.

A still further object of the invention is to provide liquid and vapor-separating pumps which agitate the incoming liquid to beat out bubbles of gas and vapor therefrom and collect

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the beaten-out bubbles of gas and vapor in chambers which are vented to the source of liquid at points remote from the inlet to the pump.

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

10 On the drawings:

Figure 1 is a broken fragmentary vertical cross-sectional view, with parts in elevation, of an external booster pump and fuel tank assembly.

15 Figure 2 is a plan view of the vented chamber-defining cap for the pump of Figure 1.

Figure 3 is a broken fragmentary vertical cross-sectional view, with parts in side elevation, of another form of external booster pump according to this invention mounted on a fuel tank.

20 Figure 4 is an enlarged horizontal cross-sectional view, with parts in plan, taken substantially along the line IV—IV of Figure 3.

25 Figure 5 is a broken fragmentary vertical cross-sectional view of a submerged type of booster pump according to this invention mounted in a fuel tank.

30 Figure 6 is a horizontal cross-sectional view, with parts in plan, taken along the line VI—VI of Figure 5.

Figure 7 is a horizontal cross-sectional view, with parts in plan, taken along the line VII—VII of Figure 5.

35 As shown on the drawings:

In Figure 1 the reference numeral 10 designates generally an airplane fuel tank having a top wall 10a with a vent 11 therein and a bottom wall 10b with an aperture 12 therethrough. The tank 10 contains a pond P of liquid fuel having a top level L beneath the vent 11.

A booster pump and motor unit 13 according to this invention is mounted on the bottom wall 10b of the tank 10. The unit 13 includes a motor casing 14 with an end cap 15 having a hollow neck portion 15a, a pump casing portion 15b defining a volute chamber 16, and an outturned mounting flange 15c. The mounting flange underlies the tank wall 10b and receives cap screws 17 therethrough which are threaded into a mounting ring 18 mounted inside the tank on the tank wall 10b to secure the unit 13 in depending relation onto the bottom wall 10b of the tank 10. The mounting ring 18 surrounds the opening 12 in the bottom wall 10b. A gasket 19

is interposed between the flange 15c and the wall 10b to prevent leakage.

The casing portion 15b defines an open-topped volute chamber 16 and a ring 20 is mounted on the casing part to extend over the top of the volute chamber. The ring 20 has a central aperture 20a.

A casing 21 is mounted on top of the ring 20 and has a peripheral skirt or side wall 21a bottomed on the ring 20. Cap screws 22 extend through the casing 21 and ring 20 into threaded relation in wells 15d of the casing 15.

The casing 21 has a top wall 21b and a converging inner wall 21c extending from the inner end of the top wall 21b to a circular rim 21d fitting freely within the aperture 20a of the ring 20. The inner wall 21c defines a converging inlet mouth to the pump.

A chamber 23 is thus provided by the casing 21 above the ring 20 and around the inlet mouth of the pump. This chamber 23 is vented to the interior of the tank through a tube or pipe 24. The pipe or tube 24 extends upwardly in the pond P for a sufficient distance to discharge out of its open top away from the downwardly flowing stream to the inlet mouth of the pump.

The motor in the casing 14 has a shaft 25 extending through the neck 15a and having a threaded end 25a projecting into the rim end 21d of the casing 21.

A centrifugal impeller 26 is secured to the threaded end 25a of the shaft 25 and has a disk portion 26a bridging the interior of the neck part 15a and extending into the volute chamber 16. Curved upstanding pumping vanes 26b are provided on the disk portion 26a and radiate outwardly from the central portion thereof. The vanes have close-running clearance with the ring 20 and have inner end portions freely exposed to the inlet mouth of the pump together with outer end portions discharging into the volute chamber 16.

The inner end portions of the vanes agitate liquid fuel flowing through the inlet mouth of the pump and beat out bubbles of gas and vapor from the fuel. Only fully liquid fuel is discharged by centrifugal force created by the vanes 26b into the volute chamber 16. The volute chamber has a discharge outlet 16a communicating with fuel pipe lines (not shown).

The rim 21d of the casing is spaced radially inward from the wall defining the aperture 20a of the ring 20 and an annular gap 27 connects the inner ends of the pumping channels between the vanes 26b with the chamber 23. Bubbles B liberated by the pumping vanes 26b, being lighter than the liquid material, will rise through the gap 27 to be collected in the chamber 23. The chamber 23 is thus filled with bubble-rich liquid, the bubbles of which can rise through the tube 24 into a portion of the pond P which is remote from the inlet mouth to the pump. The bubbles will then rise through the remaining portion of the pond to burst at the surface thereof and discharge their gases and vapors to the outlet vent 11. In the event that the level L of the pond P falls below the top of the tube 24, the bubbles, of course, will discharge directly from the top of the tube into the atmosphere above the pond.

The pumping vanes 26b effect somewhat of a circulation of bubble-rich liquid through the chamber 23 and tube 24.

The pump unit 13 of this invention therefore efficiently separates fully liquid fuel and bubble-

rich fuel containing occluded gases and vapors. The bubble-rich fuel is directed back to the interior of the tank at a point remote from the inlet of the pump where the bubbles will rise in the pond to discharge their gases and vapors while the fully liquid material will be pumped through the volute chamber and out of the pump.

In the embodiment of the invention shown in Figures 3 and 4, a pump 30 is mounted on the bottom wall 10b of the tank 10 in the same manner as the pump 13. Thus the pump 30 has a shaft well-defining portion 31 of a casing with an outturned mounted flange 31a receiving the cap screws, 17 therethrough which are threaded into the mounting ring 18 for suspending the unit on the bottom wall of the tank.

Superimposed rings 32 and 33 are mounted on the flange part 31a and project through the opening 12 of the tank into the interior of the tank. The ring 33 receives a plurality of upstanding spacer tubes 34 on the top thereof on which is mounted a guide shield 35. Bolts 36 extend through the shield 35, the tubes 34, and both rings 33 and 32 into threaded engagement in wells 31b of the mounting flange 31a.

The ring 32 has a plurality of radial slots 32a therearound connecting the interior of the ring with the pond P. The ring 32 also has a top shoulder 32b for a purpose to be hereinafter described.

The ring 33 defines an annular pumping chamber 33a discharging into a tube 37 extending through the pond P and through the top wall 10a of the tank.

The ring 33 has an upper portion 33b defining a converging mouth 37. The guide shield 35 has a converging central wall portion 35a extending into the mouth 37 and cooperating therewith to provide a passageway therebetween. The portion 35a defines an inlet mouth for the pump.

A motor shaft 38 extends through the shaft wall 31 and receives an impeller 39 thereon. The impeller has a central hub surrounding a reduced-diameter portion of the shaft 38 and is bottomed on a washer 40 disposed on a shoulder of the shaft at the ends of the reduced-diameter portion. A nut 41 clamps the hub on the washer 40.

The impeller 39 has a radial disk portion 39a bridging the aperture of the ring 32 about level with the bottom of the slots 32a.

A hollow inverted frusto-conical portion 39b extends from the top of the hub 39 into the ring 33 and has an out-turned multi-apertured flange 39c at the upper end thereof. This flange 39c has a depending skirt 39d provided with an out-turned flange 39e. A sealing ring 42 of graphitic carbon or the like is disposed around the skirt 39d to have a slip fit thereon and is bottomed on the flange 39e to form a floating seal. The sealing ring also has a slip fit on the shoulder 32b and separates the pumping chamber 33a from the interior of the ring 32.

Curved pumping vanes 43 are mounted on the outturned flange 39c of the hub and have inner upper end portions 43a aligned with the mouth 37 together with radially extending outer end portions 43b extending under the ring portion 33b and communicating with the pumping chamber 33a. The vanes also have depending portions 43c aligned with the apertures 44 in the flange 39c.

The shield 35 has an inclined deflecting skirt

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portion 35b which cooperates with the portion 35a to direct fuel from the pond P into the pump. This fuel is received by the inner ends of the pumping vanes 43. The fuel is thus agitated and bubble-rich liquid is acted on by the vane portions 43a to rise through the mouth 37 around the portion 35a of the shield and under the portion 35b of the shield. The bubbles, being lighter than the liquid of the pond, tend to rise in the pond and will hug the under face of the shield until they reach the periphery, whereupon they will rise through the pond to the top level L thereof and burst to discharge the gases and vapors through the tank vent 11.

The vane portions 43c serve to direct bubble-rich liquid through the apertures 44 around the conical portion 39b of the impeller and into the ring 32. This bubble-rich liquid discharges through the slots 32a of the ring back to the interior of the tank. The bubbles, of course, will rise around the ring 33 to be deflected by the portion 35b of the shield and merge with the stream of bubbles from the mouth 37.

The impeller 39 has the vanes 43 thereof arranged outwardly from its axis of rotation and an open-ended channel is provided along the inner ends of the blades. Thus, the inner ends of the blades communicate with the mouth 37 and with the holes 44. Both the mouth 37 and the holes 44 communicate back to the pond.

The fully liquid material, being heavier than the gas and vapor-rich material, is thrown by centrifugal force of the outer ends 43b of the blades into the pumping chamber 33a, from which it is discharged through the tube 37.

As shown in Figure 4 the holes 44 through the impeller flange portion 39c are preferably in the form of elongated slots.

The pump 30 thus receives liquid through the guide shield 35 and the inner ends of the pumping vanes 43 agitate this fuel to release streams of bubble-rich liquid through the mouth 37 and the holes or slots 44. Both the mouth 37 and the holes communicate back with the interior of the pond and the bubble-rich liquid is allowed to rise in the pond under the deflector portion of the shield to the periphery thereof, whereupon it will rise to the surface of the pond P. The shield 35 has a sufficiently large periphery so that the bubble-rich liquid will be remote from the incoming liquid.

The pump 30 differs from the pump 13 in providing an arrangement whereby bubble-rich liquid can flow upwardly back to the pond of fuel as well as downwardly through a chamber communicating with the pond of fuel.

In the embodiment shown in Figures 5 to 7, a pump and motor unit 50 is submerged in the tank 10. The unit 50 includes a base plate 51 bridging the aperture 12 of the bottom tank wall 10b. The base 51 has a downwardly sloping portion pitched to a threaded boss portion 51a receiving a plug 52 in threaded relation therein. A circular boss 51b depends from the base 51 adjacent the pitched portion thereof and a flat mounting flange portion 51c underlies the tank wall 10b to receive the mounting screws 17 therethrough. The mounting ring 18 is mounted on the bottom wall of the tank for receiving the screws 17 in threaded relation therein.

A sump S is created by the sloping portion of the base within the ring 18.

A plate 53 extends across the sump portion in spaced relation thereabove and has a plurality of depending legs 53a bottomed on the base por-

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tion 51 together with a tubular portion 53b extending into the boss 51b. The plate 53 is thus held in spaced relation from the plate 51 and has a central aperture therein providing an inlet opening O at the bottom of the pump.

The plate 53 receives a plate 54 on the top thereof which is curved to cooperate therewith for providing an annular chamber 55 around the inlet opening O. This chamber 55 is connected with the inlet opening O through a gap 56.

The plate 54 has a tubular section 54a mounted on top of the tubular portion 53b.

A third plate 57 is mounted on top of the plate 54 and cooperates therewith to define an annular chamber 58. The plate 57 has a tubular portion 57a mounted on top of the portion 54a. A passageway 59 connects the chamber 58 with the interior of the tubular portion 57a.

Another plate 60 is mounted on top of the plate 57 and cooperates therewith to define an annular chamber 61. The plate 60 has a tubular portion 60a mounted on the top of the portion 57a.

The plate 60 has a converging central aperture defining a top opening O' to the pump.

The intermediate plates 57 and 54 have curved lip portions 57b and 54b respectively, sloping toward the inlet openings O' and O to cooperate therewith for providing an open ended central passage through the pump. The lip 57b cooperates with the plate 60 to define a gap 63 connecting the chamber 61 with the inlet opening O'. The two diverging lips 54b and 57b cooperate to define a gap or inlet 64 connecting the central passage with the chamber 58.

The chambers 55 and 61 discharge into a passage 65 provided by the plates. This passage 65 has an arcuate contour as shown in Figures 6 and 7 and as shown is continued by a leg portion 60b of the plate 60 to a level materially above the top inlet opening O'. The leg portion 60b can be omitted if desired by having the passage 65 discharge at any point relatively remote from the inlets O and O' to prevent the bubbles from being entrained in the fluid flowing to the inlets.

A motor mounting base 66 including a collar portion 66a surrounding the tubular portion 60a of the plate 60 and a ring portion 66b surrounding a neck 60c of the plate 60 has an arm 66c between the ring and collar portions extending upwardly to a motor casing 67. Screws such as 68 are provided at intervals around the neck 60c and are passed through holes in plate 60 into threaded engagement with the ring portion 66b of the base 66.

A motor shaft 69 depends from the casing 67 and carries an impeller 70 thereon. The impeller 70 has a hub 71 keyed onto the shaft 69. This hub 71 flares outwardly as at 71a at a level opposite the opening 64 to the chamber 58. Vanes 72 are mounted in spaced relationship around the flaring portion 71a. These blades 72 have inner end portions terminating adjacent the bottom plate 53 and the top plate 60 to communicate with the gaps 56 and 63. The vanes have central portions extending into the gap 64.

A nose piece or nut 73 is threaded on the shaft 69 to lock the hub 71 on the shaft against a shoulder provided on the shaft.

Fuel from the pond P can flow into either end of the pump through the inlets O and O'. The blades 72 will agitate the fuel to discharge bubble-rich streams into the annular chambers 55 and 61. These chambers discharge through the passage 65 back to the interior of the tank. The fully liquid material, however, is impelled by the

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vanes 72 into the chamber 58 and through the passageway 59 into a discharge passageway 74 provided by the superimposed nested tubular sections 53b, 54a, 57a and 60a.

An end cap 75 forms a closure for the bottom of the passageway 74 and a discharge nipple 76 communicates with the top of the passageway 74. The nipple 76 is connected to a pipe line (not shown).

A bolt 77 extends through the nipple 76 and through the passage 74 into threaded relation in the cap 75 to draw the cap and nipple together, thereby holding all of the superimposed tubular section parts in position and also securing these parts to the base plate 51.

The form of the pump shown in Figures 5 to 7, therefore, is submerged in a fuel pond and receives fuel from the pond through the top and bottom open ends thereof. The inner ends of the blades of the pump impeller agitate the fuel and discharge bubble-rich mixtures to top and bottom annular chambers communicating back with the interior of the tank at a point remote from both pump inlets. The fully liquid material is centrifugally pumped by the vanes into a chamber between the bubble-rich receiving chambers and this pumping chamber discharges into a discharge passageway communicating with a pipe line.

The superimposed plates are held together by the bolt 77 and also by bolts 78 extending through the plates and legs 53a and threaded into bosses 51d of the base plate.

The various forms of pumps illustrated on the drawings thus have vapor-receiving chambers coacting with pump impellers to receive vapor-rich liquid liberated by the impellers and to direct this liquid back to the source of liquid at points remote from the pump inlet so that the vapors in the bubble-rich liquid can be liberated. Repeated circulation of liquid through the pump will result in production of a stabilized liquid.

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

I claim as my invention:

1. A vapor expelling pump comprising a casing defining an annular pumping chamber having a central passageway therethrough, means cooperating with said casing defining flow paths on opposite sides of said pumping chamber, a pump impeller in said central passageway having pumping vanes for discharging bubble-rich liquid into said flow paths together with vanes for discharging bubble-freed liquid into said annular pumping chamber, and means for directing bubble-rich liquid from said flow paths away from said central passageway.

2. A vapor expelling pump comprising a casing defining an annular pumping chamber and a central passageway therethrough, said annular pumping chamber having an annular inlet communicating with said central passageway and a peripheral outlet, means coacting with said casing on opposite sides of said pumping chamber to define flow paths isolated from said pumping chamber, an impeller in said central passageway having pumping vanes for centrifugally discharging liquid from the passageway through the annular inlet into said pumping chamber and additional pumping vanes for agitating liquid in said

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central passageway to discharge bubble-rich streams of liquid through said flow paths, and means guiding the bubble-rich stream from said flow paths to discharge the bubbles in spaced relation from the central passageway.

3. In a fuel system including, a tank having an apertured bottom wall and a pump unit suspended on said bottom wall around the aperture thereof, said pump unit having an annular pumping chamber, the improvement of a centrifugal impeller for pumping liquid directly from the tank through said pumping chamber, vanes disposed on said impeller adjacent the inlet of said pumping chamber for concurrently liberating bubble-rich liquid from fully liquid material being pumped, a casing in said tank mounted on said pump defining an annular chamber and a central inlet mouth for said pump, said inlet mouth of said casing terminating adjacent said impeller and cooperating with the pump structure to provide an annular opening around the inlet mouth communicating with said annular chamber to direct bubble-rich liquid from said impeller vanes into said annular chamber to prevent passage of said bubble-rich liquid through said pumping chamber, and said casing having a conduit associated therewith extending into the tank to a point remote from the inlet mouth of the pump whereby bubble-rich liquid discharged from said conduit will not be commingled with liquid entering the pump inlet.

4. A vapor expelling device comprising a casing having a central passageway therethrough and an annular chamber around said central passageway communicating with the central passageway, a shield on said casing extending into said central passageway and cooperating with the casing to provide an annular passage, said shield having a deflecting wall overlying the casing and radiating from said annular passage, a pump impeller in said central passageway having an outturned flange with slots at spaced intervals therearound, upstanding vanes mounted on said outturned flange of the impeller and extending into said annular chamber, and said upstanding vanes including portions aligned with and intermediate said slots and said annular passage for directing streams of bubble-rich liquid concurrently through the slots and annular passage for discharge under the deflecting portion of the shield.

5. In combination, a tank having an apertured bottom wall, a pump mounted on said bottom wall of the tank having a portion closing the aperture therein, a casing ring on said pump projecting through said aperture into said tank and having a central passageway and a pumping chamber around said passageway communicating therewith, said casing ring having a conduit connecting the lower portion of the central passageway with the interior of the tank, a shield mounted on the top of said casing ring having a central mouth-defining portion providing an inlet mouth to the top of the central passage, said shield being spaced from said casing ring to cooperate with the top portion of the casing ring for defining an annular flow path, and an impeller rotatably mounted in said casing ring having pumping vanes for discharging liquid material through said pumping chamber together with agitating vanes for discharging bubble-rich liquid concurrently through said annular flow path and through said conduit of the casing ring, and said guide shield having a deflecting wall radiating outwardly from said inlet mouth re-

ceiving the bubble-rich liquid thereunder to deflect the liquid away from the inlet mouth.

6. A vapor expelling pump comprising an annular casing defining an open-ended central fluid inlet passageway, a central annular pumping chamber communicating with said passageway intermediate the ends thereof, and annular bubble-receiving chambers on opposite sides of said pumping chamber surrounding and communicating with said central passageway, and an impeller rotatably mounted in said central passageway having vanes associated therewith for discharging fully liquid material into said pumping chamber and for concurrently discharging bubble-rich liquid into said chambers on opposite sides of the pumping chamber to prevent passage of said bubble-rich liquid into said pumping chamber.

7. A vapor expelling pump comprising a casing having a central fluid inlet passage therethrough and three superimposed annular chambers therein surrounding and communicating with said central passage, means defining a common discharge conduit for the outer chambers, means defining a separate discharge conduit for the central chamber, and a pump impeller rotatably mounted in said central passage having vanes associated therewith for discharging fully liquid material through the central chamber and for concurrently discharging bubble-rich liquid through the outer chambers into said common outlet.

8. A submerged pump and motor unit comprising a base plate for securing the unit to a tank wall in submerged relation in the tank, a casing carried by said base plate in spaced relation therefrom having an open-ended central passageway and three annular chambers in superimposed relation surrounding said central passageway and in communication therewith, said casing having a discharge conduit communicating with the outer chambers, said casing having a second discharge conduit communicating with the middle chamber, a motor shaft extending into said central passageway, an impeller on said motor shaft in said central passageway, and vanes on said impeller arranged relative to said chamber for discharging fully liquid material through the middle chamber into said second conduit and for concurrently discharging bubble-rich liquid through the outer chambers into said first mentioned common discharge conduit.

9. In combination, a tank having an apertured bottom wall, a base plate mounted on said bottom wall closing the aperture thereof, an upstanding tubular leg on said base plate having a discharge passage therethrough, a casing associated with said leg defining an open-ended passageway communicating with the interior of the tank at both ends thereof, said casing having three annular chambers around said open-ended passageway in communication therewith, the middle of said chambers communicating with the passage in said upstanding leg, means on said casing providing a discharge outlet for the outer chambers communicating with the interior of the tank in spaced

relation from the passageway, and a pump impeller rotatably mounted in said passageway having vanes associated therewith for pumping liquid material through the middle chamber and bubble-rich liquid through the outer chambers.

10. A vapor expelling pump comprising a casing defining an annular pumping chamber and a central passageway therethrough, said annular pumping chamber having an annular inlet communicating with said central passageway and a peripheral outlet, means coacting with said casing on opposite sides of said pumping chamber to define flow paths isolated from said pumping chamber, a centrifugal impeller rotatable in said central passageway, said impeller having vanes thereon with inner ends projecting into said central passageway to agitate the liquid to create a stream of bubble-rich liquid and with outer ends projecting into said annular inlet to pump bubble-free liquid from the central passageway through said annular inlet into the pumping chamber and then into the said peripheral outlet, the inlets of said flow paths being disposed adjacent said inner vane ends and respectively on opposite sides thereof to receive said bubble-rich stream of liquid, and means guiding the bubble-rich stream from said flow paths to discharge the bubbles in spaced relation from said central passageway.

11. A vapor expelling pump comprising an annular casing defining an open ended central fluid inlet passageway, a central annular pumping chamber communicating with said passageway intermediate the ends thereof, and annular bubble-receiving chambers respectively disposed on opposite sides of said pumping chamber surrounding and communicating with said central passageway, and a centrifugal impeller rotatably mounted in said central passageway, said impeller having vanes thereon with inner ends projecting into said central passageway to agitate the liquid to create a stream of bubble-rich liquid for discharge into said bubble-receiving chamber and with outer ends projecting into said annular pumping chamber to concurrently pump bubble-free liquid from said central passageway into said pumping chamber.

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