United States Patent

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[54] PUMP WITH AUTOMATIC PRIME DEVICE
11 Claims, 6 Drawing Figs.

[52] U.S. Cl. 417/202, 417/216, 417/316
[51] Int. Cl. F04d 9/00, F04b 23/14
[50] Field of Search ..... 417/202, 203, 316, 319, 223, 201, 216; 103/113; 192/86, 91 A

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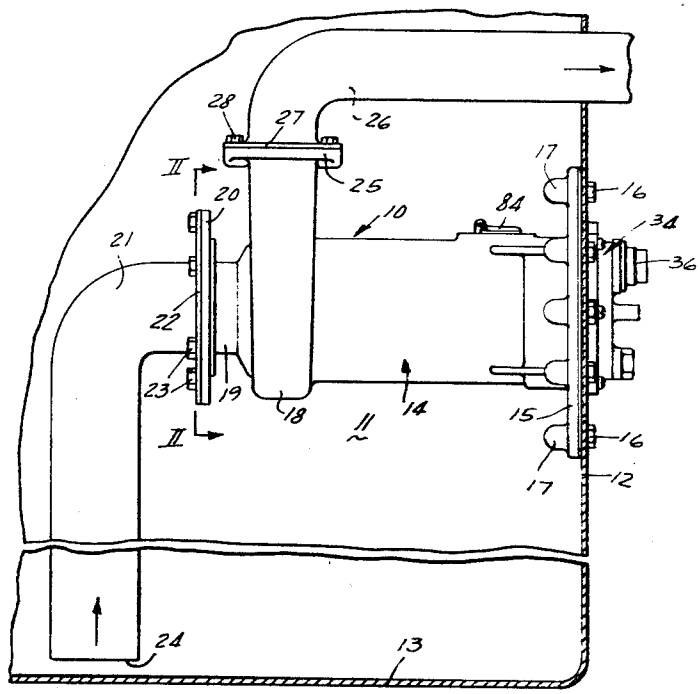
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ABSTRACT: A motor-driven pump with a priming device which is automatically disengaged from the motor when the pump is primed. In the preferred embodiment a submerged centrifugal booster pump and electric motor unit has a built-in hydroturbine priming pump driven by the motor through a spring biased clutch which is disengaged whenever the booster pump is primed and developing sufficient liquid pressure to overcome the spring bias on the clutch.



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Fig. 1

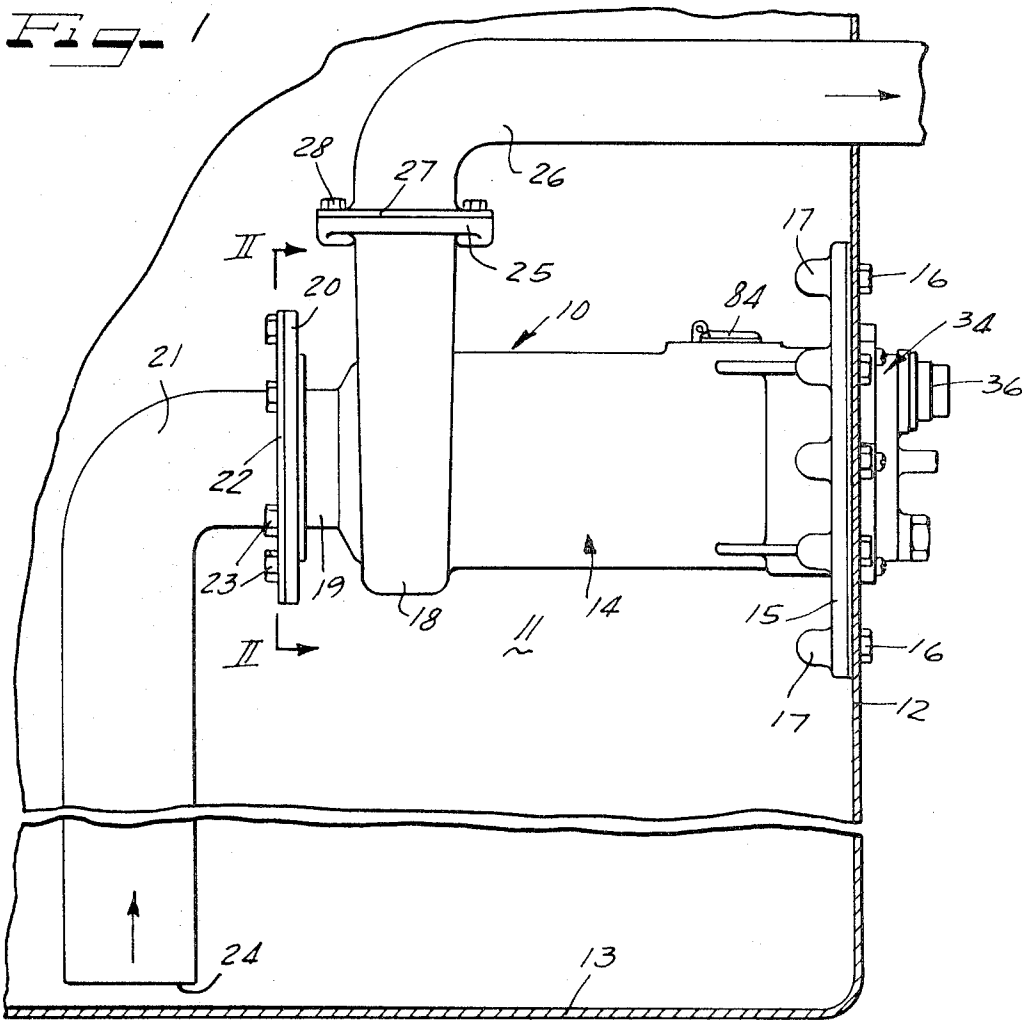
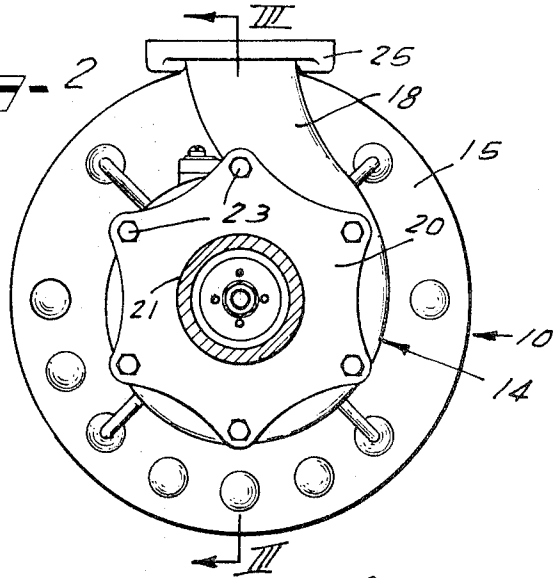


Fig. 2



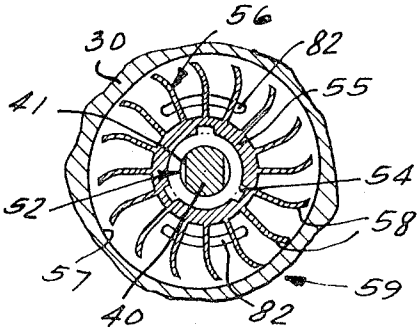


Fig. 4

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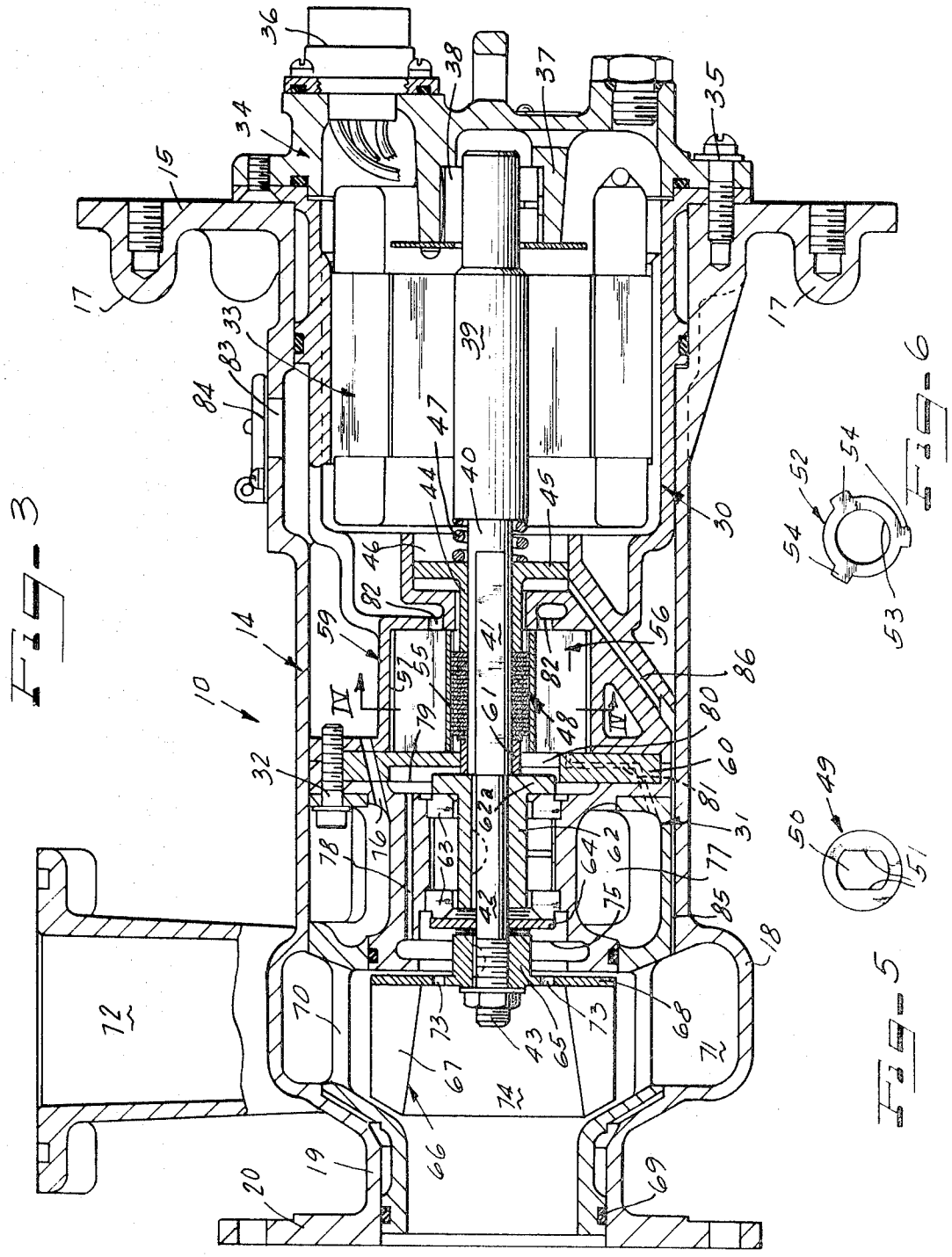


Fig. 3

Fig. 6

Fig. 5

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PUMP WITH AUTOMATIC PRIME DEVICE

FIELD OF THE INVENTION

The invention relates generally to pumps with priming devices which are disengaged or rendered inoperative whenever the pump is primed to thereby reduce the power requirements for driving the pump. The priming device includes a clutch actuated by a pressure signal that is self-induced by the pump. The invention will be hereinafter specifically described as embodied in an electric motor-driven self-priming gas-expelling centrifugal pump and motor unit submerged in a tank of liquid to be pumped such as the fuel tank of an aircraft fuel system for delivering vapor-free liquid fuel to the engine. In such aircraft installations the liquid fuel may be temporarily displaced away from the pump inlet as the aircraft is maneuvered, permitting a conventional booster pump to become gas bound or to lose its prime. The built-in priming device of this invention becomes operative under such conditions to reprime the pump.

DESCRIPTION OF THE PRIOR ART

Self-priming gas-expelling booster pumps are known in the prior art as for example in the Miles Lowell Edwards U.S. Pat. No. 3,021,974 dated May 1, 1962. In this prior art, however, the priming device for the pump is in operation whenever the pump is driven thereby wasting power during the major portion of pump operation when the pump does not need to be primed. The constantly driven priming device has forced the use of larger and heavier pump motors which are especially undesirable in aircraft installations and which drain additional power from the electrical system of the aircraft

SUMMARY OF THE INVENTION

According to this invention there is now provided mechanism for automatically disengaging the priming device of a self-priming gas-expelling pump whenever the pump is primed. The priming device has a clutch drive from the pump motor which is actuated by a pressure signal that is self-induced by the pump to overcome a spring bias on the clutch. In the priming phrase of operation a spring acts against a piston which locks clutching discs to the rotor of the priming device so that when the pump motor is energized it will drive both the priming device and the pump. When the pump is primed and developing liquid pressure in its pumping chamber the piston is actuated under the influence of this pressure to overcome the spring bias and unlock the clutching discs so that the priming pump will be disengaged. Then continued operation of the motor will be free of the load of the priming device. As long the predetermined high pressure remains in the pumping chamber, the pump will maintain the priming device in disconnected inoperative condition, but as soon as the pump loses its prime causing the pressure in the pumping chamber to drop, the spring bias will again act against the piston engaging the clutch and starting the priming device into operation for again priming the pump. The cycles will repeat each time the pump loses its prime.

A feature of the invention resides in the provision of a stack of discs to form the clutch permitting the clutch capacity to be varied by changing the number of discs without materially altering the size of the other parts and thereby making possible the use of the same parts for different prime pump requirements.

Another feature of the invention is the use of high pressure existing in the volute or pumping chamber of a centrifugal pump for controlling operation of a priming device for the pump.

It is then an object of this invention to provide a pump equipped with a priming device which is respectively placed into and out of operation whenever the pump loses and gains its prime.

A further object of this invention is to provide an electric motor-driven gas-expelling submerged booster pump unit with a built-in priming device preventing the pump from becoming gas bound and only placed in operation when the pump loses its prime.

Another object of this invention is to provide a submerged centrifugal booster pump and motor unit with a built-in hydroturbine priming pump which is disengaged from the motor as long as the centrifugal pump maintains a desired pressure in its pumping chamber.

Another specific object of this invention is to provide a self-priming centrifugal booster pump and electric motor unit with a pump pressure actuated clutch responsive to pump pressure for driving the priming pump only when the centrifugal pump loses its prime.

Another specific object of this invention is to provide a simplified clutch composed of a stack of alternate driving and driven clutch discs spring biased into driving position and unloaded by pump pressure to disconnect the rotor of a primimg pump whenever a centrifugal pump is developing a predetermined liquid pressure.

Other and further objects of this invention will become apparent to those skilled in this art from the following detailed description of the annexed sheets of drawings which, by way of a preferred example illustrate one embodiment of the invention.

BRIEF DESCRIPTIOn OF THE DRAWINGS

FIG. 1 is a fragmentary, broken, sectional view of an aircraft fuel tank with the pump and motor unit of this invention mounted on a sidewall thereof and shown in elevation;

FIG. 2 is a front end elevational view of the pump and motor unit of FIG. 1 taken along the line II–II of FIG. 1;

FIG. 3 is a longitudinal cross-sectional view of the pump and motor unit taken along the line III–III of FIG. 2;

FIG. 4 is a cross-sectional view of the hydroturbine priming pump built into the pump and motor unit taken along the line IV–IV of FIG. 3;

FIG. 5 is a plan view of a driving clutch disc for the hydroturbine pump; and

FIG. 6 is a plan view of a driven clutch disc for the hydroturbine pump.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

The reference numeral 10 designates generally a self-priming gas-expelling submerged pump and motor unit of this invention mounted horizontally in a fuel tank 11 on a tank sidewall 12 above the tank bottom wall 13.

The unit 10 has a generally cylindrical casing or housing 14 with a radial mounting flange 15 on one end thereof which is bolted to the tank sidewall 12 by means of capscrews 16 extending through the tank wall and threaded into bosses 17 around the periphery of the flange 15.

The housing 14 has a volute chamber defining portion 18 adjacent the end remote from the flange 15 and surrounding the casing. A reduced diameter throat portion 19 projects forwardly from the volute portion 18 and terminates in a radial end flange 20 of smaller diameter than the flange 15. This flange 20 mounts on elbow pipe 21 having a mounting flange 22 on the end thereof secured to the flange 20 as by capscrews 23. The pipe 21 extends downwardly in the tank 11 to terminate in an open mouth 24 close to the bottom wall of the tank.

The volute chamber defining portion 18 terminates in a flange 25 on which is bolted a second elbow pipe 26 through an end flange 27 thereon by means of capscrews 28. The pipe 26 extends through the sidewall 12 of the tank and may be sealingly coupled with this sidewall by means not shown.

Fuel from the bottom portion of the tank 13 enters the mouth 24 of the pipe 21 and is pumped by a centrifugal pumping means in the unit 10 through the chamber of the volute section 18 and then out of the tank through the pipe 26.

As shown in FIG. 3 the cylindrical housing 14 receives a motor and prime pump casing 30 through the flange end 15 thereof and this insert casing in turn has a sleeve 31 secured to the leading end thereof by means of capscrews 32. The main casing 30 houses an electric motor 33 and is closed by an end cap 34 secured to the flange 15 by means of screws 35. The end cap 34, as shown in FIG. 1, is on the outside of the tank sidewall 12 and has a socket 36 with electrical connections for energizing the motor 34. The cap 34 has a boss 37 projecting into the motor casing and providing a support for a motor shaft bearing 38. The motor shaft 39 supported at one end by the bearing 38 has a reduced diameter portion 40 with flat side faces 41 extending almost to the sleeve 31 and then is further reduced in diameter at 42 to terminate in a threaded end 43 projecting into the chamber defined by the volute portion 18. The shaft portion 41 is rotatably journaled in a sleeve 44 with a piston head 45 fitted in a cylinder 46 defined by the casing portion 30. A spring 47 bottomed on the shoulder between the shaft portions 39 and 40 acts on the piston 45 to bias the sleeve against a stack 48 of clutch elements composed of alternate clutch discs or washers 49 having apertures 50 therethrough with flat sides 51 riding on the flats 41 of the shaft and clutch discs or washers 52 with cylindrical apertures 53 freely embracing the shaft portion 40 and having radially projecting lugs 54 keyed to the surrounding hub 55 of a hydroturbine pump rotor 56 housed in a double lobe bore 57 provided by the leading end of the casing member 30. The rotor 56 has radial vanes 58, best shown in FIG 4, coacting with the bore 57 to provide a liquid ring or hydroturbine priming pump 59.

A plate 60 is clamped between the opposed flanges of the casing sections 30 and 31 by the capscrews 32. A sleeve 61 surrounding the shaft portion 40 is bottomed at one end on the stack of clutch discs 48 and on the other end by a journal thrust bearing 62 keyed to the shaft portion 42 to rotate therewith. The journal thrust bearing 62 is surrounded by the casing portion 31 is spaced relation and this portion carries carbon thrust rings 63 respectively in face-to-face engagement with a flange 62*a* on one end of the thrust bearing 62 and with a mating thrust ring 64 on the shaft portion 42 and clamped between the thrust bearing 62 and the hub 65 of a centrifugal impeller 66 keyed on the threaded end 43 of the shaft.

The impeller 66 has a ring of circumferentially spaced centrifugal impeller blades 67 depending from a shroud or radial flange 68 on the hub 65. The casing member 31 is contoured to extend through the volute portion 18 and fit in the neck 19 where it is sealed to the outer housing 14 by a seal ring 69. Circumferential slots 70 around the periphery of the casing 31 communicate the interior of the casing freely with the volute chamber 71 defined by the housing portion 18 so that fluid entering the open end of the casing 31 is acted on by the impeller blades 67 and centrifugally discharged into the impeller chamber 71 to the tangential outlet 72 which is connected with the outlet pipe 26 described above.

The impeller flange or shroud 68 is ported at 73 close to the hub 65 and these ports bleed the inlet chamber 74 surrounded by the blades 67 into a chamber 75 ahead of the thrust bearing 64. An annular reservoir 77 behind the chamber 75 provided by the casing section 31 around the thrust rings 63 is vented at the top through a passage 76 to a chamber in the housing 14 above the priming pump 59 to receive pumped fluid from the priming pump. The chamber 75 is directly ported through a passageway 78 with an annular chamber 79 which communicates with an inlet port 80 to the hydroturbine pump 59. In addition, the bottom of the reservoir 77 is bled into the hydroturbine pump by passages 81 shown in dotted lines in FIG. 3.

Thus, the pumping chamber 74 is vented inwardly of the pumping vanes 67 to the hydroturbine priming pump 59. The pump 59 in turn discharges through ports 82 into a chamber surrounding the cylinder 46 which in turn is in open communication with the reservoir 77 and an outlet opening 83 in the top of the housing 14. The opening 83 is closed by a light spring-biased flap valve 84 which when opened under the influence of pressure of fluid from the priming pump will discharge the fluid back to the interior of the tank shown in FIG. 1.

A passageway 85 is provided between the casing 31 and housing 14 from the volute chamber 71 to a passageway 86 through the casing 31 which opens into the cylinder 46 under the piston 45. The piston is thus exposed to the pressure in the volute 71.

It will be understood that the liquid ring or hydroturbine pump 56 is effective to maintain a ring of liquid in the pump bore 57 under the influence of centrifugal force from the hydroturbine vanes 58 and fluid will be drawn into the pump adjacent the axial central portion of the pump bore through the inlet port 80 to be discharged out of the other end of the pump through the ports 82. The rotating liquid ring creates a suction chamber in the axial central portion of the pump and this suction is developed by pulsing the liquid ring radially as it revolves through the lobes of the pump bore. The hydroturbine pump thus acts as a vacuum pump effective to draw gases and vapors from the central portion of the pumping chamber of the centrifugal pump.

OPERATION

When the centrifugal pump is primed and operating, liquid fuel will be drawn from the bottom portion of the tank 13 through the inlet pipe 21 and then discharged through the outlet pipe 26. The liquid in the volute chamber 71 will be under pressure and this pressure is vented to the piston 45 for overcoming the spring bias 47 to slide the sleeve 44 to the right when viewed in FIG. 3 thereby taking the load off of the stack 48. The driven discs 49 on the shaft portion 40 are thus free to slip relative to the driving discs 52 and the rotor 56 of the hydroturbine pump will be idle.

Whenever the centrifugal pump loses its prime or becomes gas-bound, pressure in the volute chamber 71 will drop whereupon the spring 47 will load the stack of discs 48 causing the rotor 56 to be driven by the electric motor 33 with the impeller 66 of the centrifugal pump. Driving of the hydroturbine impeller 56 draws gas or vapor from the pumping chamber 74 of the centrifugal pump through the ports 73, chamber 75, passageway 78, and chamber 79 into the inlet port 80 of the hydroturbine pump 59. The gases and vapors will be discharged from the pump through the outlet 83.

In order to maintain the hydroturbine pump under prime, liquid from the pumping chamber is collected in the reservoir 77 and bleeds to the hydroturbine pump through the passageways 81 if needed. The expelling of gases and vapors from the pumping chamber 74 by the hydroturbine pump will draw liquid into the pumping chamber 74 permitting the centrifugal impeller blades 67 to act on the liquid and again build up a pressure in the volute chamber 71 sufficient to overcome the spring bias 47 and declutch the rotor 56.

As shown in FIG. 6, the driven clutch members 52 are keyed at 54 into the hub of the hydroturbine pump rotor 56 while the flats 41 on the shaft portion 40 drives the driving clutch members 49. The stack 48 of these alternating driving elements 49 and driven elements 52 can be any desired height to give the driving couple that is desired for the hydroturbine rotor. Likewise, the spring 47 can be varied to provide the desired spring bias on this stack 48.

From the above descriptions it will be therefore be understood that this invention provides a self-priming gas-expelling centrifugal pump and electric motor unit with a built-in hydroturbine priming pump which is automatically rendered inoperative whenever the centrifugal pump is primed and which is automatically placed into operation whenever this centrifugal pump loses its prime.

Any buildup of gases or vapors in the centrifugal pump sufficient to cause the pump to lose its prime will be drawn out of the centrifugal pump under the suction effect of the hydroturbine priming pump.

Although minor modifications might be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.

I claim:

1. A submerged pump and electric motor unit especially adapted for aircraft fuel tanks which comprises a housing having a mounting flange at one end thereof for attachment to the sidewall of a fuel tank and having an inlet flange on the other end thereof for attachment to an inlet pipe in the fuel tank, said housing defining a centrifugal pump volute chamber adjacent the inlet pipe mounting flange, a casing in said housing having an open end adjacent the mounting flange, and end cap attached to the housing closing the open end of the casing and providing a shaft bearing support, a motor in the casing adjacent said cap, a motor shaft having one end supported from said cap, said casing providing a piston chamber, a hydroturbine pump chamber, a bearing chamber, and a pump inlet chamber communicating with the volute chamber of the housing, said motor shaft extending through said chambers, a centrifugal impeller in said pump inlet chamber mounted on said motor shaft, thrust bearings in said bearing chamber surrounding said shaft, a hydroturbine pump rotor in said hydroturbine pump chamber, a clutch connecting said rotor with said motor shaft, a piston in said piston chamber, a spring biasing said piston for loading said clutch to couple the motor shaft with the hydroturbine rotor, passageways connecting the volute chamber with the cylinder chamber to act on said piston against the bias of said spring for declutching the hydroturbine rotor from the motor shaft, passageways connecting the pump inlet chamber with the hydroturbine pump chamber, and an outlet in said housing vented to said hydroturbine pump chamber for releasing gases and vapors from the hydroturbine pump back to the fuel tank whereby said hydroturbine pump will draw gases and vapors from the pump inlet chamber and will remain operative only when pressure in the volute chamber is insufficient to overcome the spring bias on the clutch.

2. A submerged gas-expelling centrifugal pump and motor unit adapted for aircraft fuel tank installation which comprises a housing having a first end flange for mounting the unit in a tank, a second opposite end flange for mounting an inlet pipe in the tank and a volute portion with a tangential outlet terminating in a side flange between said first and second flanges for mounting an outlet pipe, an electric motor in said housing adjacent said first end flange, a centrifugal pump impeller in said housing adjacent said second end flange and discharging into said volute portion, a liquid ring priming pump in said housing between said electric motor and said centrifugal pump impeller, a clutch selectively coupling the liquid ring pump with said motor, means venting the central portion of the area of the housing containing the centrifugal pump impeller with said liquid ring pump to draw gases and vapor from said portion into the liquid ring pump, said housing having a discharge passage from the liquid ring pump to an outlet for feeding the gases and vapors back to the tank in which the housing is mounted, and means actuated by pressure in the volute portion for releasing said clutch whenever liquid is being pumped by said impeller through the volute portion whereby said liquid ring pump will only be driven by said motor when the centrifugal pump loses it prime.

3. The pump of claim 2 including a stack of clutch places coupling the liquid ring pump to the motor and a spring-biased piston loading said stack and actuated by centrifugal pump pressure against the spring bias for unloading said stack.

4. An electric motor-driven centrifugal pump unit which comprises a casing housing an electric motor, a centrifugal pump, and a liquid ring priming pump having an inlet and an outlet in the casing, means in the casing venting the centrifugal pump to the priming pump inlet for drawing gases and vapors from the centrifugal pump, means in the casing venting liquid from the priming pump outlet back to the priming pump inlet to prime the priming pump, an outlet in said casing for gases and vapors expelled from said priming pump, and clutch actuated by pressure from the centrifugal pump for disconnecting the priming pump from the electric motor upon development of a predetermined pressure by said centrifugal pump whereby the priming pump will be actuated only when the centrifugal pump loses its prime.

5. The pump of claim 4 including a clutch composed of a stack of alternating driving and driven discs.

6. The combination of claim 4 wherein a liquid-collecting reservoir is provided between the centrifugal pump and the priming pump for maintaining liquid in the priming pump.

7. In combination a centrifugal pump having a pumping chamber discharging into a surrounding volute, a liquid ring priming pump having an inlet vented to said pumping chamber and effective to draw gases and vapors therefrom and an outlet communicating with said inlet, a vent for releasing gases and vapors from said outlet, a drive shaft, a centrifugal impeller in said pumping chamber driven by said shaft, a priming pump rotor receiving said shaft therethrough, a stack of alternating discs coupled to said shaft and to said priming pump rotor, means loading said stack to cause the discs coupled to the shaft to drive the discs coupled to the rotor, and means sensitive to pressure in the volute chamber for unloading said stack to declutch the priming pump rotor whenever the centrifugal pump is operating under primed conditions.

8. The combination of claim 7 wherein the driving discs of the clutch are internally keyed to the shaft and wherein the driven discs of the clutch are externally keyed to the priming pump rotor.

9. The combination of claim 7 including a liquid reservoir between the centrifugal pump chamber and the priming pump for maintaining liquid in the priming pump.

10. The combination of claim 7 wherein the priming pump is a hydroturbine pump and a reservoir is provided for supplying liquid to the hydroturbine pump to maintain a liquid ring therein.

11. A gas-expelling centrifugal pump and liquid ring priming pump said pump inlet connecting for aircraft fuel tank installation which comprises a housing providing a central inlet, a surrounding volute chamber, a liquid ring pump chamber behind the inlet chamber, a clutch chamber behind the liquid ring pump chamber, and an electric motor chamber behind the clutch chamber, a centrifugal pump impeller in said pump inlet having a ring of vanes discharging centrifugally into the volute chamber, an electric motor in said motor chamber having a shaft extending through the clutch and liquid ring pump chambers into the pump inlet, means mounting the centrifugal pump impeller on said shaft in said pump inlet, ports in the central portion of said pump inlet connecting the central portion of the pump impeller inwardly from the pumping vanes thereon with the liquid ring pump chamber, a liquid ring pump impeller in said liquid ring pump chamber receiving gases and vapors from said ports, a clutch in said clutch chamber connecting said liquid ring pump impeller with said shaft, means actuated by pressure in said volute chamber declutching said liquid ring pump impeller from said shaft, said housing having a chamber surrounding said liquid ring pump communicating with the inlet and outlet of said liquid ring pump whereby liquid discharged from the ring pump may flow to the inlet of the liquid ring pump for priming the pump, and said housing having a gas and vapor outlet communicating with said chamber surrounding the liquid ring pump chamber for releasing gases and vapors from liquid discharged by the liquid ring pump whereby gases and vapors will be drawn from the centrifugal pump inlet by said liquid ring pump to prevent the centrifugal pump impeller from becoming gas bound, the liquid ring pump will be primed liquid as needed from liquid discharged therefrom and the clutch will couple the liquid ring pump impeller whenever the centrifugal pump pressure is established.