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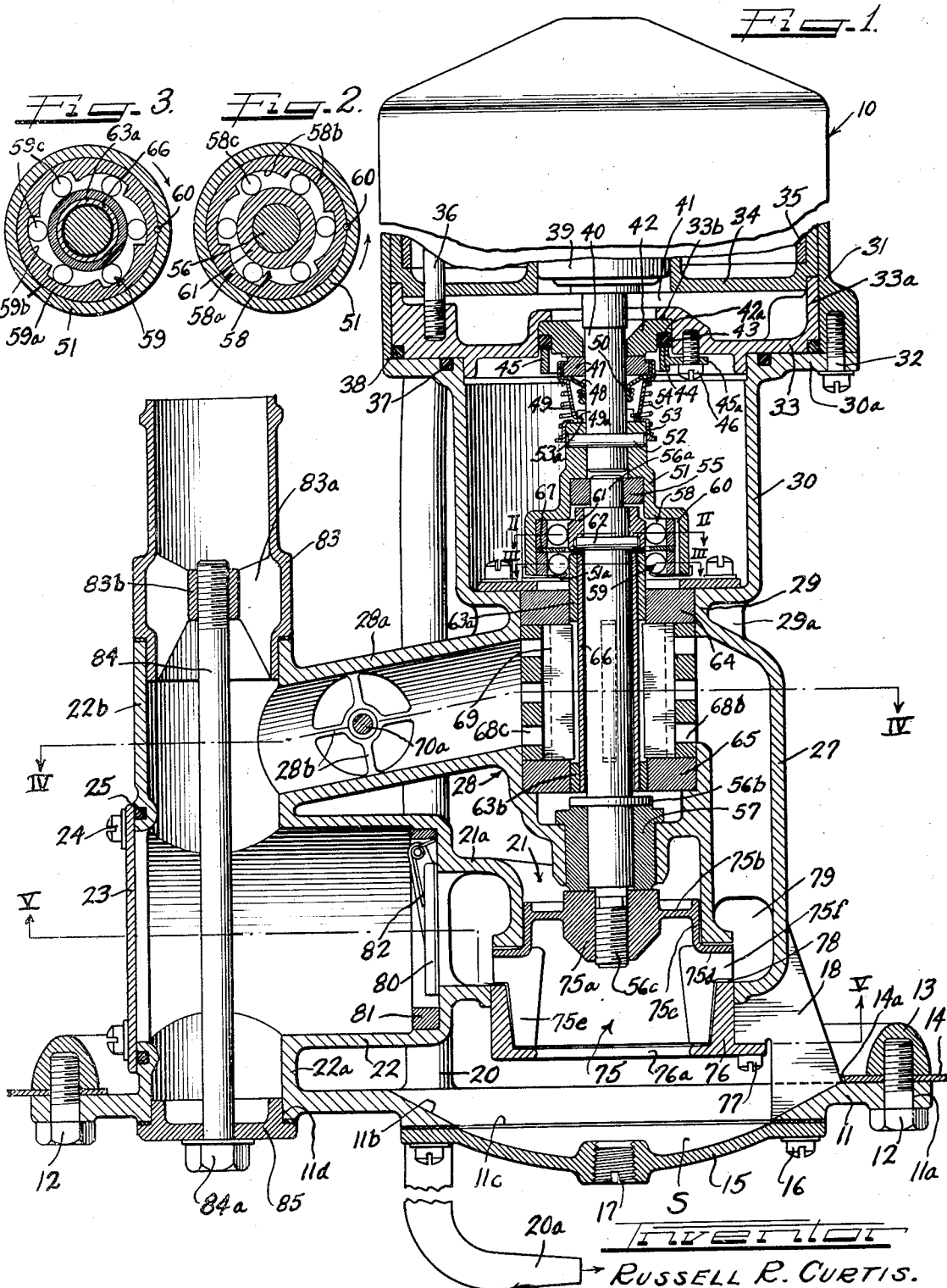
R. R. CURTIS

2,390,204

COMBINATION BOOSTER PUMP

Filed May 12, 1944

4 Sheets-Sheet 1



Charles Hill

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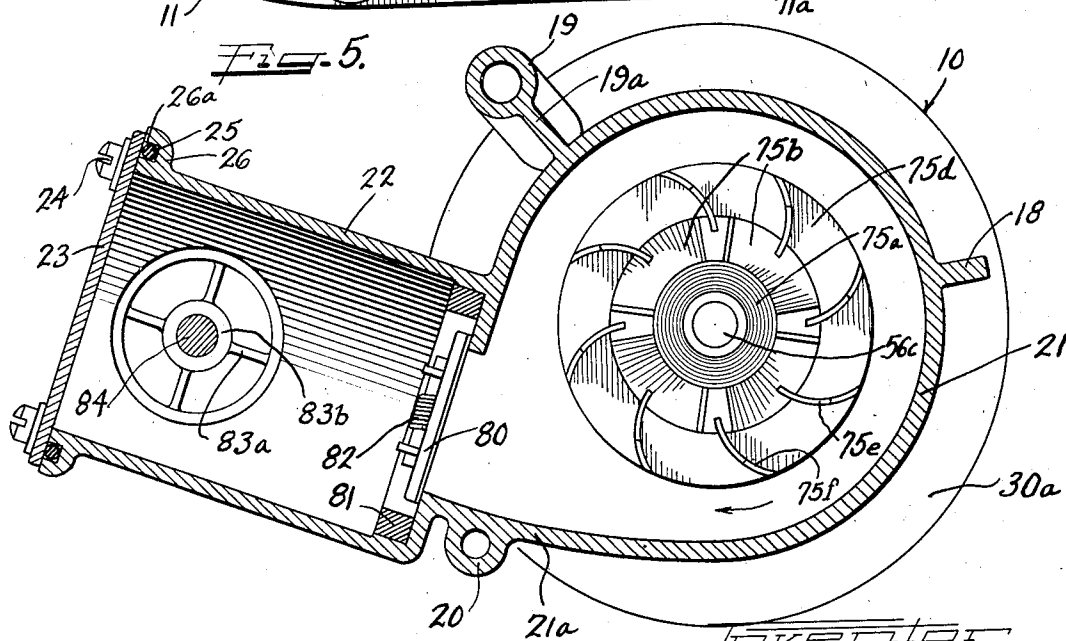
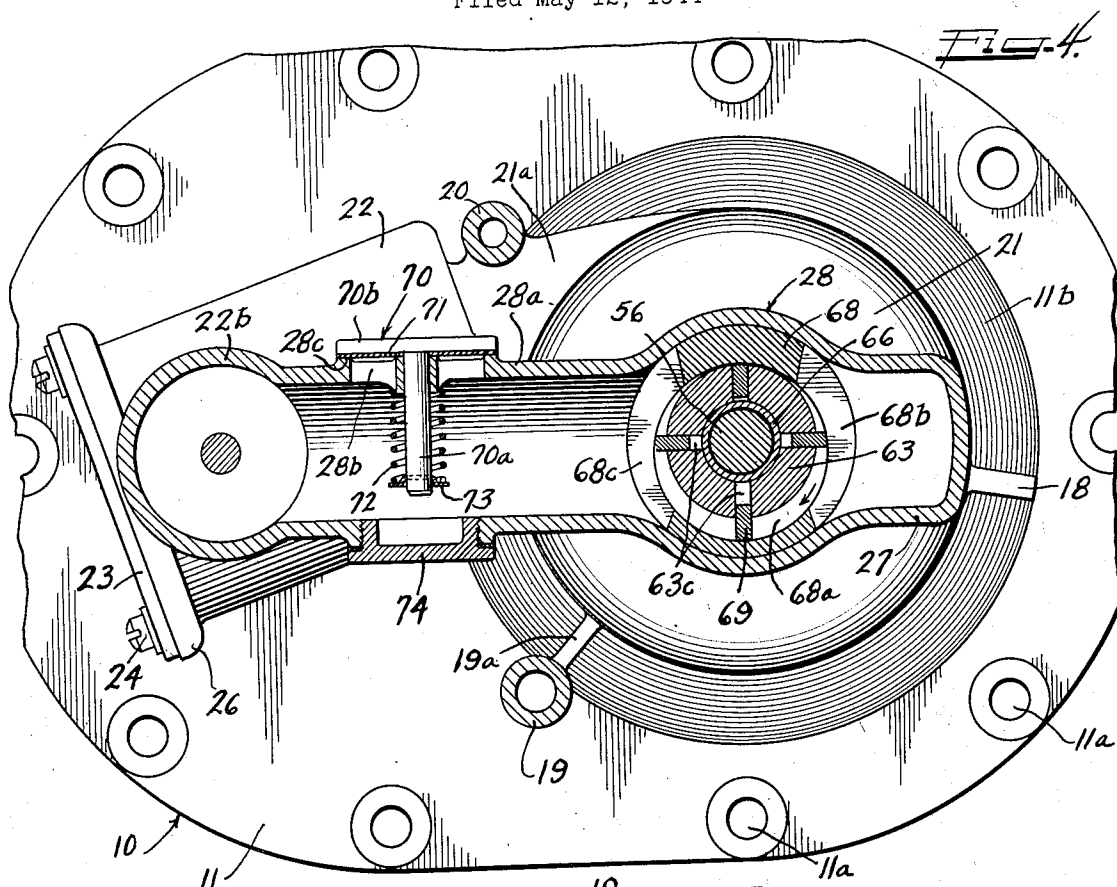
R. R. CURTIS

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COMBINATION BOOSTER PUMP

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RUSSELL R. CURTIS.

Charles H. Hill **Att. 5.**

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R. R. CURTIS

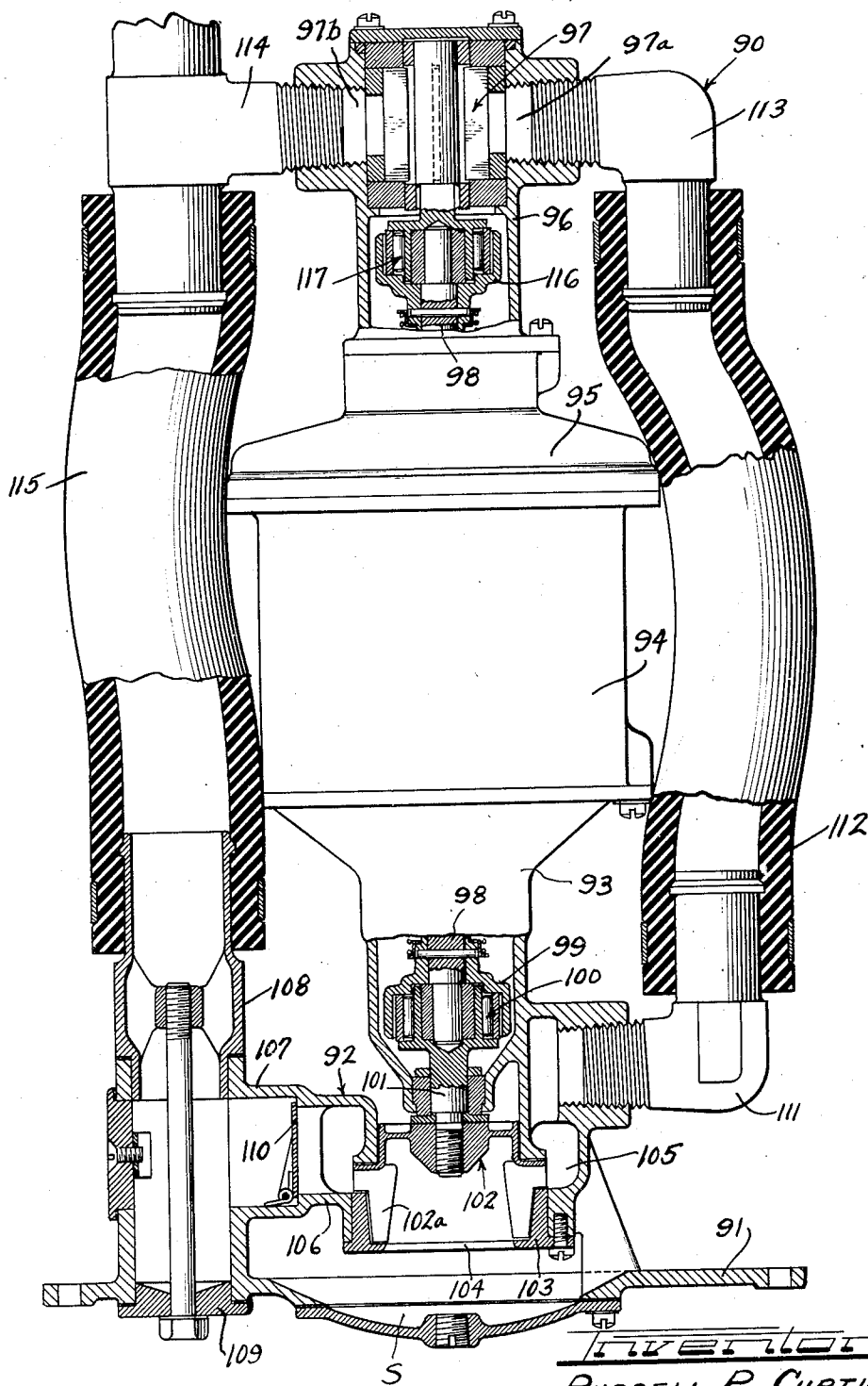
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Fig. 6.



Charles E. Hill Att. 5.

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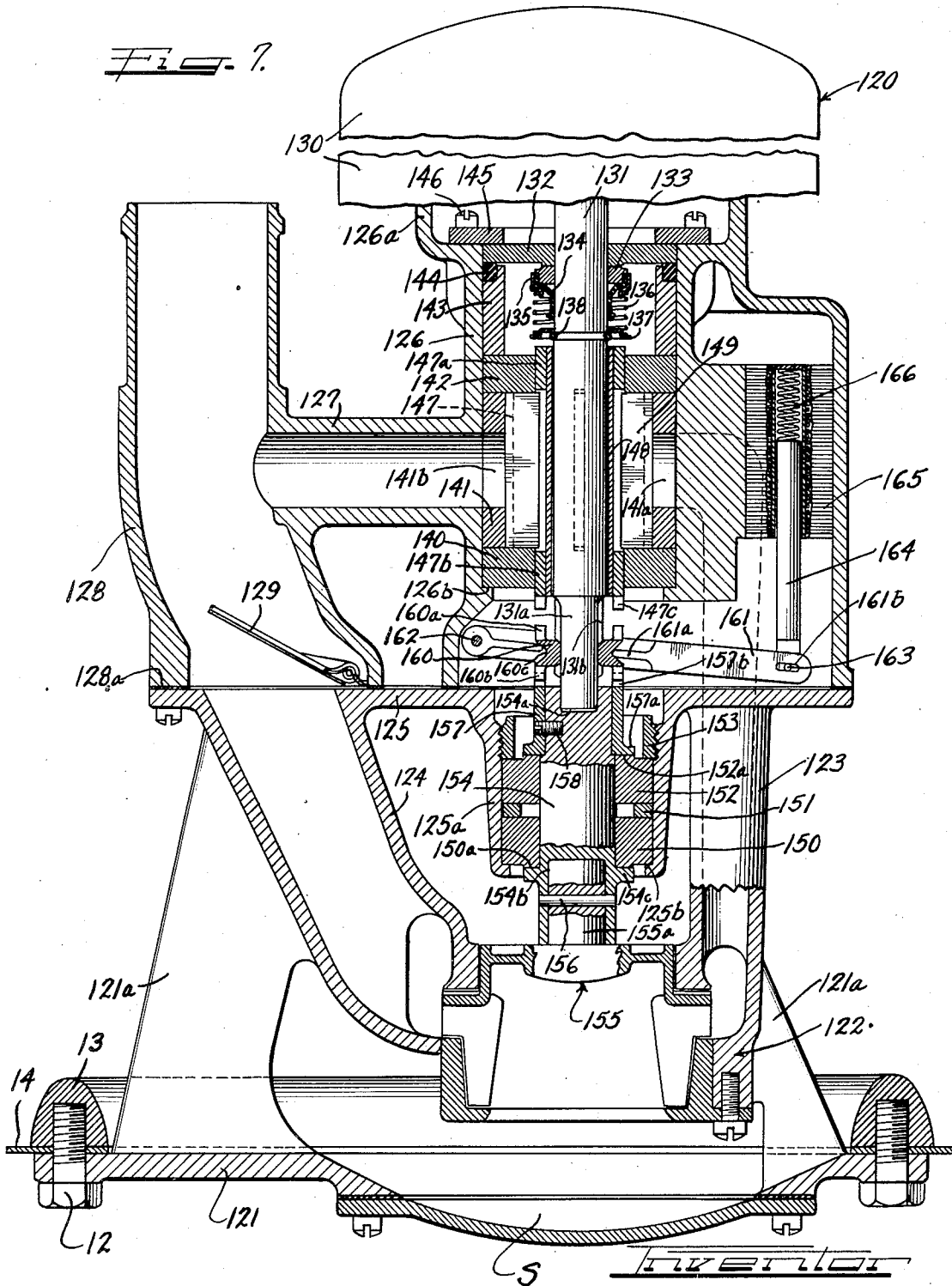
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UNITED STATES PATENT OFFICE

2,390,204

COMBINATION BOOSTER PUMP

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16 Claims. (Cl. 103—11)

This invention relates to multiple pump assemblies and specifically deals with assemblies having a single prime mover in selective driving relation with a plurality of pumps.

The invention will hereinafter be specifically described as embodied in electric motor-driven submerged type pumps for airplane fuel systems, but it should be understood that the principles of this invention are broadly applicable to multiple pump assemblies, and especially assemblies having a plurality of pumps selectively driven by a single motor.

In airplane fuel systems it is desirable to pressure fuel from the supply tank into the fuel line feeding the engine-driven fuel pump to insure an ample feed to the engine-driven fuel pump especially in installations where the fuel tanks are at lower levels than the intakes of the fuel pumps. Since, at high altitudes, the highly volatile gasoline in the fuel tanks tends to gasify and form bubbles of gas and vapor in the fuel lines, it is also desirable to provide a pump which rejects all non-liquid material and only pressures fully liquid material into the fuel line. Centrifugal type booster pumps have been successfully used for bubble separation, and have been equipped with agitators to actually beat out bubbles of gas and vapor from the liquid fuel. Frequently, however, as, for example, at low altitudes, agitation of the fuel to beat out bubbles is not necessary and it is desirable to pressure fuel from the tanks into the fuel line at relatively high pressures for feeding fuel to the engine when the engine driven fuel pump is not operating. Thus, for example, in starting an airplane engine, the engine-driven fuel pump is idle, or turning only quite slowly, but the engine, to be quickly started, should receive highly pressured fuel. Also, if for any reason the engine-driven fuel pump should fail, highly pressured fuel feed is required for maintenance of operation.

Therefore, according to this invention, the combination pump unit is equipped with a positive-displacement type pump as well as a centrifugal bubble-separation type pump. Either pump can be selectively driven from the same prime mover.

The combination pump units of this invention can be equipped with reversible motors which, when operated in one direction drive the positive-displacement pump and, when operated in the reverse direction, drive the centrifugal type bubble-separating pump. Reversed roller or ball clutches can be interposed in the drive from the motor to each pump so that each pump will be selectively driven, depending upon the direction of rotation of the motor. The reversing motor drive can be replaced with a non-reversing motor drive and the pumps can be selectively operated by means of a controlled clutch interposed in the drive be-

tween the pumps. This clutch can conveniently be operated by a solenoid.

It is, then, an object of this invention to provide a single unit for separation of bubbles in airplane fuel systems and for pumping airplane fuel without effecting bubble separation.

Another object of the invention is to provide a combination booster pump unit adapted to be submerged in an airplane fuel tank and containing a centrifugal type bubble-separating pump and a positive-displacement type pump selectively driven by a single electric motor.

A still further object of the invention is to provide a multi-pump and motor unit equipped with an electric motor, a rotary vane type pump, a centrifugal type pump, and means selectively connecting each of said pumps for corotation with said motor.

A further object of the invention is to provide a submerged combination type booster pump adapted to be mounted on the bottom wall of a fuel tank and project into the fuel tank for receiving fuel directly therefrom to selectively pump this fuel by means of a centrifugal type pump, or by means of a rotary vane type pump.

Another object of the invention is to provide a pump and motor unit having a single inlet, a single outlet, and a plurality of pumps each connecting the inlet with the outlet.

Another object of the invention is to provide a multi-pump-electric motor unit having a centrifugal type pump arranged to directly receive liquid material from a pond and propel this liquid material to an outlet, and also having a rotary vane type positive-displacement pump receiving liquid from the centrifugal type pump and discharging the liquid to the outlet together with a valve which seals off communication between the outlet and the centrifugal pump whenever pressure in the outlet is greater than pressure in the centrifugal pump.

A specific object of the invention is to provide a multi-pump-reversible electric motor unit having reversed one-way drive clutches between each pump and the motor.

Another specific object of the invention is to provide a multi-pump-electric motor unit having a solenoid-operated clutch controlling driving of the pumps from the motor.

A still further object of the invention is to provide a submerged type booster pump assembly especially adapted for airplane fuel systems which assembly has a scavenging device for discharging liquid leaking past the seal thereof.

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 several embodiments of the invention,

On the drawings:

Figure 1 is a broken side elevational view, with parts in vertical cross section, of a combination booster pump according to this invention mounted on the bottom wall of a tank and projecting into the tank to be submerged therein.

Figure 2 is a transverse horizontal cross-sectional view taken along the line II—II of Figure 1 illustrating the centrifugal pump driving ball clutch.

Figure 3 is a transverse horizontal cross-sectional view taken along the line III—III of Figure 1 illustrating the positive-displacement pump driving ball clutch.

Figure 4 is a transverse horizontal cross-sectional view taken along the line IV—IV of Figure 1.

Figure 5 is a horizontal transverse cross-sectional view taken along the broken line V—V of Figure 1.

Figure 6 is a side elevational view, with parts in vertical cross section, of a modified combination booster pump according to this invention.

Figure 7 is a broken side elevational view, with parts in vertical cross section, of another modified embodiment of combination booster pump according to this invention.

As shown on the drawings:

In Figures 1, 4 and 5, the reference numeral 10 designates generally a combination multi-pump-electric motor unit according to this invention. The unit 10 has a base plate 11 with apertured mounting bosses 11a around the periphery thereof receiving cap screws 12 therethrough. The cap screws 12, as shown in Figure 1, are threaded into a mounting ring 13 on the bottom wall 14 of a tank around an aperture 14a in the bottom wall. The screws 12 pass through the tank wall around the aperture and a gasket (not shown) can be interposed between the base 11 and the tank wall to prevent leakage.

The base 11 has a tapered mouth 11b converging to a large opening 11c at a level below the tank wall 14. This opening 11c is closed by a concave cap 15 bolted to the base 11 as by means of cap screws 16. The cap 15 has a central boss portion defining a drain outlet closed by a plug 17.

The base 11 has an opening 11d therethrough in spaced lateral relation from the opening 11c for a purpose to be more fully hereinafter described.

Three spaced upstanding portions including a leg 18, a wire conduit tube 19, and a leakage drain tube 20 are provided at spaced intervals around the tapered mouth 11b of the base 11 and support a centrifugal type pump casing 21 defining a volute chamber. The pump casing 21 has a peripheral discharge conduit-defining portion 21a integral with the tube 20 connected to and integral with an enlarged cylindrical casing 22 projecting laterally from the casing 21 and having an integral depending boss portion 22a integrally connected with the base 11 around the aperture 11d. The casing 22 has an outer end portion closed by a removable cover 23 secured thereon as by means of cap screws 24 and sealed therewith by means of an O ring 25 carried in the groove 26a of a flange 26 around the casing 22.

The casing 22 also has an upstanding boss portion 22b.

As shown in Figures 4 and 5, a flange 19a is provided to connect the tube or pipe 19 with the casing 21.

An upstanding conduit-defining portion 27 in-

tegral with the casing 21 carries, in spaced relation above the casing 21, a casing 28 for a rotary vane type pump. The casing 28 has a discharge conduit portion 28a intersecting and integrally connected with the upstanding boss 22b of the casing 22. The rotary vane type pump casing 28 is thus supported from the base 11 by both the upstanding conduit 27 on the casing 21 and the upstanding boss 22b on the casing 22.

A reduced neck portion 29 projects upwardly from the top of the casing 28 and is integral with the bottom wall of a cup-shaped casing 30 having an outturned flange 30a around the open top thereof. Ribs such as 29a can be provided at spaced intervals around the neck 29 to reinforce the neck.

A motor casing 31 is mounted on top of the flange 30a and secured to the flange as by means of cap screws 32.

As shown in Figure 1, a support ring 33 is mounted on the flange 30a and has an upstanding flange portion 33a snugly seated in the casing 31 carrying an end cap 34 of motor structure which includes a side wall 35 carrying the field of an electric motor. Through bolts such as 36 extend through the ring 34 and are threaded into the ring 33 to hold the motor assembly together.

An O ring 37 is seated in a groove of the flange 30a to act on the ring 33 and prevent leakage from the casing 30 into the motor casing. A second O ring 38 is seated in a groove cut around the periphery of the ring 33 acting on the flange 30a and also on the casing 31 to prevent leakage into the motor compartment.

The ring 34 carries a bearing 39 rotatably supporting the motor shaft 40. This motor shaft 40 carries the armature of the motor.

As shown in Figure 1, the lower end of the tube 20 has a nozzle-like extremity 20a projecting into the slip stream beneath the tank 14 and facing downstream so as to cause a suction pull for scavenging material out of the chamber 41 between the rings 33 and 34. Thus any liquid leaking past the seals into chamber 41 will be drained out of the unit.

The ring 33 has a thickened central boss portion receiving a stationary seal ring 42 against an upper shoulder 33b thereof. This stationary seal ring 42 has a peripheral groove 42a around the under face thereof receiving a resilient gasket 43 covered by a fiber washer 44. A retainer collar 45 having radially extending outturned ears such as 45a is secured to the boss portion as by means of cap screws such as 46 and acts on the fiber washer 44 to cause the resilient washer 43 to sealingly connect the seal ring 40 with the boss.

The motor shaft 40 projects freely through the stationary seal ring 42 and also through a rotating seal ring 47 having a top end face in sliding sealing engagement with the bottom end face of the stationary washer 42. A rubber sleeve 48 embraces the rotating seal ring 47 and is held thereon by means of a metal cup 49 spun over a shoulder of the rotating seal ring 47. The sleeve 48 is secured to the shaft 40 as by means of clamping wires 50.

A coupling member 51 depends from the motor shaft 40 in the casing 33 and is secured to the shaft by means of a pin 52. A retainer 53 is seated on top of this coupling 51 and bottoms a coil spring 54 surrounding the cap 49 and acting on a shoulder of the cap to urge the cap and seal ring 48 against the stationary seal ring 42. The cap 49 has inturned tangs 49a engaging up-

standing tabs 53a on the retainer 53 so that the cap will be driven from the coupling 51 to insure rotation of the seal member 47 with the shaft 40. The retainer 53 has the skirt or side wall thereof overlying the ends of the pin 52 to prevent inadvertent removal of the pin.

The coupling 51 carries a plain bearing 55 rotatably supporting the reduced upper end 56a of a pump shaft 56. This pump shaft 56 extends from the casing 30 containing the coupling 51 through the casing 28 into the open central portion of the casing 21. The shaft has a collar 56b riding on a plain bearing 57 carried in the lower end of the casing 28. A reduced-diameter threaded end portion 56c on the lower end of the shaft 56 projects beyond the bearing 57.

The coupling 51 has superimposed ball clutches 58 and 59 therein. The clutch 58 includes an outer clutch ring 58a keyed by means of key 60 to the coupling 51 and having cam tracks 58b around the inner periphery thereof for balls 58c. When the coupling 51 is driven by the motor shaft 40 in a counterclockwise direction, the cam tracks 58b will act on the balls 58c to wedge the balls into driving engagement with a collar 61 pinned onto the pump shaft 56 as by means of a pin 62. Thus, counterclockwise rotation of the motor shaft 40 will cause the clutch 58 to drive the pump shaft 56.

The clutch 59 has an outer clutch ring 59a keyed by means of the same key 60 to the coupling 51 and having cam tracks 59b for the balls 59c. Clockwise rotation of the coupling 51 by the motor shaft 40 drives the clutch ring 59a in a clockwise direction and the cam tracks 59b wedge the balls 59c against the top hub 63a of a pump rotor 63. The rotor 63 includes a bottom hub 63b. The hubs 63a and 63b of the rotor are rotatably mounted in plain bearings 64 and 65 carried by the casing 28. A tube 66 loosely fitting around the shaft 56 permits free rotation of the shaft within the rotor.

Clockwise rotation of the motor shaft 40 will thus cause the ball clutch 59 to engage the hub 63a of the rotor 63 and drive this rotor. Clockwise rotation of the ball clutch 58, on the other hand, will free the clutch from the collar 61 and the pump shaft 56 will not be driven. When the motor shaft 40 is driven in a counterclockwise direction the ball clutch 58 drives the pump shaft 56 and this counterclockwise rotation frees the ball clutch 59 from engagement with the pump rotor 63. Therefore, reversed rotations of the motor shaft 40 will selectively drive the pump shaft 56 or the pump rotor 63.

The clutches 58 and 59 are held in the coupling 51 by means of a cover 51a on the coupling and are separated from each other by means of a partition washer 67.

The casing 28, as best shown in Figure 4, has a pump liner 68 press-fitted therein and defining a pump chamber 68a with inlet ports 68b communicating with the passageway provided by the conduit portion 27, and outlet ports 68c communicating with the passageway provided by the conduit portion 28a. The rotor 63 is eccentrically mounted in the liner 68 and has radial slots 63c slidably supporting pump vanes 69 acting on the inner wall of the liner 68.

When the motor shaft 40 is driven in a clockwise direction the rotor 63 will be driven to cause the vanes 69 to pump liquid from conduit portion 27 into the conduit portion 28a. The conduit portion 28a has a relief valve associated therewith adapted to open automatically under

abnormal pressures and discharge materials in the conduit 28a back to the interior of the tank. As shown in Figures 1 and 4, a spider 28b is formed in a side wall of the conduit 28a and provides a central boss in which the stem 70a of a relief valve 70 slides. This valve 70 has a head 70b on the outside of conduit 28a acting on a seat 28c formed on the outer face of the conduit. Facing material 71 may be carried by the head 70 to act on the seat and provide a seal. A coil spring 72 surrounds the valve stem 70a and is held under compression between the spider 28b and a retainer 73 carried by the valve stem. The spring 72 is effective to urge the valve head 70b against the seat 28c. A plug 74 is threaded in the conduit 28a opposite the spider 28b to give access to the interior of the conduit for mounting the spring on the stem 70a.

The casing 21 has a central opening there-through and a volute chamber 79 surrounds this central opening. An impeller 75 has a central boss portion 75a secured on the threaded end 56c of the shaft 56. Vanes 75b extend radially from the boss portion 75a in spaced relation around the boss portion as shown in Figure 5. These vanes 75b carry a cylindrical collar 75c in spaced radial relation outwardly from the boss portion 75a. This collar 75c has an outturned flange 75d from which depends a plurality of curved impeller vanes 75e in spaced peripheral relationship. These impeller vanes 75e have outer edges in close operating clearance relation with an inlet ring 76 secured in the bottom end of the casing 21 as by means of cap screws 77. This inlet ring 76 defines an opening 76a above the sump S defined by the tapered mouth 11b and concave closure cap 15 on the base 11.

The vanes 75e have inner edges converging from aligned relationship with the wall defining the opening 76a into spaced relation beneath the vanes 75b. The outer edges of the vanes 75e, as explained above, have close operating clearance with the inlet ring 76 and have radially extending portions 75f projecting into an annular opening 78 of the volute chamber 79 provided by the casing 21. These vanes 75e and vane portions 75f are effective, when rotated, to centrifugally discharge liquid from the opening 76a into and through the volute chamber 79 to the conduit 21a and casing 22.

Flap valve 80 is pivotally mounted on a ring 81 seated in the casing 22 around the mouth of the conduit 21a. A weak spring 82 acts on the valve 80 to urge the same into position for closing the mouth of the conduit 21a.

When the impeller 75 is driven, pressure of liquid in the volute chamber 79 will be sufficient to open the flap valve 80 and discharge the liquid under pressure into the casing 22. This casing 22 communicates with the fuel line (not shown) to the engine-driven fuel pump and, for this purpose, has a conduit fitting 83 mounted on the upper end of the boss 22b. This conduit fitting has a spider 83a therein providing a threaded boss 83b receiving, in threaded relation, a bolt 84 passed through a cap 85 closing the opening 11d in the base 11. The bolt 84 has a head 84a bottoming the cap 85. The fitting 83 is interchangeable with the cap 85 so that liquids from the casing 22 can be discharged to a conduit inside the tank or a conduit outside of the tank, as desired.

When the motor is operated to drive the motor shaft 40 in a counterclockwise direction the ball clutch 58 will drive the shaft 56 to rotate

the impeller 75. Counterclockwise movement of the coupling 51 will disengage the ball clutch 59 from the rotor hub 63a. The impeller 75 is effective to centrifugally discharge liquid from the sump S through the volute chamber 79 into the casing 22 for feeding under pressure to the feed conduit supplying the engine-driven fuel pump (not shown). At the same time, the vanes 75e, being radially outward from a central open space in the impeller 75, create a centrifugal separation of liquid from gases and vapors. The fully liquid material, being heavier than the gases and vapors, will be thrown outwardly by centrifugal force, while the lighter gases and vapors will rise through the center of the impeller to be discharged by the vanes 75b back into the pond of liquid in the tank. Therefore, the impeller acts as a separator and liberates bubbles of gas and vapor from fully liquid material, returning the bubbles to the tank and only pumping the fully liquid material.

Liquid under pressure in the casing 22 cannot flow back through the conduits 28a and 27 into the volute chamber 79 because the positive-displacement pump in the casing 28 is inactive when the impeller is being driven, and the rotor and vanes of this pump effectively seal off the conduits 27 and 28a.

When the motor is driven in a clockwise direction, the coupling 51 releases the ball clutch 58 from driving engagement with the shaft 56 and engages the ball clutch 59 in driving engagement with the rotor hub 63a to operate the positive-displacement pump. This pump receives liquids from the tank through the pump opening 76a and through the openings between the vanes 75b. The liquid flows from the volute chamber 79 through the conduit 27 to the inlet 68b of the positive-displacement pump. The pump will pressure the liquid from the inlet thru the outlet 68c into the conduit 28a. Since the conduit 28a communicates with the boss 22b and with casing 22, liquid will be maintained in this casing 22 under pressure. This pressure will hold the flap valve 80 in closed position so that the liquid is not recirculated back to the interior of the tank unless it is under pressure sufficient to open the relief valve 70.

Since the entire assembly 10 is submerged in the tank, and since it is desirable to seal the motor compartment from the fuel in the tank and from the fuel in the pump, the seal arrangement above described has been provided on the motor shaft 40, and the sealing gaskets have been provided for the motor casing.

From the above descriptions it will be understood that the unit 10 is readily mounted in a fuel tank and is preferably suspended from the bottom wall of the tank. The unit 10 includes a centrifugal pump which is effective to separate gases and vapor from liquid fuel in the tank returning the separated vapors to the tank and pressuring only the fully liquid fuel into the fuel line. This pump is driven when the motor is actuated in one direction. A second pump of the positive-displacement type is driven when the same motor is actuated in the reverse direction. The positive-displacement pump is adapted to pressure liquids received from the tank through the inlet of the centrifugal pump. The positive-displacement pump does not include the vapor-separating feature of the centrifugal pump, but is adapted to deliver fuel at higher pressures without substantial agitation of the fuel. The positive-displacement pump is useful at low alti-

tudes, and especially when starting the engine or when the engine-driven fuel pump is inoperative. The centrifugal pump is useful at higher altitudes to prevent vapor lock in the fuel system. The positive-displacement pump develops higher pressures than the centrifugal pump but has lower pumping capacity than the centrifugal pump. Because of the very high pressures required for starting and emergency duties, the positive displacement pump has been made quite small to minimize power requirements and this power requirement is balanced with the power requirements of the centrifugal pump when operated at high delivery rates and low pressures.

In the embodiment shown in Figure 6, a pump and motor unit 90 has a base 91 similar to the base 11 described in Figures 1 to 5 adapted to be mounted on the bottom of an airplane fuel tank. The base 91 supports a centrifugal type pump casing 92 in spaced relation thereabove, and this casing 92 has an upwardly projecting head portion 93 forming a bottom end cap for a motor casing 94. The motor casing 94 has a top cap 95 carrying a casing 96 in which is mounted a rotary vane-type positive-displacement pump 97 similar to the pump described in connection with Figures 1 to 5.

An electric motor in the casing 94 has a drive shaft 98 projecting into both casings 93 and 96. The portion of the shaft 98 projecting into the casing 93 has a coupling 99 pinned thereon. A one-way drive roller clutch 100 operating in the identical manner as the ball clutch 58 selectively connects the coupling 99 with a pump shaft 101 rotatably mounted in the lower end of the casing 93 and drivingly connected with a centrifugal impeller 102 operating in the identical manner as the impeller 75 described in Figures 1 to 5. The casing 92 has an inlet ring 103 defining an inlet opening 104 and vanes 102a of the impeller discharge liquid material from the opening 104 into and through a volute chamber 105 defined in the casing. This volute chamber 105 communicates with a discharge conduit 106 connected with a cylindrical casing 107 receiving a conduit fitting 108 at the upper end and closed at the lower end by means of a cap 109. As explained in connection with Figures 1 to 5, the fitting and cap are interchangeable. A flap valve 110 is mounted in the casing 107 and is spring urged into closed position.

The volute chamber 105 also communicates with a fitting 111 connected through a hose 112 with a fitting 113 communicating with the inlet 97a of the rotary vane pump 97.

The outlet 97b of this pump 97 receives a T-fitting 114 having one leg connected through a hose 115 to the fitting 108 and having another leg connected to the fuel line to the engine-driven fuel pump (not shown).

The upper end of the motor shaft 98 is pinned to a coupling 116 containing a one-way drive roller clutch 117 operating in the same manner as the ball clutch 59 described in Figures 1 to 5.

When the motor in the casing 94 is driven in a counterclockwise direction, the roller clutch 100 drivingly engages the pump shaft 101 to rotate the centrifugal impeller 102 and centrifugally discharge fuel from the tank through the volute 105 into the conduit 106 for acting on the flap valve 110 to open the same. The fuel enters the casing 107 where it is discharged into the fuel line through the hose 115. As explained above, the impeller 102 is effective to separate liquid material from gases and vapors, and the gases and

vapors are returned back to the tank. This counterclockwise driving of the motor disengages the roller clutch 117 so that the pump 97 is idle.

When the rotor of the pump 97 is not operating, it is effective to seal the outlet 97b thereof from the inlet 97a thereof, and fuel under pressure in the coupling 114 cannot return through the hose 112 and coupling 111 back to the volute chamber 105.

When the motor in the casing 94 is driven in a clockwise direction, the coupling 99 disengages the roller clutch 100 and the coupling 116 engages the roller clutch 117 to drive the rotor of the pump 97. This causes the pump 97 to operate and receive liquid from the tank through the inlet 104, volute chamber 105, fitting 111, hose 112, and fitting 113. The liquid will be discharged through the outlet 97b into the fitting 114 to the fuel line (not shown). Flap valve 110 will be closed since the pressure in the casing 107 will be greater than pressure in the volute chamber 105.

Thus driving of the motor in one direction causes operation of the centrifugal pump while driving of the motor in the reverse direction causes operation of the positive-displacement pump.

In the embodiment shown in Figure 7, the unit 120 has a base 121 carrying, in spaced relation thereabove on legs 121a, a centrifugal pump casing 122 having upstanding conduit-defining portions 123 and 124 carrying a top flange 125. The top flange 125 has a depending cup-shaped portion 125a. A casing 126 is mounted on top of the flange 125 and has a laterally projecting conduit portion 127 connected with an upstanding conduit fitting portion 128. The fitting portion 128 has a depending mouth 128a on the flange 125. A flap valve 129 is mounted in the depending mouth portion 128a of the fitting 128 and acts on the flange 125 as a seat to close the conduit 124.

The casing 126 has an upwardly projecting collar portion 126a on which is carried a motor casing 130. A motor in the casing has a drive shaft 131 extending through collar 126a and through casing 126 terminating in a reduced lower end portion 131a having diametrically opposed elongated keys 131b thereon.

The shaft 131 projects through a stationary seal ring 132 and through a rotating seal ring 133 in face engagement with the stationary seal ring 132. A rubber sleeve 134 embraces the rotating seal ring 133 and is held thereon by a cup member 135. The cup member is acted on by a coil spring 136 bottomed on a retainer 137 disposed around the shaft 131 and held against longitudinal movement away from the cup member 135 by means of a lock wire 138.

The casing 126 has a bottom shoulder 126b on which is mounted a bearing 140. A pump liner 141 for a rotary vane type positive-displacement pump is bottomed on this bearing 140 and has an inlet opening 141a communicating with the conduit 123 and an outlet opening 141b communicating with the conduit 127.

A second bearing 142 is mounted on the liner 141 and is secured thereagainst by means of a sleeve 143 slidable in the casing. A gasket 144 is seated in the groove provided around the upper end of the sleeve 143 and the stationary seal 132 is bottomed on this gasket. A cover ring 145 acts on the stationary seal 132 and is secured to the casing 126 by means of cap screws 146.

A rotor 147 has a hub 147a rotatably mounted

in the bearing 142 and a second hub 147b rotatably mounted in the bearing 140. A tube 148 is freely disposed around the shaft 131 and projects through both hubs 147a and 147b.

The rotor 147 carries pumping vanes 149 slidably mounted in slots thereof and acting on the liner 141 to propel liquid from the inlet 141a to the outlet 141b.

The hub 147b has depending dogs 147c in spaced relation therearound for a purpose to be more fully hereinafter described.

The cup shaped depending portion 125a of the flange 125 has a bearing 150 bottomed on a bottom shoulder 125b thereof. A spacer ring 151 is mounted in the cup on the bearing 150 and supports a second bearing 152. The bearings 150 and 152 are plain carbon or graphite bearing rings and are secured in the cup 125a by means of a plug ring 153 threaded into the top of the cup.

The bearings 150 and 152 rotatably support a shaft 154 having a well 154a in the top thereof receiving the end of the shaft portion 131a. A well 154b is formed in the bottom of the shaft 154 and receives therein a stub shaft 155a of a centrifugal impeller 155 identical with the impeller 75 described in connection with Figures 1 to 5. A pin 156 secures the stub shaft 155 for corotation with the shaft 154.

The shaft 154 has a flange 154c underlying the bearing 150 and riding on a raised end face 150a of the bearing.

A sleeve 157 is mounted around the top of the shaft 154 and secured thereon by means of a locking pin 158. This sleeve has a flange 157a riding on a raised end face 152a of the bearing 152.

The upper end of the sleeve 157 has dogs or vertical teeth 157b.

A clutch element 160 is slidably keyed on the portion 131a of the shaft 131 and has upstanding dogs or teeth 160a for meshing with the dogs or teeth 147c on the rotor hub 147b together with depending dogs or teeth 160b for meshing with the dogs or teeth 157b of the sleeve 157. The clutch element 160 is loosely embraced by a lever 161 pivoted as at 162 to the casing 126. The clutch element 160 rotates freely in an aperture defined by rib 161a on the lever 161. The clutch element 160 has a concave peripheral wall 160c adapted to be engaged by the rib 161a for raising and lowering the clutch element 160.

The end of the lever 161 remote from the pivot 162 has an elongated slot 161b receiving a pin 163 on the core 164 of a solenoid 165 carried in the casing 126. A spring 166 acts on the core 164 to urge it downwardly thereby causing the pin 163 to tilt the lever 161 downwardly for moving the clutch element 160 into position for engagement of the clutch teeth 160b with the sleeve teeth 157b. In this position of the clutch the shaft 131 drives the clutch element 160 through the keys 131b and the clutch 160, in turn, drives the shaft 154 through the sleeve 157. The shaft 154 rotates the impeller 155 to actuate the centrifugal pump. The impeller 155 is effective, as explained above in connection with Figures 1 to 5, to receive liquid gasoline or other fuel in the tank, centrifugally separate the fully liquid material from gases and vapors, pump the fully liquid material through the volute chamber into the discharge conduit 124 under pressure sufficient to open the flap valve 129 and discharge the material into the fitting 128. The separated gaseous material is forced back to the interior

of the tank by the vanes in the top of the impeller. Gasoline under pressure in the conduit 128 will not flow through the conduit 127 when the positive-displacement rotary vane pump is idle since the rotor and vanes of this pump separate the outlet 141b from the inlet 141a.

When the solenoid 165 is energized, the core 164 is drawn into the solenoid coil against pressure of the spring 166 to raise the lever 161 and thus move the clutch element 160 out of engagement with the sleeve 157 and into engagement with the rotor hub 147b through intermeshing relation between the dogs or teeth 160a and 147c.

Rotation of the rotor 147 will impel liquid from the inlet 141a to the outlet 141b. The conduit 123 supplies the inlet 141a from the volute chamber. The positive-displacement pump pressures the liquid from the conduit 123 through the conduit 127 into the fitting 128 and, when pressure in the fitting 128 is greater than pressure in the conduit 124, the flap valve 129 will be closed, so that the liquid will not be recirculated back to the volute chamber.

In the pump 120 the motor shaft 131 is driven in one direction only, and the solenoid 165 selectively controls sequential driving of the positive-displacement pump or the centrifugal type pump.

From the above descriptions it will be understood that the invention now provides multipump and motor units adapted to be submerged in airplane fuel tanks wherein one pump is of the centrifugal type effective for separating gases from the liquid fuel and for pressuring the fully liquid fuel into a pipe line, while the other pump is of the positive-displacement type and pressures the fuel without separating gases and vapors therefrom. A single electric motor is arranged for selectively driving either pump, and clutch means are included in the unit to control the selective driving. The positive displacement pump will pressure fuel at relatively high pressures to an airplane fuel line and serve to take the place of the engine-driven fuel pump during starting and emergencies. It will maintain engine operation sufficient for sustaining flight when the main pump or engine-driven fuel pump is totally inoperative. The centrifugal pump separates gases and vapors from the liquid fuel and pressures the fully liquid fuel into the fuel line and serves as a high altitude booster.

It will also be understood that the units of this invention can be completely inoperative without stopping flow of fuel from the tank to the fuel line, since fuel can always flow through the impeller and casing of the centrifugal pump. The weak spring urging to closed position the flap valve in the discharge conduit of the centrifugal pump will readily permit the valve to open whenever there is a suction pull in the fuel line as when the engine-driven fuel pump is operative and the booster pump unit is inoperative.

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 pump and motor unit comprising a plurality of pumps having a common inlet and a common outlet, a motor for driving said pumps, clutch means selectively connecting said pumps with said motor for sequential operation of the pumps, and means between said outlet and said

inlet preventing back flow from the outlet through an inoperative pump.

2. A booster pump adapted for attachment to the fuel tank of an aircraft fuel system which comprises casing means having a mounting flange for attachment to a tank and providing a pumping chamber for a centrifugal pump with an inlet for open communication with the interior of the tank, said pumping chamber having a first outlet and a second outlet in open communication with said inlet, an impeller rotatably mounted in said casing means cooperating with said pumping chamber to pressure fluid to said second outlet, means on said impeller for eliminating bubbles from fluid being pumped, a positive displacement type pump having an inlet communicating with the first outlet of said pumping chamber and an outlet communicating with the second outlet of said pumping chamber, a single prime mover for driving said impeller and said positive displacement type pump, and clutch means selectively connecting said prime mover with the positive displacement type pump or with the impeller.

3. A booster pump unit adapted for aircraft fuel systems comprising a centrifugal pump, a rotary vane pump, said pumps having a common inlet and a common outlet, an electric motor for driving said pumps, mechanism for selectively connecting the pumps with said motor, and means preventing back flow from the outlet through an inoperative pump.

4. A pump and motor unit adapted to be submerged in a pond of liquid in a tank comprising a mounting base adapted to be attached to a tank wall, a centrifugal pump casing having an inlet above the base, said base beneath said pump inlet defining a sump receiving liquid from the pond for supplying said inlet, said centrifugal pump casing having a main outlet and a secondary outlet, an impeller in said casing arranged for pressuring liquid from the inlet to the main outlet, chamber defining means on said base communicating with said main outlet to receive liquid therefrom, a vaned rotor type pump mounted adjacent said centrifugal pump casing having an inlet receiving liquid from said secondary outlet of the centrifugal pump casing and an outlet discharging liquid to said chamber defining means, an electric motor, and clutch means drivingly connecting said electric motor with said impeller and said vaned rotor.

5. A submerged type booster pump assembly comprising a mounting plate defining a sump, a centrifugal pump casing secured on said mounting plate in spaced relation above said sump, said casing having a central opening therethrough and a peripheral pumping chamber around said opening in communication therewith, an impeller rotatably mounted in said central opening having pumping vanes around the periphery thereof for discharging liquid received from the sump into said pumping chamber together with additional vanes in the top thereof for discharging vapors out of the central passageway, a pump shaft driving said impeller, a second pump casing having an inlet communicating with said pumping chamber, a rotary vane type pump including a vaned rotor in said second casing, a single motor on said unit, and clutches for selectively connecting said single motor with said pump shaft and with said vaned rotor.

6. A combination booster pump comprising a unit including a centrifugal type pump having a first pumping chamber and means associated

therewith for separating gases from liquids and for pressuring fully liquid material, a positive displacement type pump having a second pumping chamber, said first and second pumping chambers having a common inlet, a single electric motor, and means for selectively connecting said motor and said pumps in driving relation.

7. A combination booster pump unit comprising a base adapted to be mounted on a tank, upstanding casing structure on said base adapted to be submerged in a tank, said structure including a centrifugal type pump casing having an inlet adjacent said base and a plurality of outlets, a positive displacement type pump casing having an inlet connected with one of said outlets of the centrifugal pump casing and an outlet communicating with the other of said outlets of the centrifugal pump casing, an electric motor, an impeller in said centrifugal pump casing, a vaned rotor in said positive-displacement pump casing, and clutch means for drivingly connecting said motor with said impeller and said vaned rotor.

8. A combination booster pump unit comprising a mounting plate adapted to be suspended on the bottom wall of a tank, upstanding means on said mounting plate adapted to project into the tank, an electric motor and a plurality of pumps on said upstanding means, and said upstanding means having passageways joining said pumps to provide a common inlet and a common outlet.

9. A combination booster pump unit adapted for aircraft fuel systems comprising a low altitude booster pump having a first pumping chamber, a high altitude booster pump having a second pumping chamber, said first and second pumping chambers having a common inlet and a common outlet, an electric motor, and means for selectively connecting said pumps with said electric motor to be driven thereby.

10. A combination booster pump comprising a mounting base, upstanding legs on said base, a centrifugal-type pump casing supported on said legs in spaced relation above the base having a central vertical opening therethrough, a volute pumping chamber around said central opening in communication therewith, a laterally extending discharge conduit, and an enlarged cylindrical casing at the end of the discharge conduit, an impeller rotatably mounted in the central opening of the casing having pumping vanes around the periphery thereof cooperating to separate liquids from vapors and pump the liquids into the volute pumping chambers together with vanes at the tops thereof for propelling the separated vapors through the open top of the opening, a second pump casing above said centrifugal pump casing having an inlet conduit depending therefrom and communicating with the volute pumping chamber together with an outlet conduit extending laterally therefrom and communicating with the enlarged cylindrical casing, a vaned rotor rotatably mounted in said second pump casing, an electric motor mounted on top of said second pump casing having a drive shaft depending therefrom, a pump shaft carrying said impeller and extending through said vaned rotor, a first clutch connecting said pump shaft with said motor shaft, and a second clutch connecting said vaned rotor with said motor shaft.

11. A combination type booster pump comprising an electric motor, a casing surrounding said motor, a second casing secured to the motor

casing and extending therefrom, said second casing defining a clutch chamber, a positive-displacement type pump chamber, and a centrifugal type pump chamber, said centrifugal type pump chamber having an inlet, a first outlet communicating with the positive displacement type pump chamber, and a second outlet, an impeller in said centrifugal pump casing, a vaned rotor in said positive displacement type pump casing, a pump shaft driving said impeller and extending through said vaned rotor into said clutch chamber, said vaned rotor having a hub extending into said clutch chamber, a coupling in said clutch chamber connected to said motor shaft, and separate clutch means interposed between said coupling, said pump shaft and said hub for selectively connecting the motor shaft in driving relation with said impeller and said vaned rotor.

12. A combination booster pump comprising a unit adapted to be submerged in a pond of liquid and including an electric motor casing, a clutch casing, a positive-displacement type pump casing, and a centrifugal type pump casing together with conduits providing a common inlet and a common outlet for the casing, an impeller in said centrifugal pump casing, a vaned rotor in said positive-displacement pump casing, clutch means in said clutch casing, a pump shaft secured to said impeller extending freely through said vaned rotor, said motor having a drive shaft depending into said clutch casing, said vaned rotor having a hub extending into the clutch casing, and said clutch means selectively connecting said hub and said pump shaft with motor shaft.

13. In a unit including an electric motor and a plurality of pumps, a drive shaft for one pump, a rotor for another pump receiving the drive shaft freely therethrough, and one-way drive clutches for drivingly connecting the motor selectively with said drive shaft and with said rotor.

14. A combination pump unit comprising an electric motor having a casing projecting from opposite ends thereof, a centrifugal type pump in one of said casings, a positive-displacement type pump in the other of said casings, said centrifugal type pump having a single inlet and a plurality of outlets, said positive-displacement pump having a single inlet and a single outlet, conduit means connecting one of the centrifugal pump outlets with the inlet of the positive-displacement pump, and second conduit means connecting the other outlet of the centrifugal pump with the outlet of the positive-displacement pump.

15. A multi-pump-single motor unit comprising a prime mover, a plurality of pumps driven by said prime mover, and a single solenoid-operated clutch selectively connecting the pumps with said prime mover.

16. A combination booster pump comprising an electric motor having a drive shaft extending therefrom, a vaned rotor loosely embracing said drive shaft, casing means for said rotor cooperating therewith to provide a first pumping chamber, a pump shaft aligned with the end of the drive shaft, an impeller on said pump shaft, casing means for said impeller cooperating therewith to provide a second pumping chamber, and a solenoid-operated clutch selectively connecting the drive shaft with said pump shaft and with said vaned rotor.

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