July 4, 1950 L. G. BURNS 2,513,992

HIGH ALTITUDE FUEL SYSTEM

Filed April 3, 1942 2 Sheets-Sheet 1

Fig. 1

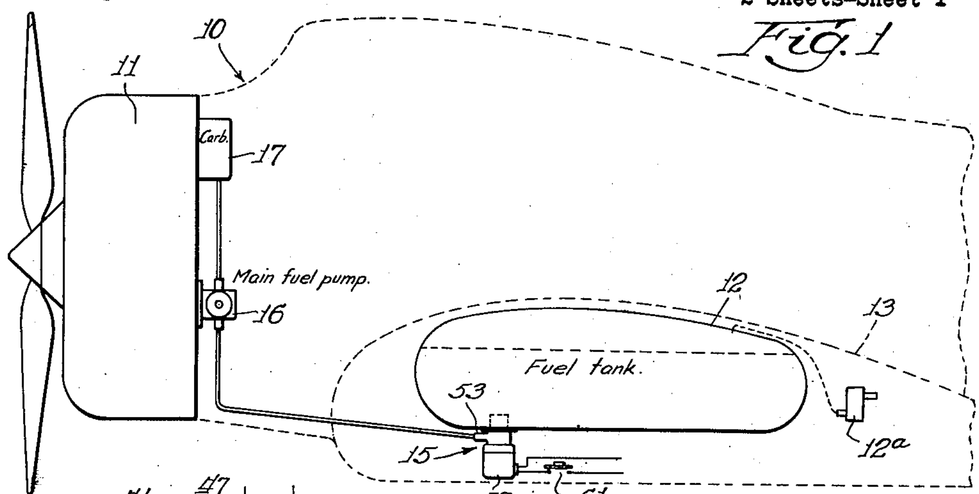

Fig. 2

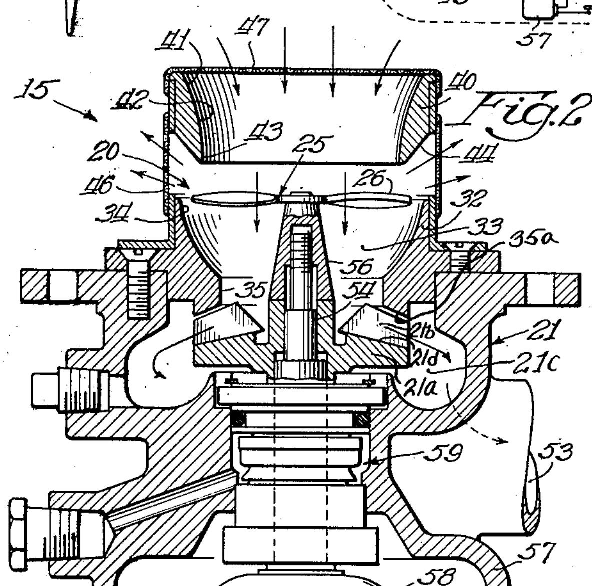

Fig. 3

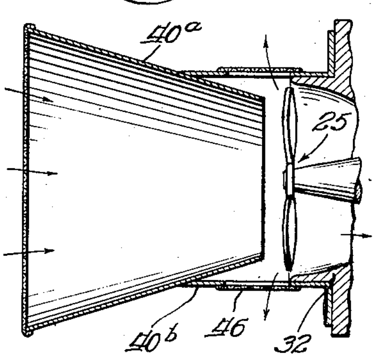

Fig. 4

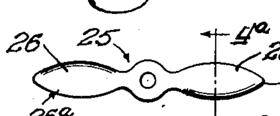

Fig. 4a

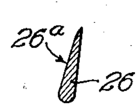

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Fig. 5

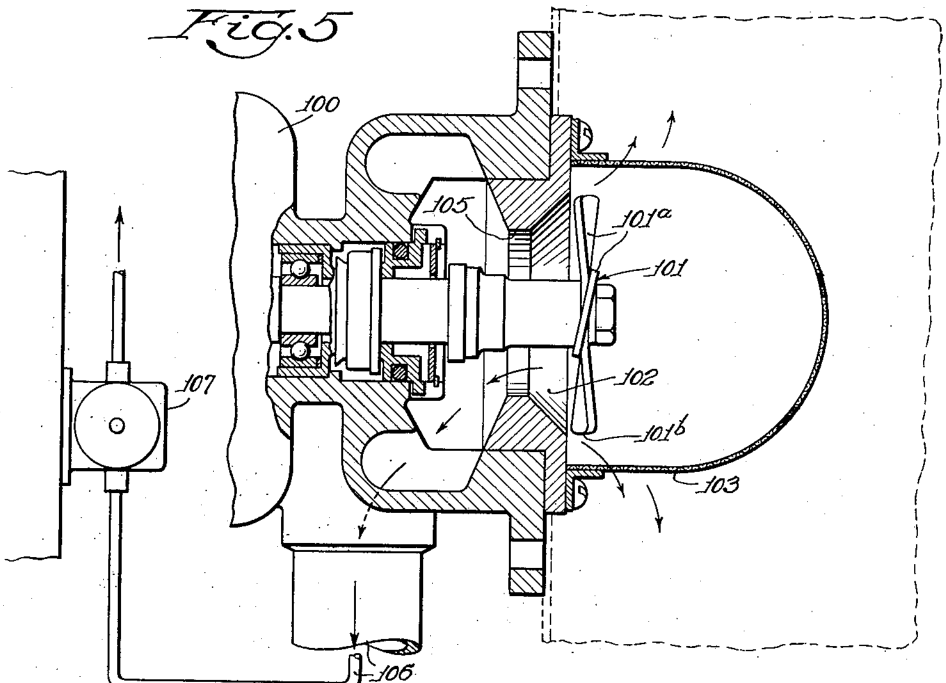
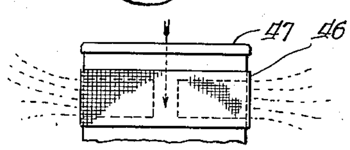


Fig. 6

Fig. 7



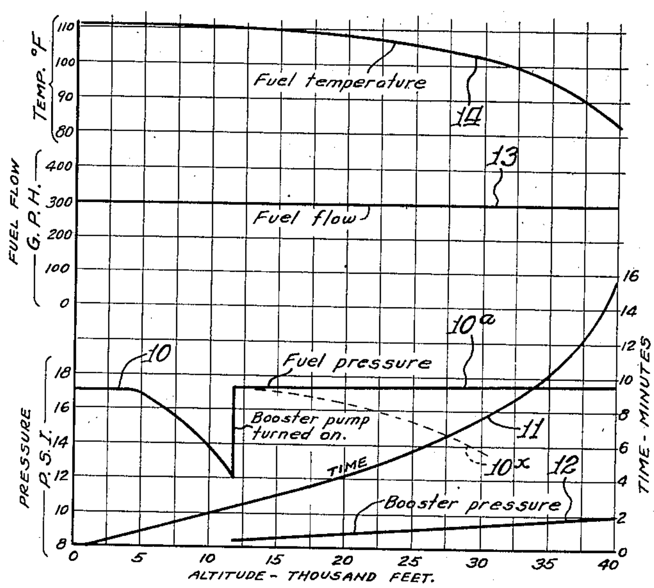


Fig. 8

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UNITED STATES PATENT OFFICE

2,513,992

HIGH ALTITUDE FUEL SYSTEM

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Application April 3, 1942, Serial No. 437,478

6 Claims. (Cl. 103—113)

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This invention relates to liquid pumping or transfer systems and methods for handling liquids which have a tendency to incorporate air therein and particularly to an arrangement for properly conditioning volatile fuel for transfer from the fuel tank to an aircraft engine.

The problem of air bubble inclusion in the fuel pumping or transfer system has become increasingly serious with the extensive use of high octane highly volatile fuel and flight at extremely high altitudes where the surrounding atmospheric pressure is considerably reduced. Also the present standard aircraft fuel has a vapor pressure of six to seven pounds per square inch, at 100° F. which adds to the difficulty of control and handling.

Under the above circumstances it has been found very difficult to prevent occluded air from becoming precipitated in the fuel in the carburetor metering passages, with the result that faulty metering occurs even before "vapor-lock" in its true sense is encountered.

I have found that this problem can be solved by properly conditioning the fuel in the tank at the point of delivery to the pumping equipment proper, and it is the object of this invention to teach how this proper conditioning of the fuel may be accomplished.

Another object of the invention is to provide a method of stabilizing volatile liquid fuel for high altitude performance and preventing vapor lock in airplane fuel systems by providing a body or pond of volatile liquid fuel, as in a tank or other enclosure, flowing the liquid fuel from the pond in a selected path under hydraulic head pressure, preferably from or near the bottom of the tank, locally agitating the liquid fuel about to flow from the pond to generate bubbles of gas and vapor from the liquid fuel to an extent substantially in excess of that resulting spontaneously from reduction of atmospheric pressure due to increase in altitude and to create in the pond a counterflow of liquid fuel carrying the bubbles of gas and vapor laterally outward from the selected path, directing the counterflow away from the selected path and upwardly to the surface of the pond to release the bubbles of gas and vapor, causing the bubble-freed liquid fuel again to flow in the selected path, so as to eliminate from the fuel flowing from the pond occluded gas, and vapor, which normally would become separated therefrom upon further increase in altitude and cause the formation of bubbles in the fuel, and subjecting the flowing fuel immediately after agitation thereof to pressure sufficient to prevent spontaneous separation of additional gas, and vapor, therefrom, whereby to deliver from the pond stable, liquid fuel substantially free of bubbles.

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It is a further object to disclose a preferred arrangement effective to remove or eject the occluded air from the fuel introduced thereto from the fuel tank, returning the air to the tank and delivering the air-feed fuel to the fuel transfer or pumping system for movement to the carburetor and aircraft engine for consumption.

Still another object is the disclosure of an arrangement of the above character which is also applicable to the conditioning and transfer of liquid generally where there exists the problem of air inclusion or "vapor-lock."

A more specific object is the provision in combination in an assembly of the present type of an optimum construction of propeller blade for conditioning the liquid and particularly highly volatile fuel brought into contact therewith.

Another particular object is provision of an improved arrangement of the above type which incorporates the additional feature of supercharging the fuel tank for preventing the loss of fuel during sustained flight.

Other and more particular objects, advantages and uses of my invention will become apparent from a reading of the following specification taken in connection with the accompanying drawings forming a part thereof and wherein:

Fig. 1 is a schematic broken-away view of an aircraft incorporating a preferred embodiment of my fuel conditioning and transfer arrangement;

Fig. 2 is an axial cross-sectional view taken substantially on the line 2—2 of Fig. 1, and showing to advantage the preferred arrangement of conditioning means located adjacent to and in communication with the fuel in the tank;

Fig. 3 is an axial cross-sectional view similar to Fig. 2 but showing the preferred arrangement of inlet separator for a horizontal installation;

Fig. 4 is a plan view of my improved air foil or converging tip propeller construction;

Fig. 4*a* is a cross-section view taken substantially on the line 4*a*—4*a* of Fig. 4;

Fig. 5 is a view of a modified arrangement having general application;

Fig. 6 is a perspective-like view showing the actual air separation at the inlet as obtained with the arrangement of Figs. 1, 2 and 4 simulating conditions of flight at 30,000 feet;

Fig. 7 is a view similar to that of Fig. 6 but taken at 40,000 feet; and

Fig. 8 presents a set of curves which bring out to advantage the improved results obtained by conditioning the fuel or ejecting the vapor therefrom before introducing the same to the pumping or transfer arrangement proper, the 30,000 and 40,000 feet points corresponding respectively to Figs. 6 and 7.

Referring in greater detail to the figures of the drawings, numeral 10 indicates schematically the essential portions of an aircraft having a preferred embodiment of my invention incorporated thereon and including an engine 11 supplied with volatile fuel from a tank 12 carried in plane wing 13 at a position remote from and lower than the position of fuel introduction to the motor. I provide a special arrangement indicated generally at 15 for receiving the fuel from tank 12, eliminating or ejecting the occluded air therefrom and pumping the same to the main fuel pump 16 located adjacent and driven from the aircraft engine 11, this main pump in turn delivering the fuel to carburetor 17 from which it is fed to engine 11 for consumption.

The arrangement indicated at 15 includes essentially an air or vapor ejector assembly designated generally at 20 which receives fuel from tank 12 and is effective to eject the occluded air therefrom and to deliver air-freed fuel to a pump proper indicated generally at 21 which in turn raises the pressure of the air-freed fuel and delivers the same to the inlet of main engine driven fuel pump 16. The pump 21 is disclosed as being of the centrifugal booster type including a centrifugal impeller 21*a*, and it has been found that the same cooperates to particular novel advantage in the present combination as will appear. It is to be understood, however, that in certain broader aspects of my invention, the same has application with other forms of pumping means.

Thus, two very important things are accomplished, first, the air which is unavoidably incorporated in the volatile fuel entering the ejector is removed and returned to the body of fuel in the tank, this being accomplished by assembly 20, and second, the pressure in the transfer line to the motor driven pump 16 is boosted and maintained at a value above the critical pressure, below which pump 16 would tend to pull the volatile fuel apart and cause the condition known as "vapor-lock."

Air or vapor ejector 20 preferably includes a propeller-like blade assembly 25 comprising a pair of oppositely radially extending blades 26, each blade having an air foil or converging tip construction shown to particular advantage in Figs. 4 and 4*a*. A housing or throat ring 32 is formed with a generally converging or funnel-like chamber 33 having a relatively large terminal or port 34 and a restricted outlet terminal or port 35. The surrounding wall of chamber 33 is shown as generally concave or cup-like in shape, which has been found to give particularly good flow characteristics. The propeller assembly 25 preferably has an overall diameter slightly less than that of terminal port 34 and is positioned for coaxial rotation in substantially opposed relation to the terminal port 34. The propeller blade pitch and direction of rotation are such as to move the liquid from the central portion of port 34 in the direction of the restricted outlet 35, which communicates with the vanes 21*b* of the centrifugal impeller 21*a*. The vanes 21*b* extend from a generally central position, exposed to the flow from the restricted outlet port 35, radially outwardly in opposed spaced relation to the outwardly flared housing wall 35*a* surrounding the discharge port 35. The radially outer terminal of the vanes 21*b* discharge into chamber 21*c*, shown as a conventional scroll or volute chamber of a centrifugal booster pump. It is considered important that the overall diameter of the propeller be substantially greater than the diameter of the restricted outlet port 35. It is important that the liquid moving capacity of propeller 25 be substantially in excess of the rate of flow through outlet port 35 so that an excess of liquid will be driven or circulated back from chamber 33 past the peripheries of the propeller blades 26 and into tank 12. It has been discovered that by properly proportioning this return circulation or excess of fuel ejected back past the propeller the same is effective to remove therewith the critical portion of the occluded air which has entered chamber 33 past the inner or central portion of the propeller.

For improving the air and liquid separation, a generally ring-like member 40 is spaced from the propeller and includes an inlet port 41 connected by a generally convex inner wall 42 to a restricted outlet terminal orifice 43. This restricted terminal 43 has a diameter less than the overall diameter of the propeller, thus facilitating the introduction of liquid to the general central portion of the propeller, the ring 40 being further provided with a diverging underside wall portion 44, serving in conjunction with the wall of port 34 to facilitate the ejection of vapor or air-laden excess fuel. A screen 46 may surround ring 40 and housing 32, while a similar screen 47 may cover the port 41 in ring 40, thus preventing the entry of foreign particles.

Referring to Fig. 3 there is shown an alternative form of separator or ring-like member 40*a*. This form of separator is particularly adaptable for a horizontal installation and differs from separator 40 principally in that it is considerably longer and has a straight funnel-like sheet metal wall. Separator 40*a* may be supported from a perforated tube 40*b* protruding from the separator wall.

Without attempting to fully explain the theory or mode of operation which accounts for the improved results obtained, it would appear that a number of factors enter into the success. One thing is certain, namely with the construction as described there is less resistance to the flow of air bubbles from chamber 33 back past the tips of propellers 26 and into tank 12 than there is to the flow of these air bubbles through outlet port 35. The general funnel shape of chamber 33 in cooperation with the action of propeller 25 particularly where the propeller is given an excess capacity over the rate of flow through restricted outlet port 35, results in this unique separation.

While the present invention has particular application to the problem of removing air from volatile fuel before delivering the same to the transfer or pumping system of an airplane it will be readily appreciated that the same has application wherever there exists the equivalent problem of vapor or air inclusion in liquid to be pumped. As above pointed out it would appear that the essential requirement is the provision of a converging or funnel-like chamber the larger terminal portion of which is in communication with the fuel to be pumped, there being provided a propeller-like assembly rotatable in close proximity to the larger terminal portion of said chamber and functioning to deliver a greater volume of liquid into the chamber than is received through the restricted outlet from the funnel-like chamber, the excess being returned to the tank past the propeller tips and carrying with it the occluded air, thus delivering the air-freed liquid through the restricted outlet to the transfer conduit.

Referring in greater detail to the preferred form of propeller shown in Figs. 1, 2, 3 and 4, an attempt will now be made to explain how this particular form accounts for superior results. The air foil section indicated generally at **26***a* and including a converging tip **26***b* is believed to account for the unusual altitude performance obtained. The blades **26** are given an optimum inclination, which is determined by the required pumping action and the factor of drag. By experiment or trial with a particular size of pump and propeller the proper inclination can be readily determined. When the proper inclination is employed a separation of the fluid occurs on the upper surface of the propeller at a point forward of the trailing edge and also at a second point on the lower surface at the trailing edge. This separation may be referred to as the burbling of flow and the position or inclination at which it occurs may be referred to as the burbling point. This separating action enters into the determination of the amount of drag, the same appearing to increase approximately as the square of the angle of inclination. If the propeller vanes or blades were of an infinite length the drag would be the result of a combination of skin friction and the eddy components set up by the accompanying conditions including pressure differences around the blade. But where the blade has a finite length as herein, there is present an additional drag resulting from pumping action or lift. There occurs when pumping, an increase of pressure on one surface of the foil section **26***a* and a decrease in pressure on the other. These pressures tend to equalize each other at the converging blade tip with the result that a vortex is formed as the blade moves through the liquid. Air laden fuel is caused to flow from chamber **33** radially outwardly through screen **46** while air-freed fuel passes through restricted port **35** to the pump impeller **52** and thence to pump **16** and carburetor **17**. It has been found that the propeller blade construction of Figs. 4 and 4*a* produces materially less drag than other usable forms such as that later to be described and hence is more efficient in that less electrical energy is required to operate the motor which turns the same. It has been found that the relationship of length and surface area of the propeller is important that it is important to maintain as high a ratio as obtainable of length squared to surface area in order to keep the drag down to the minimum. The form of Figs. 4 and 4*a* more completely satisfy this condition than any other known form of propeller.

While any suitable driving means may be employed for turning propeller **25**, it has been found to be particularly advantageous to connect the propeller assembly in driving relation to electrically driven booster pump **21**. This pump **21** may take a number of forms, but the electrically driven centrifugal impeller type disclosed has a number of special advantages and therefore is to be preferred. The outlet port **35** of propeller chamber **33** forms the coaxial inlet port of pump **21**, which pump, as pointed out above and shown in Fig. 2, includes an impeller chamber **21***c* enclosing a centrifugal liquid impeller **21***a* effective to force the liquid out of discharge port **53** and deliver the same at an increased pressure to pump **16**. The impeller **21***a* includes a plurality of radially extending vanes **21***b* facing in the direction of flow from restricted port **35**. The inner radial portion of these vanes is exposed to the column of fuel discharged from restricted port **35**, while the radial outer portion thereof lies under the outwardly flared wall **35***a* surrounding port **35** and in closely spaced relation thereto. The vanes **21***b* and the connecting surface **21***d* therebetween define with the opposed wall surface **35***a* guiding or directing conduits through which the fuel is centrifugally discharged radially outwardly into the scroll or volute chamber **21***c*. Impeller **21***a* is mounted for rotation on a shaft **54**, which may also support propeller assembly **25** through the medium of an adjustable connector **56** providing for the maintenance of a definite coaxial relationship between the propeller and the booster pump impeller. Shaft **54** is driven by an electric motor **57** including a rotor **58**. The usual seal and bearing arrangement indicated generally at **59** is provided between the motor and the pump impeller. A switch **61** controls the "on" and "off" positions of the electric motor **57**, since under certain conditions it may not be desirable or necessary to operate the booster pump and vapor eliminator. Such may be the case for example when the ground temperature is relatively low, or where flying at low altitudes below four or five thousand feet. In this connection it is important to note that propeller assembly **25** and centrifugal impeller **21***a* offer substantially no resistance to the passage thereby of fuel from the tank **12** to main engine driven pump **16** when switch **61** is open and assembly **15** is not operating.

In certain installations having less exactly requirements than that above described for an aircraft, it will be satisfactory to eliminate either the main pump **16** or the booster pump **21**, this reduction in pumping equipment being made possible by the air elimination effected by the propeller assembly.

As an example of a less expensive arrangement suitable for transferring liquid generally under conditions where air removal is important, reference is had to the alternative modification shown in Fig. 5. A small relatively inexpensive electric motor **100** drives the propeller assembly **101** located at the entrance of a straight-side funnel-shaped chamber **102**. A screen **103** prevents entry of foreign matter. The air-freed liquid may be drawn from the restricted outlet **105** through conduit **106** by a remotely located pump **107** illustrated as being of the rotary vane or blade type and driven by any suitable means not shown. The important thing is the removal of the air by the action of the propeller cooperating with converging chamber **102**, thus preventing the liquid in the transfer line from being pulled apart by pump **107** which would be the case if the air were not previously removed.

In the arrangement of Fig. 5 there is shown a modified form of propeller assembly, which assembly while less efficient than that of Figs. 2 and 4, nevertheless represents a very important advance. In this form, which can be readily stamped out of sheet metal, the propeller assembly **101** is composed of four radially extending generally triangular-shaped blades **101***a*, the base **101***b* of each of which triangles is arcuate in shape and forms the radially outward periphery of the blade.

Referring to Figs. 6, 7 and 8, there is shown the manner in which the air is ejected and by way of example a representative set of curves bringing out to advantage the improved performance results obtained in an actual test of an assembly such as that shown and described in Figs. 1, 2 and 4. Referring to curve 10, conditions were simulated from zero altitude to about 12,000 feet, and as brought out, the fuel pressure at the carburetor dropped from about 17 pounds per square inch to about 12 pounds per square inch with switch 61 open and booster pump 21 and vapor eliminator 20 out of operation. This drop-off in pressure delivery was the result of "vapor lock," namely, so much air became included in the fuel that the delivery of fuel was cut off. Switch 61 was then closed and assembly 15 cut into operation, whereupon the pressure at the carburetor immediately rose to slightly above 17 pounds per square inch. Further reference to curve 10a brings out that as the elevation was increased to 30,000 feet and then up to 40,000 feet, the vapor eliminator 20 continued to eject the air from the fuel entering the same notwithstanding a reduction in pressure above the liquid level and this, together with the action of booster pump 21 prevented any drop in the pressure of fuel delivery at the carburetor. As a matter of fact there was a slight rise in pressure delivery at the carburetor between 20,000 and 35,000 feet. The remaining curves are more or less self-explanatory, curve 11 showing the time relationship; curve 12 showing the booster pressure in inches of mercury; curve 13 showing the relationship of engine speed to gallons per hour of fuel consumed; while curve 14 shows the temperature relationship. A 60-gallon supply of 87 octane fuel having a seven pound per square inch vapor pressure was used. Figs. 6 and 7 show the actual appearance of the fuel and air bubbles in the tank in the area about the air eliminator assembly as observed through a transparent partition during the test recorded in Fig. 8, and at altitudes respectively of 30,000 feet and 40,000 feet. The air bubbles can be seen very clearly and are indicated in the figures in dotted lines.

As a further feature of particular importance, advantage may be taken of the action of assembly 15 for supercharging the tank 12. This is of particular importance on sustained flight where if the tank were muted to atmosphere the loss of fuel would in some cases run as high as 7 to 10 per cent. at altitudes of the order of 30,000 feet. Where the tank is thus to be supercharged, there will of course be employed a suitable relief valve assembly indicated schematically at 12a such as that disclosed in co-pending Roth et al. Patent No. 2,345,547, issued March 28, 1944, the function of which is to limit both the maximum value of pressure in the tank as well as the degree of vacuum.

As a final check on the improved results attributable to the propeller 25, the same was removed and curve 10x shown in dotted lines was plotted, from which it is readily apparent that the booster pump 21 alone will not maintain the delivery pressure at the inlet of main fuel pump 16. Not only is this true, but it will be seen further from an examination of curve 10x that it was not feasible to attempt to simulate altitude above about 30,000 feet. In other words, due to the occlusion of air bubbles in the fuel entering the booster pump 21, without the use of the vapor eliminating propeller 25, vapor lock occurred at about 30,000 feet which, in actual flight, would result in a loss of altitude due to failure to maintain the necessary delivery pressure at the carburetor. No attempt has been made to incorporate the other curves corresponding to 10x, since to do so might unduly confuse the picture.

While I have disclosed and described my invention in connection with certain specific embodiments thereof, this is to be understood as being by way of example only, and that my invention is to be defined by the appended claims.

I claim:

1. In an arrangement for transferring a liquid from a source of liquid supply to a point remote therefrom wherein air is unavoidably included in said liquid to be transferred, said arrangement including means in communication with said liquid supply for receiving a portion thereof to be transferred to said remote point, said means comprising a housing having a general funnel-shaped chamber therein, said chamber being defined in part by a first relatively large terminal port, a surrounding converging wall terminating in a second restricted terminal port having a substantially smaller diameter than that of said first terminal port, a propeller blade-like assembly including a plurality of radially extending blades having an overall diameter substantially greater than the diameter of said second terminal port and positioned for coaxial rotation with the tips of said blades in generally coplanar relation to said first terminal port of said chamber, and means for moving liquid from said second restricted port to said remote point including a conduit and a pump having a rotary impeller for displacing said liquid in the direction of said remote point, and means for rotating said pump and said propeller, said propeller having a fluid displacing capacity greater than that of said pump whereby an excess of liquid is moved into said funnel-shaped chamber over that received by said pump, said excess being ejected back past the tips of said propeller and into the main body of said liquid supply, said excess returned fuel removing therewith the excess air contained in the liquid introduced into said chamber whereby air-freed liquid is delivered to said pump for transmission to said remote point.

2. In an arrangement for transferring a liquid from a source of liquid supply to a point remote therefrom under conditions wherein occluded air is unavoidably precipitated in the liquid to be transferred, said arrangement including means in communication with said liquid supply for receiving a portion thereof to be transferred, said receiving means comprising an ejector housing formed with a bore therethrough, said bore being defined in part by a first terminal port, a surrounding inner peripheral wall converging in the direction of the other extremity of said bore and terminating in a restricted outlet port, said surrounding inner peripheral wall being generally concave in shape, a propeller blade assembly including a plurality of radially extending blades having an overall diameter substantially greater than the diameter of said restricted outlet port, said propeller blade assembly being positioned in generally coplanar relation to said first terminal port of said bore for coaxial rotation with reference thereto, a generally annular shaped ring spaced from said propeller assembly and having a bore therethrough defined by a generally convex inner peripheral wall terminating in an outlet port having a diameter less than the overall

diameter of said propeller assembly and functioning to direct liquid flow to said propeller assembly, said ring being further defined by a diverging underside portion, means defining a pump including a housing, said housing formed with an open-ended impeller chamber, said ejector housing being fastened in the open end of said chamber, said restricted outlet port of said ejector housing defining a coaxial inlet port to said pump chamber, a centrifugal pump impeller received in said pump chamber and conduit means connecting said propeller assembly and said pump impeller together for rotation about the same axis and an electric motor for driving said impeller and propeller assembly, said propeller assembly having a displacement greater than that of said pump impeller whereby a greater volume of liquid is delivered into said ejector chamber than is received by said pump impeller with the result that an excess of liquid is ejected back past said propeller tips into the main body of liquid supply, said excess returned liquid carrying with it the occluded air thus delivering air-freed liquid to said pump impeller for transmission to said remote point.

3. In an arrangement for transferring a liquid from a source of liquid supply to a point remote therefrom wherein air is unavoidably included in said liquid to be transferred, said arrangement including means in communication with said liquid supply for receiving a portion thereof to be transferred to said remote point, said means comprising a housing having a general funnel-shaped chamber therein, said chamber being defined in part by a first relatively large terminal port, a surrounding converging wall terminating in a second restricted terminal port having a substantially smaller diameter than that of said first terminal port, a propeller blade assembly including a pair of radially oppositely extending blades each being characterized by converging tip portions, said propeller having an overall diameter substantially greater than the diameter of said second terminal port and positioned for coaxial rotation with the tips of said blades in generally coplanar relation to said first terminal port of said chamber, and means for moving liquid from said second restricted port to said remote point including a conduit and a pump having a rotary impeller for displacing said liquid in the direction of said remote point, and means for rotating said pump and said propeller, said propeller having a fluid displacing capacity greater than that of said pump whereby an excess of liquid is moved into said funnel-shaped chamber over that received by said pump, said excess being ejected back past the tips of said propeller and into the main body of said liquid supply, said excess returned fuel removing therewith the excess air contained in the liquid introduced into said chamber whereby air-freed liquid is delivered to said pump for transmission to said remote point.

4. In an arrangement for transferring a liquid from a source of liquid supply to a point remote therefrom under conditions wherein occluded air is unavoidably precipitated in the liquid to be transferred, said arrangement including means in communication with said liquid supply for receiving a portion thereof to be transferred, said receiving means comprising an ejector housing formed with a bore therethrough, said bore being defined in part by a first terminal port, a surrounding inner peripheral wall converging in the direction of the other extremity of said bore and terminating in a restricted outlet port, said surrounding inner peripheral wall being generally concave in shape, a propeller blade assembly including a single pair of radially oppositely extending blades having a generally elongated cross-section throughout the radial extent thereof except for the terminal portion, said terminal portion converging in points at the tips of said blades, said propeller having an overall diameter substantially greater than the diameter of said restricted outlet port, said propeller blade assembly being positioned in generally coplanar relation to said first terminal port of said bore for coaxial rotation with reference thereto, a generally annular shaped ring spaced from said propeller assembly and having a bore therethrough defined by a generally convex inner peripheral wall terminating in an outlet port having a diameter less than the overall diameter of said propeller assembly and functioning to direct liquid flow to said propeller assembly, said ring being further defined by a diverging underside portion, means defining a pump including a housing, said housing formed with an open-ended impeller chamber, said ejector housing being fastened in the open end of said chamber, said restricted outlet port of said ejector housing defining a coaxial inlet port to said pump chamber, a centrifugal pump impeller received in said pump chamber and conduit means connecting said propeller assembly and said pump impeller together for rotation about the same axis and an electric motor for driving said impeller and propeller assembly, said propeller assembly having a displacement greater than that of said pump impeller whereby a greater volume of liquid is delivered into said ejector chamber than is received by said pump impeller with the result that an excess of liquid is ejected back past said propeller tips into the main body of liquid supply, said excess returned liquid carrying with it the occluded air thus delivering air-freed liquid to said pump impeller for transmission to said remote point.

5. In an aircraft volatile fuel conditioning and transferring arrangement for moving said fuel from a remotely located fuel supply tank to the aircraft carburetor, including an electrically driven selectively operable centrifugal booster pump located adjacent said fuel tank, the combination therewith of means in communication with the fuel in said tank for receiving a portion thereof ejecting therefrom the air included therein and delivering the air freed fuel to said centrifugal booster pump, said means comprising a housing formed with a coaxial bore therethrough defined in part by a first relatively large terminal port joined by generally funnel shaped converging surrounding wall portion with a restricted terminal outlet port, said restricted outlet port also forming the inlet port of said centrifugal booster pump, a propeller assembly including at least one pair of radially oppositely extending blades having an overall diameter substantially greater than the diameter of said outlet port, said propeller assembly being positioned in generally coplanar relation to said relatively large terminal port, means connecting said propeller assembly to said centrifugal impeller for rotation therewith about the same axis, and motive means for rotating said impeller and propeller, said propeller having a pumping capacity greater than that of said booster pump impeller whereby an excess of fuel is pumped into said converging chamber over and above that

which is received by said centrifugal impeller, said excess fuel being ejected back past the tips of said propeller and into the main body of fuel in said tank, the ejection of said excess fuel being effective to remove therewith the critical portion of the air incorporated in the fuel delivered into said converging chamber by said propeller, whereby to deliver air freed fuel to said rotary impeller, said arrangement being further particularly characterized by the fact that said removed air returned to said tank becomes effective to increase the pressure in the area above the fuel in said tank to thus supercharge said tank, and means including a relief valve assembly for controlling the degree of said supercharged pressure.

6. In a pump construction including a pump casing formed with an inlet throat, an impeller with pumping vanes underlapping said throat, an agitating propeller positioned to act on material fed to said throat before the same reaches said vanes, said throat being funnel-like in shape and defined by a generally concave inner peripheral wall leading from a relatively large outer inlet terminal to a converged outlet terminal adjacent said impeller vanes, a guide shield mounted in advance of the throat and the agitating propeller defining an annular bell mouthed passage to the throat in localized transverse communication with the exterior of said shield, said shield including an outlet terminal opening adjacent said propeller of lesser diameter than the overall diameter of said propeller whereby to direct air-laden fuel generally centrally of said propeller and to provide a path for air ejected by said propeller radially outwardly between the enlarged terminal of said throat and the exterior of said guide shield.

LOUIS G. BURNS.

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