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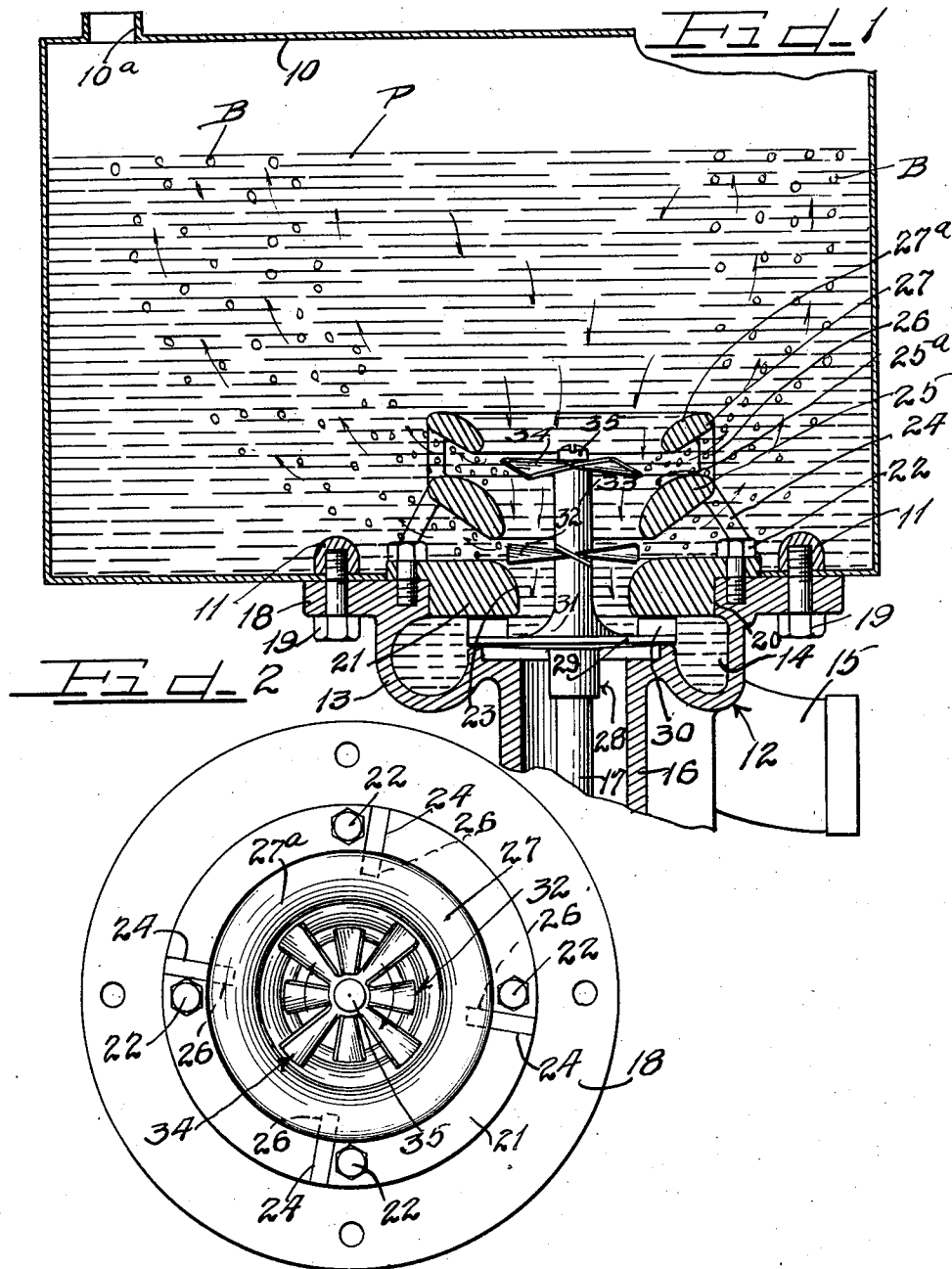
R. R. CURTIS

2,306,301

MULTISTAGE PROPELLER PUMP

Filed March 14, 1942

2 Sheets-Sheet 1



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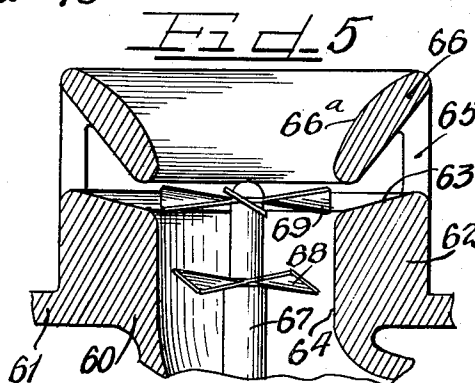
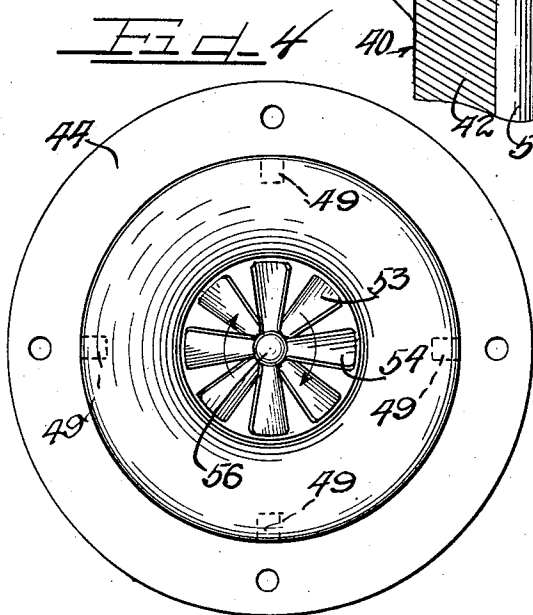
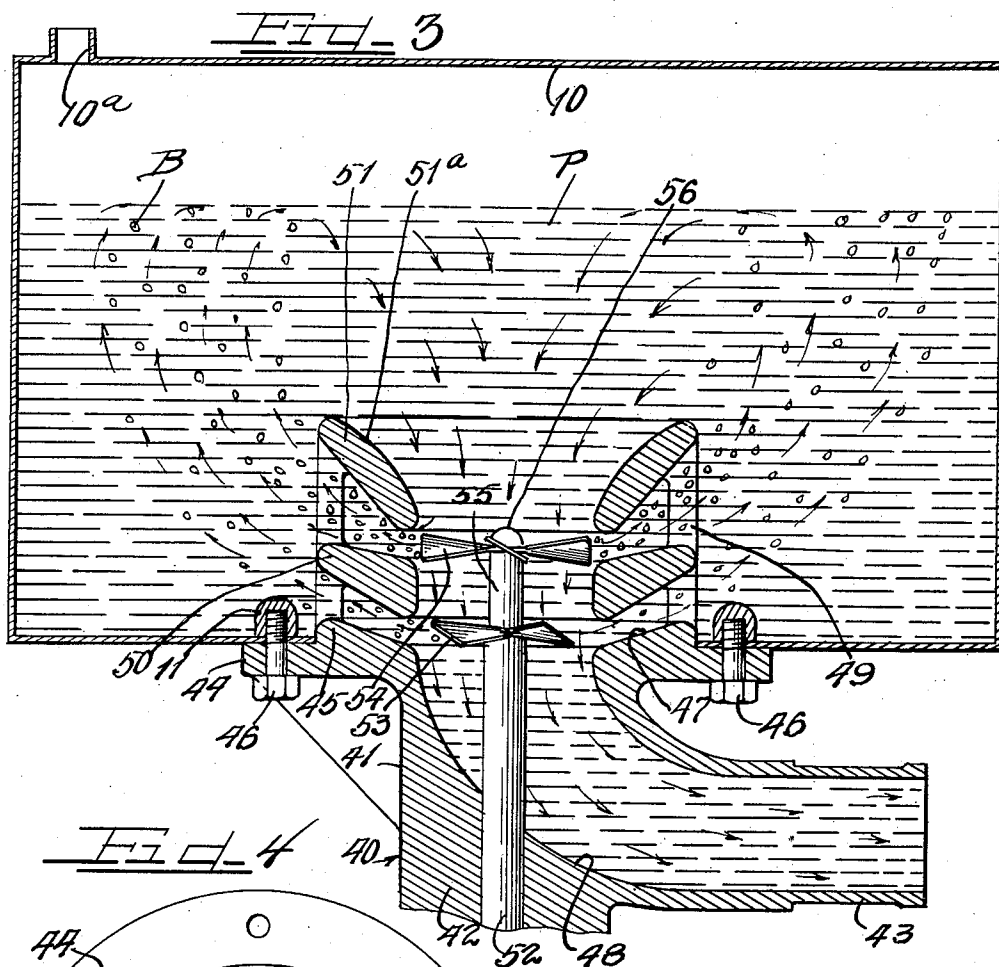
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2 Sheets-Sheet 2



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2,306,301

MULTISTAGE PROPELLER PUMP

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Application March 14, 1942, Serial No. 434,718

15 Claims. (Cl. 103—88)

This invention relates to pump assemblies especially adapted for use in aircraft fuel systems for efficiently separating gases and vapors from liquids so that only fully liquid material is pumped thereby.

More specifically, this invention relates to pump assemblies of the multi-stage bubble generating and separating type having a plurality of agitators for treating liquids flowing therethrough.

In accordance with this invention, a pump is provided for receiving highly volatile liquid fuel from a source of supply and pressuring the fuel to a point, such as to a fuel pump or directly to the carburetor of a vehicle to which the fuel system is applied. The pump includes a bell-mouthed shaped shield or guide for directing, to the agitators, the liquid to be treated and pumped. The guide is arranged for directing, in one or more paths, the separated gases and vapors out of the path of the incoming liquid. The agitators beat out, in bubble form, the occluded gases and vapors in the liquid and also induce, in the cavities or pockets behind the rotating blades thereof, the formation of gas and vapor from the volatile liquid ingredients. Such an arrangement of elements effects a more efficient separation of gases and vapors from the liquid fuel than has been possible in present known devices.

While the agitators are primarily effective for separating the gases and vapors from the fuel, they also sufficiently discharge the fully liquid fuel under pressure for normal operations. However, should it be necessary to discharge the fuel at greater than normal pressures, then a pumping impeller may also be provided to receive fully liquid fuel from the agitators and pressure the liquid to a delivery line.

It is, therefore, an object of the present invention to provide improved agitating means for booster pumps which are adapted to more efficiently beat out bubbles of gases and vapors from liquids while simultaneously pressuring the bubble-freed liquid.

A further object of this invention is the provision of a multi-stage propeller pump wherein the propellers successively act on a liquid to beat out bubbles of gases and vapors from the liquid, while simultaneously pressuring the bubble-freed liquid.

Another and further object of this invention is the provision of a propeller pump for consecutively treating liquid material as it flows through a localized passage to free the material

of gases and vapors and simultaneously pressure the gas and vapor-freed material.

Another and further object of this invention is the provision of a pump having a guide spaced from the pump for guiding liquid fuel in a path to the pump inlet and a plurality of agitating propellers positioned in the guided liquid fuel for beating out bubbles of gases and vapors therefrom, which bubbles are guided away from the fuel in said path.

A further object of this invention is the provision of a pump having a plurality of hollow members spaced from each other and from the pump to guide liquid fuel in a path to the pump inlet with agitating propellers adjacent each of said hollow members in the guided path of liquid fuel for simultaneously pressuring and beating out bubbles of gas and vapor from the liquid which bubbles are guided between said hollow members away from said path.

A still further object of this invention is the provision of a booster pump assembly having a plurality of agitating members for simultaneously pressuring liquids and beating out bubbles of gas and vapor therefrom and an impeller for increasing the pressuring of the gas and vapor-freed liquids.

Another object of this invention is to provide a booster pump having a plurality of agitating propellers and a pumping impeller driven from the same source.

A specific object of this invention is to provide a booster pump assembly adapted for aircraft fuel systems, wherein agitating propellers successively treat a liquid fuel to generate bubbles of gas and vapor, wherein the bubbles are guided away from the bubble-freed liquid and wherein the bubble freed liquid is pressured by an impeller to the outlet pump.

The novel features believed to be characteristic of the present invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and manner of construction, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a fragmentary vertical cross-sectional view, with parts in elevation, of a booster pump and fuel tank assembly in accordance with this invention;

Figure 2 is a plan view of the booster pump assembly as seen when disconnected from the fuel tank;

Figure 3 is a view similar to Figure 1 illustrating a modified form of booster pump in accordance with this invention;

Figure 4 is a plan view of the booster pump assembly illustrated in Figure 3 when disconnected from the fuel tank; and,

Figure 5 is a fragmentary vertical cross-sectional view, with parts in elevation, of another form of booster pump in accordance with this invention.

In Figure 1, the reference numeral 10 designates a fuel tank, vented as at 10a, and containing a pond P of liquid fuel such as gasoline. The bottom wall of the tank has a circular aperture therein and a ring 11 mounted thereon around the aperture.

A booster pump 12, of the centrifugal type, includes a casing 13 defining a volute or pumping chamber 14, a discharge outlet 15 for the pumping chamber and a shaft housing 16. The casing 13 is connected with a source of motive power such as an electric motor (not shown) which drives a shaft 17 in the shaft housing 16 of the casing. The casing has an out-turned annular flange 18 for mounting on the bottom wall of the tank 10. This flange receives therethrough cap screws 19 at spaced intervals therearound which are threaded into blind tapped wells in the mounting ring 11. The mounting ring may be welded, soldered or otherwise secured to the bottom wall of the tank. The casing defines a circular opening 20 into which a throat ring 21 is seated and secured to the casing by means of cap screws such as 22.

The throat ring 21 has an aperture 23 therethrough for joining the interior of the tank 10 with the pumping or volute chamber 14. The aperture is flared outwardly to provide an inlet mouth for the booster pump 12, and, if desired, may also be slightly flared at the bottom thereof to increase the passageway to the pumping or volute chamber 14.

A plurality of standards or ribs 24 are spaced around and extend upwardly and inwardly from the throat ring to support an imperforate bell-mouthed annular shield 25. The ribs 24 carry the shield in spaced relation above the throat ring 21.

The shield 25 has an inner face 25a which, as best shown in Figure 1, converges from the upper end of the shield at a relatively high rate to a point intermediate the top and bottom of the shield. The face then converges at a slower rate from this point to the bottom or discharge end of the shield. The smooth continuous curvature of the inner face is especially designed for a high fluid flow capacity.

Additional standards or ribs 26 extend upwardly from the ribs 24 to carry at their upper ends another bell-mouthed annular shield 27. The ribs 26 carry the shield 27 in spaced relation above the shield 25.

The shield 27 has an inner face 27a which, as shown in Figures 1 and 2, converges from the upper end of the shield at a relatively high rate to a point intermediate the top and bottom of the shield in much the same manner as the lower shield 25. Similarly, the face then converges at a slower rate from this point to the bottom or discharge end of the shield. The smooth continuous curvature of the inner face 27a is also especially designed for a high fluid flow capacity.

It will be noted that the portion of the inner face 25a of the shield 25 which is not overlapped by the shield 27 and the inner face 27a of the

shield 27 together form a curved guide for the flow of liquid fuel from the interior of the tank 10 axially into the inlet throat opening 23. The co-acting curved inner surfaces of the annular shields provide a curvature which greatly enhances the pumping capacity of the booster pump since the curvature flares outwardly at the inlet end thereof to receive fuel from the pond P over a relatively large area and then guides the fuel inwardly from this large area along a path having a relatively small vertical component to a point ahead of the discharge mouth of the shield. While the path continues to converge from this point, it converges at a slower rate.

The booster pump 12 has an impeller assembly 28 mounted on the drive shaft 17. This impeller assembly includes a disk or flange portion 29 spanning the inlet or aperture of the throat ring and communicating freely around the periphery thereof with the inner rim of the pumping or volute chamber 14. Pumping vanes 30 are mounted on the flange 29 around the periphery thereof to underlie the throat ring 21. These pumping vanes define, with the throat ring 21 and the flange 29, open ended pumping channels communicating at their outer ends with the pumping or volute chamber 14 and at their inner ends with the flared inlet of the throat ring.

A cap or fairing member 31 extends upwardly from the impeller disk 29. The outer surface of the fairing member tapers upwardly from the pumping channels through the throat ring. As best shown in Figure 1, the axial curvature of the fairing member follows substantially the curvature of the throat ring aperture to guide the liquid to the pumping channels.

It is preferred that the drive shaft 17 extend through the fairing member 31 to receive a four-bladed propeller assembly 32 to be mounted on the free end of the fairing member 31. The blades of the propeller are spaced above the throat ring 21 and below the shield 25 where they are in transverse communication with the liquid between the shield and the throat ring.

A tubular spacer 33 is received over the end of the shaft 17 to seat on the hub of the propeller assembly 32. A second four-bladed propeller assembly 34 is mounted on the spacer 33 and maintained in position thereon by a cap screw 35 which is threaded into a tapped recess (not shown) in the end of the shaft 17. The blades of the propeller 34 are spaced above the shield 25 and below the shield 27 where they are in transverse communication with liquid between the shields.

Liquid fuel from the pond P flows through the shields which guides the liquid in a path axially to the inlet aperture 23 of the throat ring. This path of flow of the liquid fuel is illustrated in Figure 1 by the downwardly extending arrows.

As the liquid flows through the annular guide shields it is successively agitated by the propellers 32 and 34 which agitation separates any entrained gases or vapors from the liquid into bubble form and generates into bubbles any gases or vapors loosely fixed or dissolved in the liquid. These bubbles B are thrown outwardly by the propeller blades to the outside of the shields where they rise in the pond P in a widening path around the shields. As the bubbles rise in the pond they become larger, as shown in Figure 1, and eventually burst at the surface of the pond into the atmosphere to liberate the gases or vapors.

It will be noted that the propeller 32 is aligned

with a space between the throat ring and the annular guide shield 25, while the propeller 34 is aligned with a space between the guide shields 35 and 27. This relation of the elements permits the bubbles of gases and vapors to be thrown outwardly by the propeller blades in the paths illustrated.

Obviously, the greatest separation of entrained gases and vapors from the liquid into bubble form will occur by the agitation of the upper propeller 34. The lower propeller 32 is an auxiliary propeller whereby further gas and vapor separation may be effected.

It has been found that the placing of propellers in such a tandem relation effects a complete separation of all entrained gases or vapors from the liquid into bubble form before the liquid flows through the inlet opening of the pump defined by the throat ring. Furthermore, each of the agitating propellers has the blades thereof at an angle or pitch arranged to push the liquid toward the pump inlet 23. Thus, as shown in Figure 2, the blades of both propellers are pitched so that, when they are driven in a clockwise direction, as indicated by the arrows, they will scoop the liquid to trap it thereunder thus giving the liquid a downward push. This somewhat pressures the liquid even though it is in transverse communication with the pond to effect a constant flow of liquid into the pump.

The gas and vapor-free liquid is then acted upon by the pumping vanes 30 of the impeller 28. Thus the pumping vanes 30 act only on fully liquid fuel to further pressure the fuel into the pumping or volute chamber where it is discharged through the outlet 15 into a delivery line leading to the fuel pump of the engine of the vehicle with which such a fuel system is used.

In certain fuel systems installations and under certain conditions, it has been found that the agitating propellers may sufficiently pressure the liquid to the pump without the need of providing an impeller for this purpose. A pump construction of the type in which the impeller assembly has been eliminated is illustrated in Figure 3.

In the modification shown in Figures 3 and 4, the vented fuel tank 10 has its bottom wall apertured and a mounting ring 11 carried thereon in much the same manner as previously described. A pump 40 has a casing 41 defining angularly extending legs 42 and 43 which converge into an out-turned annular flange 44. The flange has an upwardly extending pilot portion which seats within the aperture in the bottom of the wall of the tank 10. Cap screw 46, spaced around the annular flange 44, extend therethrough into threaded engagement within blind tapped openings in the mounting ring 11 thereby securing the pump to the tank.

The casing 41 has an inwardly tapering surface 47 adjacent the pilot portion 45 and which surface communicates with a pumping channel 48 which sweeps downwardly in a curve through the leg 43.

A plurality of standards or ribs 49 extend upwardly from the pilot portion 45 of the casing. An annular ring or guide shield 50 is carried by the ribs 49 intermediate their ends and spaced above the pump casing. It will be noted that the guide shield 50 is substantially triangular in cross-section and that a thickened inner portion provides a substantially cylindrical opening.

The upper ends of the ribs 49 have secured thereto a bell-mouthed annular shield 51 which

shield is spaced from the shield 50. The shield 51 has an inner face 51a which, as best shown in Figure 3, converges from the upper end of the shield at a relatively high rate to a point intermediate the top and bottom of the shield. The face then converges at a slower rate from this point to the bottom or discharge end of the shield. The inner face 51a has a smooth continuous curvature especially designed for a high fluid flow capacity. This particular curvature has been found to greatly enhance the flow of liquid therethrough since it curves outwardly at the inlet end thereof to receive fuel from the pond P over a relatively large area and then guides the fuel inwardly from this large area along a path having a relatively small vertical component to a point ahead of the discharge mouth of the shield. While the path continues to converge from this point, it converges at a slower rate.

The leg 42 of the pump casing is apertured to receive therethrough a rotatable driving shaft 52 which is driven by a source of motive power, such as an electric motor (not shown).

Spaced four-bladed propeller assemblies 53 and 54 are mounted on the drive shaft 52 with a spacer 55 therebetween and a cap screw 56 or the like threaded to the free end of the drive shaft against the propeller 54.

The propeller 53 is arranged in alignment with and spaced between the pump casing and the guide shield 50 in transverse communication with liquid therebetween. The propeller 54 is arranged in alignment with the space between the guide shields 50 and 51 in transverse communication with liquid therebetween.

As the propellers 53 and 54 are rotated in a clockwise direction, as shown by the arrows in Figure 4, the blades of the propellers are pitched as described above to scoop the liquid and push it into the casing 41 by the driving shaft 52, the liquid from the pond P is drawn and pushed downwardly as indicated by the downwardly extending arrows. The liquid fuel flowing through the guide shield 51 is also agitated by the propeller 50 to separate any entrained gases or vapors from the liquid in a bubble form and to generate into bubbles any gases or vapors loosely fixed or dissolved in the liquid. These bubbles B are thrown outwardly by the propeller blades through the space between the guide shields where they rise through the pond P in a widening path to eventually burst at the surface of the pond to liberate the gases or vapors. Likewise, the propeller 53 agitates the liquid fuel received from the propeller 54 to further separate any gases or vapors left in the liquid into bubbles, which bubbles are thrown outwardly through the space between the pump casing and the guide shield 50 where they rise in the pond to eventually burst into the surface thereof and liberate the gases or vapors.

The tandem action of the propellers on the liquid flowing through the guide shields is thus the same as that previously described with the device illustrated in Figure 1.

In the pump illustrated in Figure 3, the liquid fuel as it leaves the propellers 53 and 54 is pressured sufficiently so that fully liquid fuel is eventually discharged through the pumping channel 48 and the outlet 43 and from there into a line leading into the fuel pump of the engine.

Figure 5 illustrates a further modified form of pump construction somewhat similar to that illustrated in Figure 3. In this construction, a

pump casing 60 extends upwardly to the same height as the guide shield 50 of Figure 3. The pump casing 60 has an annular flange 61 by which the pump is secured to a fuel tank in the same manner as illustrated and described previously herein. A central portion 62 of the casing is formed as an extended pilot to be inserted through an opening in the bottom wall of the fuel tank and terminates in an inwardly tapered surface 63. A pumping channel 64, similar to the pumping channel 48 of the previously described pumping construction, is provided through the casing.

A plurality of standards or ribs 65 extend upwardly from the hollow portion 62 and carry on their upper ends a bell-mouthed annular shield 66. This shield is carried in spaced relation axially of the pilot portion 62 which pilot portion acts as a throat ring. The inner face 66a of the shield converges in much the same manner and for the same reasons as the inner face of the shields 27a of Figure 1 and 51a of Figure 3.

A drive shaft 67 carries thereon spaced four-bladed propellers 68 and 69. These propellers are substantially of the same diameter and in the same spaced relation as in Figures 3 and 4. The propeller 68 is mounted entirely within the pumping channel 64 while the propeller 69 is in alignment with the space between the pilot portion 62 of the casing and the guide shield 66.

The propeller 69 agitates liquid fuel flowing through the guide shield 66 for separating from the fuel any gas and vapors entrained therein. The separated gas and vapor forms into bubbles which are thrown outwardly through the space between the pump casing and the guide shield 66. The gas and vapor-free liquid fuel is then pressured by the propeller 69 to the casing inlet and to the propeller 68. As the propeller 68 lies wholly within the pumping channel 64, the fully liquid fuel will be additionally pressured to the discharge of the pump.

It will be apparent from the foregoing that a multi-stage propeller pump is provided herein by which liquid fuel flowing through a guided path is acted on successively by the propellers to beat out bubbles of gas and vapor entrained therein. The fully liquid fuel is pressured by the propellers simultaneously with the agitating or beating action. Should the pressure of the fuel acted upon by the propellers be insufficient, an impeller may be provided for increasing the discharge pressure of the pump to a value desired.

While particular embodiments of this invention have been illustrated it will, of course, be understood that the invention should not be limited thereto, since many other modifications may be made and, therefore, it is contemplated by the appended claims to cover all such modifications as fall within the true spirit and scope of the present invention.

I claim as my invention:

1. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a pump having an inlet for receiving liquid material from said source, an outlet for discharging fully liquid material, tandem propeller means between said inlet and said outlet for successively agitating the liquid material received through the inlet from said source to beat out bubbles of gas and vapor therefrom and for pressuring the gas and vapor freed liquid material toward said pump outlet, and means defining a path separate from

the inlet for bubble flow from at least one of said propeller means back to said source.

2. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a pump having an inlet for receiving liquid material from said source, an outlet for discharging fully liquid material, and tandem propeller means adjacent said pump inlet positioned to act in the liquid material flowing from the source to the pump outlet, at least one of said propeller means being arranged for transverse communication with a body of liquid material surrounding the liquid material entering the inlet, said propeller means successively agitating the liquid material before it becomes trapped in the pump to beat out bubbles of gas and vapor therefrom and for pressuring the gas and vapor freed liquid material toward said pump outlet.

3. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a pump having an inlet for receiving liquid material from said source, an outlet for discharging fully liquid material, means arranged in tandem positioned in advance of the pump inlet to act in the liquid material flowing to the pump inlet for agitating and pressuring said liquid material toward the pump inlet, said means including a plurality of propeller means successively agitating the liquid material to beat out bubbles of gas and vapor therefrom, and means defining paths extending outwardly from the propeller means back to the source.

4. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing having an inlet and an outlet, a guide shield mounted in advance of and spaced from said casing inlet, and means arranged in tandem and positioned to act in the liquid material flowing through a path defined by the shield and the casing for agitating and pressuring said liquid material, said means including a plurality of propeller means successively agitating the liquid material to beat out bubbles of gas and vapor therefrom.

5. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing having an inlet and an outlet, guide shield means mounted in advance of and spaced from said casing inlet, and means arranged in tandem and positioned to act in the liquid material flowing through said guide shield means and said casing for agitating and pressuring said liquid material, said tandem arranged means including a plurality of propeller means successively agitating the liquid material to beat out bubbles of gas and vapor therefrom, at least one of said propeller means being arranged for transverse communication with a body of liquid material surrounding the liquid material flowing through said guide shield.

6. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing defining an inlet and an outlet, a plurality of spaced guide shields mounted in advance of and spaced from said casing inlet, and a plurality of propellers positioned in the flow path defined by the shields and arranged in tandem for successively agitating and pressuring liquid material flowing through said guide shields to beat out bubbles of gas and vapor from the material, said

propellers being arranged for transverse communication at the spaces between said shields and casing with a body of liquid material surrounding the liquid material flowing through said shields.

7. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing defining an inlet and an outlet, a plurality of spaced guide shields mounted in advance of and spaced from said casing inlet, a propeller in alignment with each space between adjacent guide shields and between a guide shield and the casing, said propellers being arranged in tandem in the flow path defined by the shields and means for co-rotating said propellers for successively agitating and pressuring liquid material flowing through said guide shields to beat out bubbles of gas and vapor from the material.

8. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing defining an inlet and an outlet, a plurality of spaced guide shields mounted in advance of and spaced from said casing inlet, said guide shields defining a curved localized flow path to the casing inlet, a propeller in alignment with each space adjacent said guide shield, and means mounting said propellers in tandem in the flow path and co-rotating the propellers for successively pressuring and agitating liquid material flowing in said curved path to beat out bubbles of gas and vapor and to throw said bubbles outwardly through said spaces in alignment with the propellers.

9. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing defining an inlet and an outlet, a plurality of ribs around said casing inlet and extending away from the casing, a plurality of guide shields carried by said ribs in spaced relation to each other and to said casing, said guide shields defining a curved localized flow path for increasing the flow of liquid material from the source to said casing inlet, propellers within said guide shields aligned with the spaces adjacent said guide shields, and means for rotating the propellers for successively axially pressuring and radially agitating the liquid material flowing in said curved path to beat out bubbles of gas and vapor and to throw said bubbles outwardly through the spaces in alignment with the propellers.

10. A booster pump construction comprising a casing defining an annular pumping chamber, an impeller mounted centrally of said pumping chamber and extending into the periphery thereof, a throat ring having an aperture therethrough flaring away from said pumping chamber, spaced guide shields in advance of and spaced from said throat ring defining a flow path to the throat ring aperture, an agitating propeller in said flow path between said throat ring and an adjacent guide shield, another agitating propeller in said flow path between said spaced guide shields, said propellers being arranged for free transverse communication through the spaces adjacent thereto with a body of liquid surrounding the guide shields, and means for rotating said impeller and propellers for successively pressuring said liquid material toward said pumping chamber and for successively beating out bubbles of gas and vapor from the liquid and throwing the bubbles outwardly through said adjacent spaces.

11. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing defining an inlet and an outlet, overlapped spaced annular guide shields mounted in advance of and spaced from said casing inlet, said guide shields co-acting to define a flared flow path converging toward said casing, and agitating means in said flow path for beating out bubbles of gas and vapor from the liquid material therein.

12. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing defining an outlet and an inlet having a flared mouth, guide shield means mounted in advance of and spaced from said casing inlet defining a flow path to said inlet, and a plurality of propellers positioned to act on liquid flowing through the guide shield and casing for pressuring and beating out bubbles of gas and vapor from the liquid material.

13. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing defining an inlet and an outlet with a channel therebetween, a guide shield mounted in advance of and spaced from said casing inlet to define a flow path to said inlet, and a plurality of propellers positioned to act on liquid flowing through said shield and said casing channel for beating out bubbles of gas and vapor from the liquid material and for pressuring the beaten liquid material toward the casing outlet.

14. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing having a channel therethrough defining an inlet at one end and an outlet at the other end, a relatively shallow annular guide shield adapted to be mounted in the source of liquid material in spaced relation from said casing at the inlet end thereof, a propeller positioned in the flow path through the shield in alignment with the space between said shield and casing, an additional propeller in said channel, and means for rotating said propellers for successively pressuring and beating out bubbles of gas vapor from the liquid material.

15. A device adapted for discharging fully liquid material, such as volatile fuel, from a source of liquid material which comprises a casing having a channel therethrough defining an inlet at one end and an outlet at the other end, a relatively shallow annular guide shield adapted to be mounted in the source of liquid material in spaced relation from said casing at the inlet end thereof, said shield having a curved inner surface and a relatively flat outer surface, the adjacent surfaces of said shield and casing sloping upwardly and away from the axis of said casing inlet, a propeller positioned in the flow path to said inlet and arranged for free transverse communication through the space between said shield and casing with a body of liquid material surrounding the guide shield, another propeller in said channel, and means connecting said propellers for co-rotation whereby the propellers successively pressure and beat out bubbles of gas and vapor from the liquid material guided through said shield into and through said channel.

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