March 11, 1958 LE ROY H. BARR ET AL 2,826,150

LIQUID AND VAPOR SEPARATING PUMP

Filed Dec. 21, 1954 2 Sheets-Sheet 1

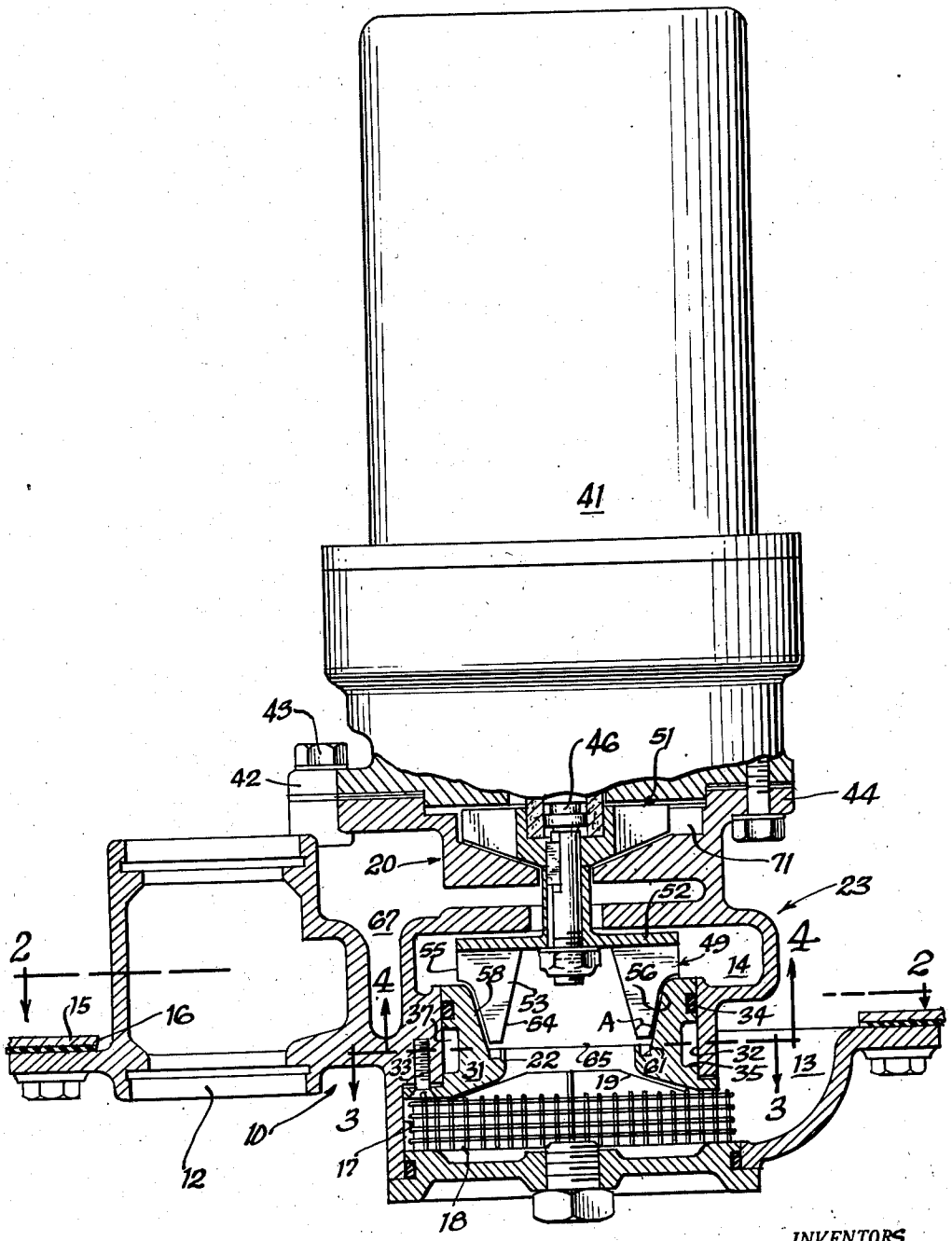


FIG. 1

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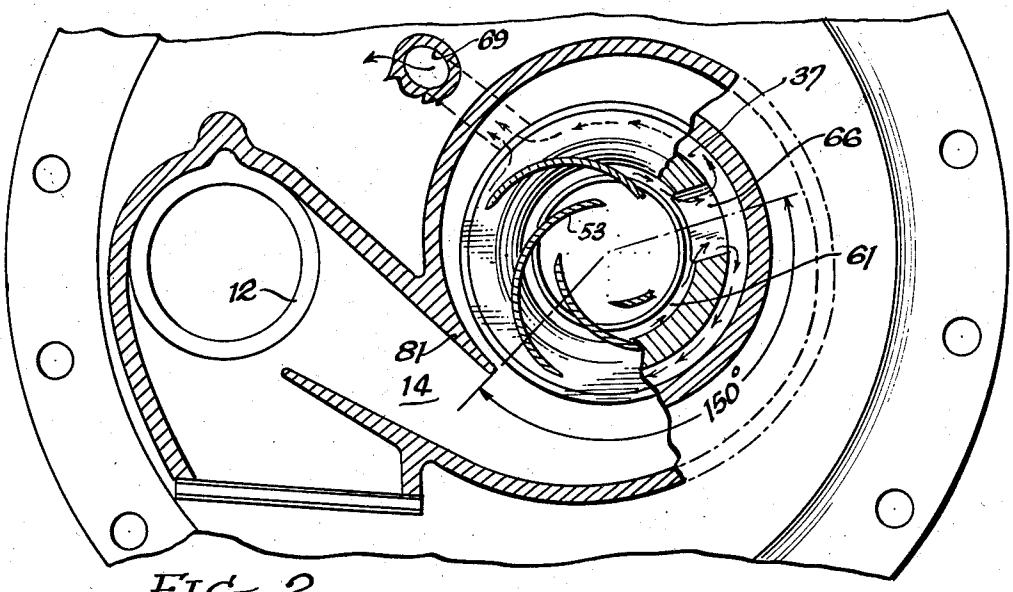


FIG. 2

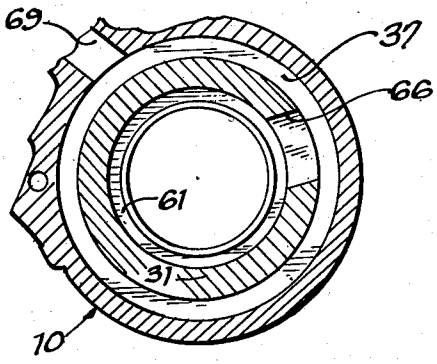


FIG. 3

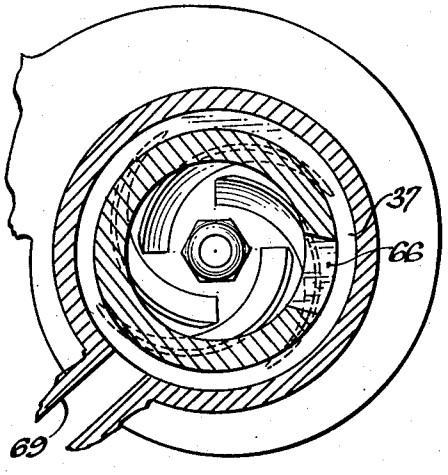


FIG. 4

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LIQUID AND VAPOR SEPARATING PUMP

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Application December 21, 1954, Serial No. 476,690
5 Claims. (Cl. 103—113)

This invention relates to a pump for liquid fuel. More particularly, it has reference to a booster pump as frequently employed aboard aircraft adjacent the fuel tank for pressuring gasoline therefrom to another point in the fuel-feeding system. Customarily, the entire pump, including its driving motor, is submerged in the fuel, for example, as disclosed in U. S. Letters Patent No. 2,418,221, granted to Russell R. Curtis.

At higher altitudes vaporization of the fuel presents a serious problem as the vapor bubbles rising in the body of fuel are pumped along with fuel and cause interference with operation of the engines, sometimes referred to as "vapor lock." Expressed otherwise, the moment the boiling point of the fuel is reached, the same is devoid of sufficient energy to move into the pump, and such condition is also described as "vapor lock." The problem of separating the vapor bubbles occluded in the fuel is by no means new, and has presented a constant challenge to workers in this art, as exemplified by a large body of patented art which includes the Curtis patent above noted. Accordingly, any elaboration of the problem and its causes is deemed superfluous.

The present invention relates to a fuel booster pump having an improved arrangement for effecting efficient separation of the occluded vapor from the fuel prior to the discharge of the same from the pump outlet and the return of the vapor to the fuel supply wherein it rises to the surface, and the accomplishment of such object by extremely simple means.

The invention arrangement performs a dual function, since it not only separates the vapor bubbles from the fuel during periods when violent boiling is not prevalent, but performs a continuous priming action during such time as boiling is at a peak rate.

Other objects will become apparent from the ensuing description taken together with the accompanying drawings, in which latter:

Fig. 1 is a combined side elevational view and cross section showing the improvement of the invention;

Fig. 2 is a cross section taken on the line 2—2 of Fig. 1;

Fig. 3 is a cross section taken on the line 3—3 of Fig. 1 and

Fig. 4 is a cross section taken on the line 4—4 of Fig. 1.

While the invention will be described in connection with a hydroturbine type of centrifugal impeller, it will become apparent that the same will find adaptation to impellers having a configuration differing from the example.

Turning now to the drawings, there is shown one design of booster pump incorporating the invention and wherein the numeral **10** designates the body or casing of the pump, including means defining a discharge port **12**, an inlet port **13** and a volute discharge chamber **14**. The body **10** and its therewith-assembled parts to be described is secured to a wall **15** of the fuel tank through a suitable opening **16**. Parenthetically, it will be noted that the port **12** is of the known dual type whereby the associated outlet conduit may be connected at either end, whereupon the unused opening will be suitably closed off. Inlet **13** includes a cylindrical chamber **17** occupied by the customary strainer **18**.

A shroud **31** is fitted within a cylindrical opening **32**

of the body **10** and is secured thereto by means of screws **33**, although the same may, if desired, be integral, in whole or part, with the casing **10**. A ring gasket **34** serves as a seal. Shroud **31** is provided with a peripheral channel **35** defining with the wall of the opening **32** an annular passage **37**, the purpose of which will be detailed hereinafter.

An electric motor **41** is secured, by means of a flange **42** and screws **43** to a suitable pad **44** of the body **10** and carries on its shaft **46** a centrifugal or primary impeller **49** and a secondary impeller **51** forming part of a suitable source of suction, for example, a water-ring pump.

The impeller **49** comprises a hub **52** bearing a plurality of helical vanes **53** (Figs. 2 and 4) supported thereon at their upper end and terminating inwardly on a frusto-conical surface **54** or eye of the impeller, although not to be regarded as so limited. At their outer periphery the vanes **53** terminate in part on a cylindrical surface **55** and a frusto-conical surface **56** likewise not to be regarded as limitative. The surface of the shroud **31** is conformed over part of its extent, namely **58**, to the adjacent periphery **56** of the vanes **53** except for the customary running clearance, as shown.

The configuration of the lower ends of the several vanes **53** is such as to cause them to fall within an annular area A. In the present example such area A has an inner diameter of 1⅛ inches and an outer diameter of 1½ inches. The angle of the surfaces **56** and **58** to the vertical is 13¼°, and the vertically measured height of the impeller vanes **53** is ⅞ inch. At their junction with the hub **52** the ends of the vanes fall within an annular area of ¾ inch interior diameter and 2$\frac{1}{32}$ inches exterior diameter and the four vanes shown commence inwardly tangentially to the ¾″ circle and are provided with an exit angle of 10°. Otherwise the same are as found generally in centrifugal pumps.

The shroud **31** is provided with a shoulder having an annular groove **61** preferably of rectangular transverse cross section but which latter may take other forms as long as an area is defined sufficient to pass the maximum volume of vapor and/or liquid by-passed thereto by the action of the impellers **49** and **51** and as will be elaborated upon hereinafter. In the present example the groove **61** has an internal diameter of 1.156 inches and an external diameter of 1.389 inches, making an effective width of 0.117 inch approximately, and a depth of 0.097 inch. The arrangement of the impeller **49** relative to the groove **61** is such that the zone A defined by the former is at least equal to the width of the groove and coextensive therewith. The gap **65** need be only sufficient to afford running clearance.

Groove **61** is in fluid communication, via a passage **66** (Fig. 2) with the passage **37**, and such latter passage is, in turn, in fluid communication with a chamber **67** via a passage **69**. Chamber **67** constitutes the inlet of a second pump, for example, a water-ring pump which includes the secondary impeller **51** and of which chamber **71** is the outlet. Such outlet communicates, by means of a conduit, not shown, with the interior of the tank **15** for delivery of the recovered vapor and some quantity of fuel thereto.

Operation is as follows: Assuming the pressure in the tank **15** is such that fuel vapor is being generated the input to the main pump **23** at **13** comprises liquid and occluded vapor which pass upwardly through the throat **22** to the eye **54** of the impeller **49** and thence into the intervane spaces. Vapor bubbles appearing within the zone of influence of the impeller vanes are forced, by the separative effect of centrifugal force to flow to the area of smallest diameter within the rotative effect of the vanes, i. e., to within the inner ends of the passages between the

impeller vanes. If, now, an axial force is applied at the zone of accumulation of the bubbles the same will be withdrawn. Thus we provide the groove **61** toward which the bubbles are constrained to move under the influence of the suction of the secondary pump **20**. Concurrently the liquid, being of higher density, is traversed radially and upwardly in the space confined by the wall **58** and outwardly into the volute **14** to the pump outlet **12** (Fig. 2). The vapor passes from the groove **61** into the passage **37**, through the passage **69** and into and through the secondary pump **20** for return to the mass of fuel in the tank.

Essentially the improved separation resulting from the invention structure is the removal of the vapor as close as may be permitted to the eye of the impeller without restricting the size of the inlet, and by application of axially applied suction sweeping the bubbles from the free lower end of the vanes.

It has been recognized that vapor bubbles may be separated from the liquid in a zone near the eye of the impeller. However, prior provisions for effecting this end have assumed that the bubbles accumulate at the extreme inner edge of the vanes, whereas we have found that the bubbles are substantially separated from the liquid over a zone extending outwardly from the inner edge of the vanes. Accordingly, sweeping of the bubbles from the zone of accumulation has been found to be accomplished best by applying the axial suction over an annular area corresponding to that portion of the impeller whereat the bubbles have their maximum concentration.

Another important factor has been found to be the relative angular location of the channel **66** to the cutwater defining the narrowest part of the volute **14**. In a pump in accordance with the invention, such angle is preferably in the range from 120° to 180°, measured in the direction of rotation, although for clarity in the drawing it is shown as just 150°. Experience has shown that the selection of such angle can critically affect the separating action. Optimum results under the operating conditions generally encountered with aircraft operating up to say 25,000 feet altitude have been realized with the angle of 150° as shown.

While we have shown a particular embodiment of my invention, it will be understood, of course, that we do not wish to be limited thereto since many modifications may be made, and we therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of our invention.

We claim:

1. A pump for delivering fluid under pressure and simultaneously separating vapor bubbles occluded in the fluid therefrom comprising a centrifugal impeller, a casing defining a pump chamber including a volute for receiving the discharge of the impeller, said impeller having a plurality of vanes, said vanes having an interior boundary constituted as a surface of revolution forming the eye of the impeller for inlet of fluid to the vanes, a portion of said casing defining an inlet throat substantially coextensive with the radial cross section of said eye and an inlet channel for the liquid and its therein-occluded vapor in communication wtih said throat, a driving source, a hub forming part of said impeller driven by said source, said vanes being carried at one end on said hub and the free ends whereof, in rotation, sweeping out an annular area positioned in a plane normal to the axis of rotation, a shoulder on said casing contiguous to said free ends positioned in a plane normal to the axis of rotation and juxtaposed to said first plane, said shoulder having an annular groove substantially coextensive with said annular area opening in said second plane and confronting said free ends of said vanes, said volute receiving liquid discharged from said vanes and said groove receiving vapor accumulating at the innermost zone of said vanes, and a source of suction in communication with said groove for providing a force through said groove for removing the vapor delivered thereto from said vanes.

2. A pump in accordance with claim 1 wherein said source of suction is a pump of the water ring type.

3. A pump for delivering fluid under pressure and simultaneously separating therefrom vapor bubbles occluded in the fluid comprising a centrifugal impeller, a casing defining a pump chamber including a volute for receiving the discharge from the impeller and a substantially frusto-conical inlet throat disposed in an axial direction to one side of the volute and coaxial with the impeller rotational axis, said impeller having a plurality of vanes terminating in part at their outer periphery on a frusto-conical surface congruent with the wall of said throat and separated therefrom by a space sufficient to provide running clearance therebetween, said vanes terminating inwardly of the impeller to define a frusto-conical eye inverted with respect to the slope of the outer periphery of the vanes whereby to provide vanes narrower at one end than at the other and terminated in blunt ends lying in an annular zone normal to the axis of rotation, said impeller having a hub whereupon the wider ends of the vanes are supported, a portion of said casing defining a shoulder extending inwardly substantially at the smaller diameter of said throat positioned in a plane parallel to said annular zone, said shoulder having a circular groove therein confronting said annular zone and separated therefrom by running clearance, said shoulder defining a central opening substantially coextensive with the eye of the impeller and providing an inlet passage to the impeller, a source of suction and means forming a fluid passage from said groove to the inlet of said source for withdrawing vapor bubbles from the innermost extent of said vanes toward and into said groove.

4. A pump in accordance with claim 3 wherein said passage-forming means includes a conduit in fluid communication with said groove, said volute includes a cutwater and the axis of said conduit is displaced angularly counter to the direction of rotation of said impeller by an angle of substantially 150°.

5. A pump for delivering fluid under pressure and simultaneously separating therefrom vapor bubbles occluded in the fluid comprising a centrifugal impeller, means defining a casing for the pump including a volute for receiving the fluid discharge from the impeller, said impeller including a hub member and a plurality of vanes outstanding therefrom, said vanes collectively having a mutual cylindrical periphery for a portion of their axial extent beginning at the junction with the hub member and said periphery continuing as a frusto-conical boundary to the free end of said vanes whereby said vanes are blunt and narrower radially at their free end than at the hub end, said vanes terminating centrally on a surface which is a surface of revolution to define an inlet eye for the impeller, said casing having an inlet passage substantially coextensive cross-sectionally with the cross-sectional transverse extent of said surface of revolution, means on said casing defining an annular groove opening toward the blunt end of said vanes, the open face of the groove being substantially coextensive with the annular area swept out by the blunt ends of the vanes and separated therefrom by running clearance, said volute including a cutwater, conduit means connecting said groove and the area of the eye of said impeller, and the junction of said conduit means with said groove being displaced angularly from the tip of the cutwater counter to the direction of rotation by an angle in the range of from 120° to 180°.

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