Oct. 8, 1946. R. R. CURTIS 2,408,918

SLOTTED THROAT BOOSTER PUMP

Filed March 25, 1944

Fig. 1.

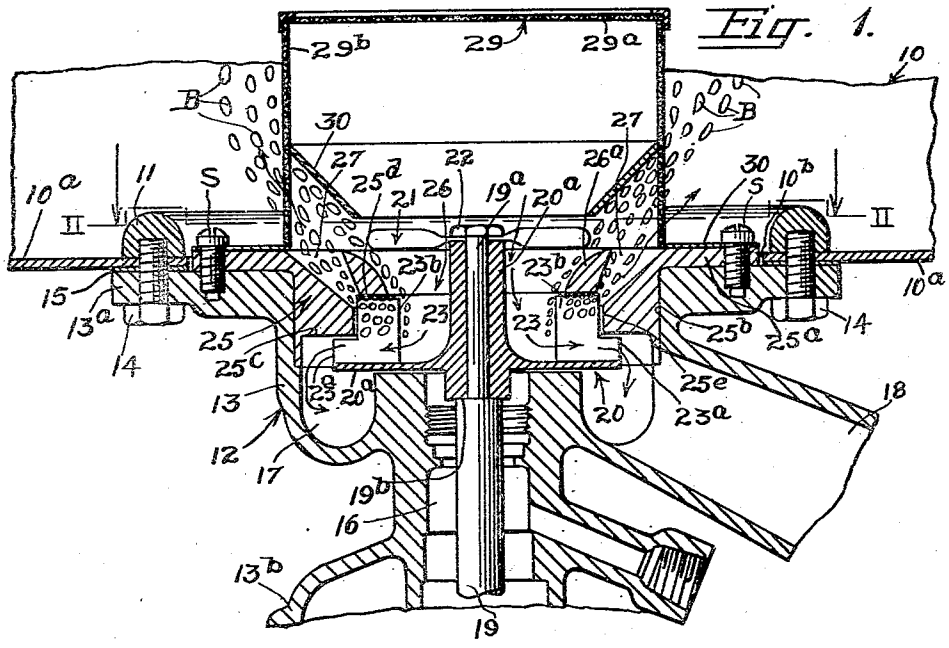
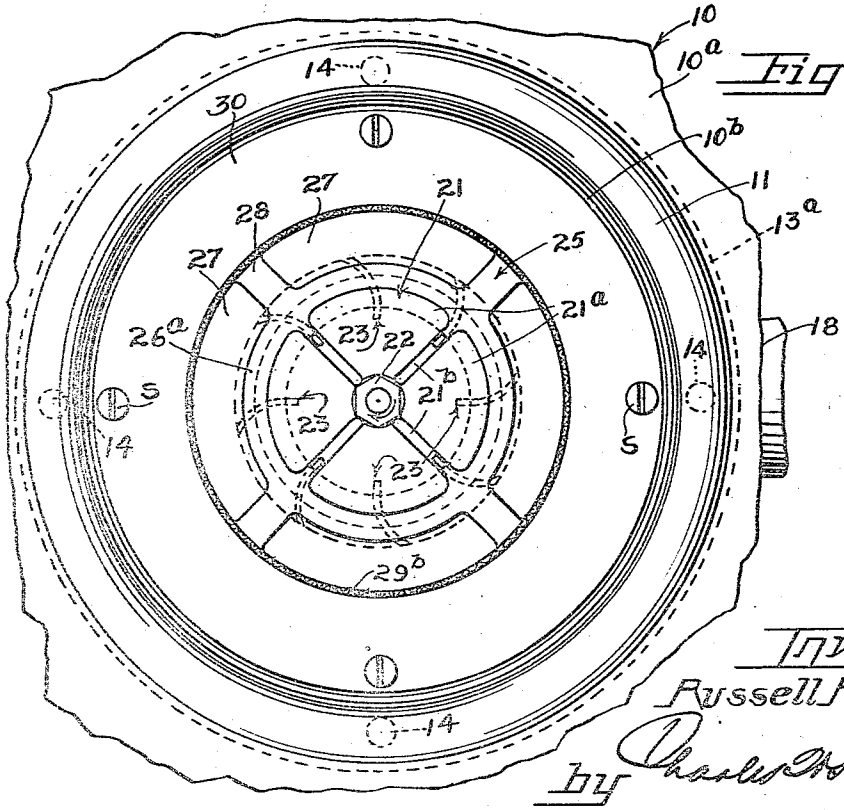


Fig. 2.



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SLOTTED THROAT BOOSTER PUMP

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11 Claims. (Cl. 103—113)

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This invention relates to pump and vapor separators especially adapted for high altitude aircraft fuel systems to maintain flow of fully liquid fuel to the airplane engine.

Particularly the invention deals with booster pumps having impellers which pump and agitate liquid at one velocity to liberate bubbles of gas and vapor from the liquid while causing the liquid to flow and then increase the velocity of the gas and vapor-freed liquid to maintain efficient pumping capacity.

While the invention will be hereinafter specifically described in connection with a booster pump unit for an airplane fuel system to efficiently liberate gases and vapors from the fuel before they become trapped in the pump and to pressure the fully liquid fuel sufficiently to prevent additional liberation of gases and vapors therefrom, it should be understood that the invention is not limited to fuel systems, since units of the invention are adapted for use wherever pumps and vapor separators are desired.

In accordance with the invention a pump casing is suspended on the bottom wall of a fuel tank and has a central inlet throat receiving fuel by gravity flow from the tank, together with an annular pumping chamber and an impeller for pumping liquid from the throat through the pumping chamber. The impeller has upstanding curved centrifugal type pumping vanes thereon, the inner portions of which are deep sectioned or relatively high and the outer portions of which are short sectioned or relatively low. The high inner portions of the vanes have communication at their inner ends with the pump inlet and also have communication at their upper outer ends with slots or an annular passageway communicating with the interior of the fuel tank. The passageway and inlet to the pump are preferably provided by a single throat ring secured on the pump casing to provide a top for the pumping chamber thereof, to cooperate with the upper ends of the impeller vanes or blades for defining wide and narrow channels, to form a converging throat inlet mouth for the pump, and to provide an annular slot or pasageway surrounding this inlet for return of bubbles back to the tank. In addition, the pump is preferably equipped with an agitating propeller mounted in advance of the pump inlet to act on fuel in the tank about to enter the pump. This propeller ejects a lateral stream of bubble-rich liquid away from the pump and the bubble-rich stream of liquid flowing through the slot or annular passageway of the throat ring can merge with this

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lateral stream ejected by the propeller to circulate around fuel being fed downwardly to the pump. The bubbles rising in the tank burst at the surface of the pond of fuel to discharge their occluded gases or vapors above the pond. Since the tank is preferably vented at the top thereof, the discharged vapors and gases escape to the ambient air.

The deep sectioned or high pumping vanes operate in a deep or high channel communicating at its bottom end with a shallow or low channel in which the shorter vanes operate. This provides for low velocity of the liquid in the deep channel where agitation takes place, and high velocity in the shallow section where efficient pumping takes place. The maintenance of low velocity in the agitating portion of the channel prevents entrainment of bubbles of gas and vapor in the material being pumped since these bubbles rise in the channel to hug the upper wall thereof and are, of course, ejected through the slot or passageway by the outer ends of the deep sectioned vanes.

The pumps of this invention have enhanced vapor separating capacity together with efficient pumping capacity.

It is, then, an object of the invention to provide booster pumps for high altitude aircraft fuel systems wherein liquid fuel is first agitated in a tank as it is about to enter a pump, is next agitated at low velocity in the pump to liberate additional bubbles of gas and vapor from the liquid which bubbles are ejected back to the tank while the bubble-freed liquid is accelerated to higher velocity.

A further object of the invention is to provide a vapor separator and pump which pumps liquid in high and low velocity stages and beats out bubbles of gas and vapor during the low velocity stage.

Another object of the invention is to provide a pump having centrifugal pumping vanes in free communication at their inner ends with material to be pumped, and in restricted communication at their outer ends with the source of material being pumped and with liquid material being pumped to a higher velocity.

Another object of the invention is to provide a pump with an inlet, an outlet, a vent between the inlet and outlet, and an impeller having agitating vanes operating in a low velocity channel between the inlet and vent, and pumping vanes operating in a high velocity channel between the vent and outlet.

Another object of the invention is to provide

a vapor separator and pump which has a deep channel and a surrounding shallow channel in which pumping vanes rotate to agitate liquid at low velocities in the deep channel and to pump the agitated liquid at high velocities in the shallow channel.

Other and further objects of the invention will be apparent to those skilled in the art from the following detailed descriptions of the annexed sheet of drawings which, by way of preferred example only, illustrates one embodiment of the invention.

On the drawing:

Figure 1 is a vertical cross-sectional view, partly in elevation, and with parts broken away, of a slotted throat booster pump and fuel tank assembly in accordance with this invention.

Figure 2 is a fragmentary plan view taken along the line II—II of Figure 1.

As shown on the drawing:

In Figures 1 and 2 the reference numeral **10** designates generally a tank such as a fuel tank of an airplane. The tank **10** has a bottom wall **10***a* with a large opening **10***b* therein. A mounting ring **11** is disposed in the tank on the bottom wall **10***a* thereof around the opening **10***b*. A pump **12** has a casing **13** with an outturned flange **13***a* around the upper end thereof underlying the bottom wall **10***a* of the tank and receiving cap screws **14** therethrough which are threaded into the mounting ring **11** to suspend the casing on the bottom wall of the tank. A gasket **15** can be interposed between the flange **13***a* and the bottom wall **10***a* of the tank to prevent leakage between the flange and tank wall.

The casing **13** defines a central shaft well **16**, an annular open-topped pump chamber **17** surrounding the well, and a discharge nipple **18** for the pumping chamber **17**.

A pump shaft **19** extends through the well **16**. This shaft **19** is preferably connected to an electric motor in a casing suspended from a head portion **13***b* of the casing **13**. The motor is not shown. The shaft **19** has a reduced upper end portion **19***a* and a flat shoulder **19***b* is provided on the shaft adjacent the upper end of the well **16**.

A pump impeller **20** has a central hub portion **20***a* disposed around the reduced diameter portion **19***a* of the shaft and bottomed on the shoulder **19***b*. The hub **20***a* extends into the tank **10** and a propeller **21** is mounted on the upper end of the hub around the shaft portion **19***a*. A nut **22** clamps the propeller hub onto the shaft and impeller.

As shown in Figure 2, the propeller **21** has four wide blades **21***a* with narrow slots **21***b* therebetween. The blades **21***a* have a relatively flat pitch and the leading end of one blade is displaced above the trailing end of the adjacent blade.

The impeller **20** has a flat disk or flange portion **20***a* spanning the shaft well **16** and overlying a portion of the open top of the pumping chamber **17**. Curved upstanding vanes **23** are mounted on or formed on the disk **20***a* around the marginal portion thereof and extend only from the periphery of the disk into spaced relation from the hub portion **20***a* thereof. Each vane **23** has an outer end portion **23***a* that is relatively shallow or short, and a higher or deeper inner end portion **23***b* in stepped relation to the shallow portion **23***a*.

A throat ring **25** is mounted on the casing **13** and includes a peripheral flange **25***a* overlying the flange **13***a* of the casing and secured to the

casing by means of screws S. The throat ring **25** has a cylindrical portion **25***b* fitting into the open top of the casing **13** to provide a top wall for the pumping chamber **17**. The end wall of the throat ring **25** disposed in the casing is stepped and has a portion **25***c* overlying the shallow vanes **23***a* together with a portion **25***d* overlying the deep vanes **23***b*.

The throat ring defines a central inlet opening **26** to the pump and has a wall **26***a* defining this opening. The wall **26***a*, as shown, flares outwardly to provide a converging throat. A plurality of segmental annular slots **27** are formed in the throat ring around the opening **26** thereof communicating with the upper outer ends of the vanes **23***b*. As shown in Figure 2, webs **28** connect the inner wall **26***a* of the throat ring with the outer body portion of the throat ring.

As best shown in Figure 1, the vane portions **23***a* are disposed in closely spaced relation to the end wall **25***c* of the throat ring but have operating clearance therewith. Likewise, the upper ends of the vane portions **23***b* are in closely spaced relation with the end walls **25***d* of the throat ring.

The throat ring, in addition, has a side wall **25***e* in operating clearance relation with the outer edges of the vane portions **23***b* and extending into communication with the slots **27**.

An inverted cup screen **29** is disposed over the inlet mouth **26** of the pump and also over the inlet mouths of the slots **27** of the pump. This screen has a flat top wall **29***a* disposed in the tank **10** in spaced relation above the bottom wall **10***a* thereof together with a cylindrical side wall **29***b* the open end of which receives therearound a mounting ring **30**. This mounting ring **30** can receive the screws S therethrough to connect the screen **29** to the throat ring.

An inverted frusto-conical guide shield or ring **30** is mounted in the screen **29** on the side wall **29***b* thereof in spaced relation above the propeller **21**. This guide shield **30** has a large open top end and a smaller open bottom end. The open bottom end of the guide shield **30** is immediately above the propeller **21**.

The pump and vapor separator of this invention operates by receiving liquid such as gasoline in the tank **10** through the screen **29** and guide shield **30**. The gasoline, as it leaves the open bottom end of the guide shield, is immediately acted upon by the propeller **21**, and this propeller beats and agitates the gasoline to liberate gases and vapors therein in the form of bubbles B. These bubbles B are ejected in a lateral stream away from the pump opening **26** to flow as a bubble-rich stream back through the screen **29** along the outer face of the guide shield **30**. The bubbles pass through the screen and rise in the pond of fuel in the tank where they can burst at the surface of the pond to discharge their occluded gases and vapors to the ambient air.

The agitated and beaten fuel is also pressured axially by the propeller **21** into the throat opening **26** where it comes into contact with the vane portions **23***b* of the impeller **20**. The innermost ends of the vane portions **23***b* are exposed to the throat opening **26**, being uncovered as shown in Figure 1, and these uncovered portions further agitate and beat the fuel to liberate additional bubbles B therefrom.

The vanes **23***b*, besides their agitating function, are curved to act as centrifugal impellers for causing a lateral or radial outward flow of the fuel. This initial outward flow of fuel is at

relatively low velocity because the vane sections are quite deep and the pumping channel between the disk **20***a* and the throat ring end face **25***d* is quite wide. Additional bubbles B may be liberated by the vanes **23***b* and, being lighter than the fuel, these bubbles hug the end face or wall **25***d* tending to rise in the liquid. However, the vanes create a lateral outward flow of liquid for sweeping these bubbles into the slots **27**, where they are ejected back to the pond of fuel in the tank to merge with the laterally flowing stream of bubbles from the propeller **21**.

The bubble-freed fully liquid fuel is thrown outwardly by the vane portions **23***b* at the bottom ends of these vanes and is picked up by the shallow vane portions **23***a* which are continuations of the portions **23***b* but operate in a shallower or narrow pumping channel between the disk **20***a* and the end wall **25***c*. Velocity of the fuel is increased due to the reduced flow channel for the liquid and the liquid is centrifugally discharged through the pumping chamber **17** to the outlet nipple **18** from which it is conveyed to a fuel line (not shown) to the inlet of an engine fuel pump.

The pumps of this invention effect an initial beating and axial impelling action on the fuel caused by the propeller **21** followed by a secondary beating and low velocity radial impelling action on the fuel caused by the vane portions **23***b* and then a high velocity radial impelling action only on the agitated bubble-freed liquid fuel. The initial and secondary beating actions produce very efficient separation of vapors from liquid material such as gasoline or other volatile liquid. However, the liquid is also accelerated to flow at increasing velocities through the successive operating stages in the pump. The first acceleration stage is in an axial direction into the inlet of the pump. The second stage is in a radial or outward direction from the pump inlet toward the pumping chamber. Both of these stages are vented sufficiently back to the interior of the tank so that any bubbles released from the fuel are actually forced back to the tank while only the fully liquid material is forced to the final pumping stage.

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. In combination with a container for a pond of liquid to be pumped, a vapor separator and pump suspended on the bottom wall of said container having an inlet mouth receiving the liquid material by gravity flow from the container, a low velocity pumping chamber in said pump receiving the liquid material from said inlet, a high velocity pumping chamber receiving the liquid from said low velocity pumping chamber, bubble-liberating means in said low velocity chamber, and said pump having a vent joining said low velocity pumping chamber with the interior of the container, said vent communicating with said high velocity pumping chamber solely through said low velocity pumping chamber.

2. In a vapor separator and pump, a deep first stage pumping chamber, a shallow second stage pumping chamber, bubble-liberating means in said first stage pumping chamber, and means providing a passageway connecting said first stage pumping chamber to the source of material supplying the pump.

3. In a centrifugal type booster pump having a central inlet and an annular pumping chamber with a peripheral outlet, a deep first stage pumping channel receiving liquid from said central inlet, a shallow second stage pumping channel connecting the first stage channel with the pumping chamber, an impeller having deep and shallow vanes operating in said channels, and means defining an annular passageway surrounding the inlet of the pump for venting the upper outer end of the first stage channel.

4. A centrifugal type booster pump having a central inlet, an annular pumping chamber with a peripheral outlet, and an impeller for pumping liquid from the inlet through the pumping chamber to the outlet, the improvements which comprise intercommunicating adjoining deep and shallow annular channels connecting the inlet with the pumping chamber, deep and shallow pumping vanes operating in said channels, and means defining an annular passageway venting the deep channel.

5. A centrifugal type booster pump having a central inlet, an impeller spanning said inlet, a pumping chamber receiving material from the impeller, and means defining a substantially annular passageway surrounding the inlet and connecting an intermediate portion of the impeller with the source of material flowing through the inlet.

6. In a centrifugal type booster pump, a throat member defining a central inlet to the pump, said throat being slotted to form a segmented annular passageway around said central inlet thereof, a pump impeller, and an agitating vane portion on said pump impeller communicating with the inlet and with said passageway.

7. In a centrifugal type pump, the improvement which comprises an impeller having a flat flange portion, upstanding pumping vanes on one face of said flange portion extending from the periphery thereof into spaced relation from the central portion thereof, said upstanding vanes having short outer end portions and high inner end portions in stepped relationship.

8. A pump and vapor separator comprising a pump casing defining an annular open topped pumping chamber and a central shaft well, a shaft extending through said well, a pump impeller on said shaft having a flat disk portion spanning the shaft well and a portion of the open top of the pumping chamber, upstanding vanes on the marginal portion of the disk having high inner portions and lower outer portions, a throat ring on said casing having a converging throat opening and an opening surrounding the throat opening together with a stepped end wall forming a top for the pumping chamber and overlying the high and low portions of the vanes in closely spaced relation, said throat opening communicating with the inner ends of the high vane portions, and said openings surrounding the throat opening communicating with the outer ends of the high vane portions, said high vane portions being effective to propel liquid from the inlet at low velocity while agitating the liquid to liberate bubbles therefrom through the openings surrounding the throat opening, and said lower vane portions being effective to pump at high velocity fully liquid material received from the high vane portions.

9. A centrifugal type booster pump and vapor separator comprising a pump having a central

inlet, an agitating propeller in advance of said inlet but spanning the inlet to agitate liquid about to enter the inlet, a two-stage impeller in said pump having low velocity pumping vane portions receiving liquid from the inlet and partially exposed in the inlet to agitate the liquid together with high velocity pumping vane portions receiving liquid from said low velocity pumping vane portions, and means defining an annular passageway surrounding the inlet connecting the outer ends of the low velocity pumping vane portions with the source of material supplying the inlet.

10. A fuel system for aircraft comprising a fuel tank for a pond of fuel, a pump mounted on said tank having an inlet receiving fuel by gravity flow from the pond of fuel in the tank, a propeller projecting through the inlet of the pump into the tank in advance of the inlet mouth, said propeller being effective to agitate the fuel in the tank and eject a lateral stream of bubble-rich liquid away from the inlet, an impeller in the pump receiving agitated fuel from the propeller, said impeller being effective to further agitate the fuel and liberate bubbles therefrom, and means defining a passageway surrounding the pump inlet for venting bubbles liberated by the impeller back to the tank to join the lateral stream of bubble-rich liquid ejected by the propeller.

11. In a fuel system including a container for a pond of liquid fuel, a booster pump and vapor separator having an inlet receiving fuel by gravity flow from the pond in said container, a deep pumping channel communicating with the inlet of the pump, a shallow pumping channel communicating with the deep channel, deep and shallow pumping vanes in stepped relationship operating in said channels to impel the fuel from the inlet first at a relatively low velocity and then at an increased velocity, and vent means connecting the discharge end of the deep channel with the pond in said container and communicating with said shallow pumping channel solely through said deep pumping channel.

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