March 7, 1944. R. R. CURTIS 2,343,752

PUMP PRESSURE LIMITING DEVICE

Filed March 26, 1942

Fig. 1.

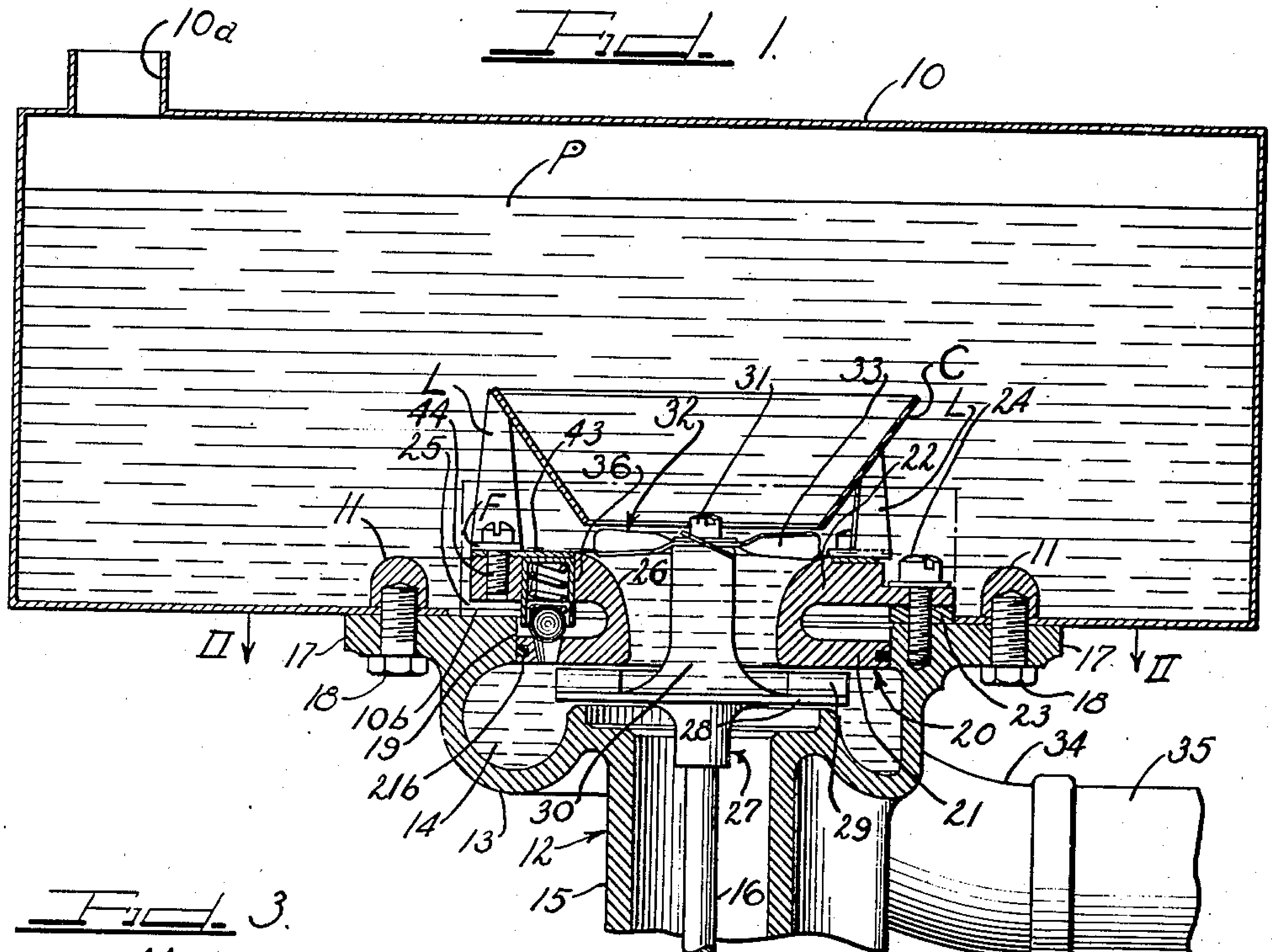


Fig. 3.

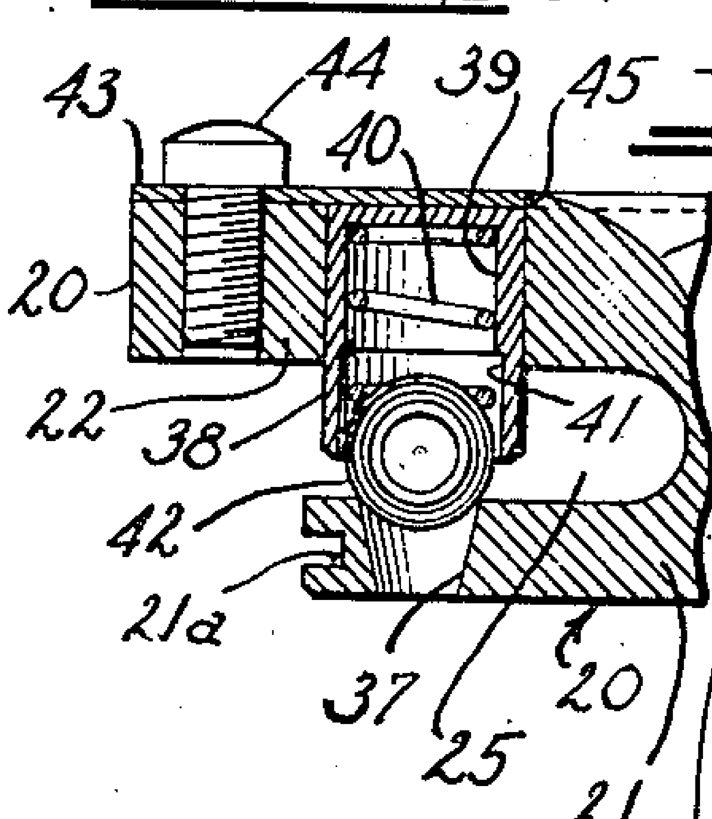
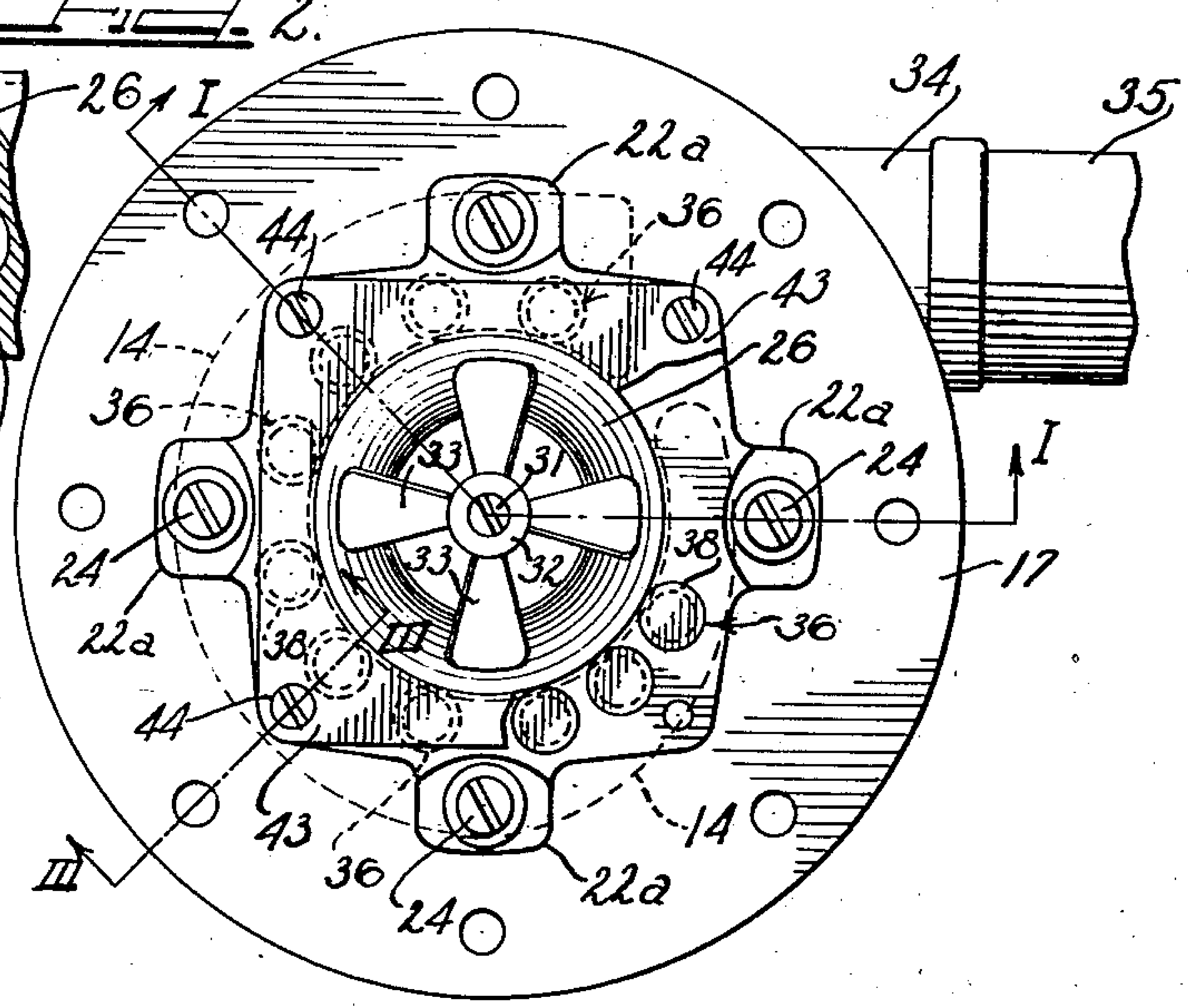


Fig. 2.



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PUMP PRESSURE LIMITING DEVICE

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7 Claims. (Cl. 103—42)

This invention relates to pump assemblies of the type especially adapted for use in high altitude aircraft fuel systems.

More particularly, the invention relates to centrifugal pump assemblies in which gas and vapors are separated from the liquids so that only fully liquid material is pumped and in which there is provided a pressure relief valve mechanism for limiting the discharge pressure of the pumped material to a predetermined value independent of variations in the speed of rotation of the pump impeller.

In accordance with this invention, a pump casing is so mounted with relation to a source of liquid, such as a fuel tank, as to be below the hydraulic gradient of the liquid. The casing has an inlet throat communicating with the source of liquid and a pumping chamber receiving pressured liquid from the throat. An impeller disk having pumping vanes thereon centrifugally pumps the liquid from the throat to the pumping chamber. This impeller also carries an agitating propeller acting on the liquid before it reaches the pumping vanes. The propeller is preferably positioned at the inlet to the pump between the pump and a guide cone carried by the pump. The guide cone is preferably disposed in the fuel in the tank to direct fuel to the pump inlet and to deflect bubbles of gas and vapor beaten out of the liquid fuel by the propeller away from the fuel flowing to the pump.

As the liquid flows from the fuel tank through the cone and into the pump it is beaten or agitated and bubbles of gas or vapor are liberated from the liquid. These bubbles are thrown radially outward from the inlet throat and rise on the outside of the cone through the liquid in the fuel tank to burst at the surface of the liquid. The gases and vapors are thus liberated from the liquid. Fully liquid material is then pumped by the vanes on the impeller and centrifugally discharged into the pumping chamber of the pump.

In those installations of a centrifugal pump in which the motive power is of the variable speed type, or when the pump is used in aircraft fuel systems to pump fuel directly from the fuel tank to the engine carburetor and the impeller speed is increased to effect a continuous flow of fuel at high altitudes, the pump discharge pressure changes in proportion to the change in impeller speed. When the impeller speed is increased the discharge pressure will likewise increase with the result that the discharge pressure might build up above a desired maximum. If uncontrolled, the discharge pressure might even reach a point sufficiently great to upset proper carburetion in the carburetor of the engine to which the fuel is eventually delivered.

In order that the discharge pressure might be limited as the speed of the impeller is increased, a relief valve mechanism is interposed between the pumping chamber and the interior of the fuel tank. This relief valve mechanism is of a type which remains closed until a predetermined discharge pressure is reached in the pumping chamber, at which time the relief valve opens and the excess pressure is vented back into the fuel tank.

The relief valve mechanism thereby determines the maximum discharge pressure of the centrifugal pump, which pressure varies in direct proportion with the rotation of the pump impeller only between predetermined limits.

It is, therefore, an object of this invention to provide a pump whose discharge pressure is limited to a value below that capable of being produced by the pump.

Another object of this invention is to provide a liquid pump with a discharge by-pass whereby the discharge pressure is variable only to a predetermined value.

A further object of this invention is to provide a by-pass mechanism between the outlet and the inlet of a pump which is operable at a predetermined discharge pressure.

A still further object of this invention is to provide a spring pressed relief valve mechanism for the volute chamber of a centrifugal pump.

Another and still further object of this invention is to provide a centrifugal booster pump having a pumping impeller with a spring pressed relief valve mechanism between the discharge and inlet sides thereof whereby the discharge pressure effected by the pump impeller is limited to a predetermined value.

A further object of this invention is the provision, in a centrifugal booster pump, of an inlet throat having a spring pressed relief valve mechanism connecting the pumping chamber of the pump with a fuel tank from which the pump receives liquid.

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 drawing, in which:

Figure 1 is a fragmental vertical cross-sectional view along the line I—I of Figure 2, with parts in elevation, of a centrifugal booster pump, a fuel tank on which the pump is mounted, and a by-pass valve mechanism between the pumping chamber of the pump and the interior of the fuel tank;

Figure 2 is an enlarged plan view, with the guide cone omitted, of the pump assembly as seen when taken substantially in the plane indicated by the line II—II of Figure 1; and,

Figure 3 is an enlarged fragmentary vertical cross-sectional view, with parts in elevation, as seen when taken substantially in the plane indicated by the line III—III of Figure 2.

In Figure 1, the reference numeral 10 designates a fuel tank, vented as at 10*a*, and containing a pond P of liquid fuel, such as gasoline. The bottom wall of the tank has a circular aperture 10*b* therein. A mounting ring 11 is positioned in the tank on the bottom wall thereof around the aperture 10*b*.

A booster pump 12, of the centrifugal type, is suspended on the bottom wall of the tank around the aperture 10*b*. The pump includes a casing 13 defining a pumping or volute chamber 14 and a shaft housing 15. The casing 13 is connected with a source of motive power (not shown) which drives a shaft 16 in the housing portion 15 of the casing. The casing has an out-turned annular flange 17 for mounting on the bottom wall of the tank. The flange 17 receives cap screws 18 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 of the tank.

The casing has a circular opening 19 into which a circular throat ring 20 is seated.

As shown in Figure 1, the throat ring includes a flat bottom wall or horizontal leg 21 and a top wall or leg 22 which extends from the inner end of the leg 21 upwardly and outwardly where it terminates in a horizontal portion in spaced parallel relation above the leg 21. The outer diameter of the leg 21 is sized to seat within the circular opening 19 of the pump casing and has an annular groove 21*a* (see Figure 3) in the periphery thereof for receiving a seal ring 21*b* preferably formed of resilient material.

The upper leg 22 has a plurality of ears or lugs 22*a* which partially overlie the flange 17 in spaced relation therefrom. Apertured spacers 23 are interposed between the flange 17 and the lugs 22*a*. Cap screws 24 are inserted through the lugs 22*a*, the spacers 23 and into threaded engagement with blind tapped wells in the pump casing. This construction of the throat ring provides a series of ports 25 connecting the space between the legs of the inlet throat and the interior of the fuel tank 10.

The upwardly and outwardly curved web portion of the inlet throat leg 22 forms a tapered central aperture 26 through the throat ring for joining the interior of the tank 10 with the pumping or volute chamber 14.

A guide cone C is disposed in the pond P in spaced relation above the throat ring 20. The cone C has a plurality of legs L at spaced intervals therearound each of which are equipped with feet F adapted to be bolted on the throat ring. The cone converges toward the aperture 26 to guide fuel to the pump but terminates in spaced relation above the aperture to provide an open space through which the beaten out bubbles can pass.

The booster pump has an impeller assembly 27 mounted on the drive shaft 16. This impeller assembly includes a disk or flange portion 28 spanning the inlet or aperture 26 in the throat ring and communicating freely around the periphery thereof with the inlet of the pumping chamber 14. Pumping vanes 29, mounted on the flange 28 around the outer margins thereof, underlie the throat ring 20 and the flange 28, open ended pumping channels communicating at their outer ends with the pumping chamber 14 and at their inner ends with the inlet of the throat ring.

A cap or fairing member 30 extends axially upwardly from the disk or flange portion 28. The cap member 30 receives the shaft 16 therein with the upper end of the shaft having a threaded well for receiving the stem of a cap screw 31. The cap screw coacts with the shaft to clamp the cap or fairing member 30 on the shaft.

A propeller assembly 32 has an apertured hub for receiving therethrough the stem of the cap screw 31. The hub is interposed between the cap screw head and the fairing member 30 where it is clamped in position. The propeller assembly 32 is illustrated as having four radially extending blades 33. This number may be more or less, it only being necessary to provide as many blades as will effect proper agitation of liquid fuel flowing towards the inlet mouth of the pump. It is to be noted that the cap or fairing member 30 extends upwardly through the throat ring to position the propeller assembly 32 on the side of the throat ring opposite the impeller assembly 27.

The blades 33 of the propeller assembly 32 agitate the fuel flowing down from the fuel tank into the inlet throat for the purpose of beating out bubbles of gas and vapor entrained in the liquid fuel. Rotation of the propeller assembly throws these bubbles outwardly from the inlet side of the inlet throat through the space between the bottom of the cone C and the top of the throat ring where they rise in the pond P around the cone to the surface thereof and burst into the atmosphere.

The bubble-freed liquid enters the pump through the inlet mouth 26 of the throat ring and it is then pressured by the impeller assembly into the pumping chamber.

The pressured liquid then passes into a discharge pipe 34 and from there into a fuel line 35. In the usual aircraft fuel systems, the pressured fuel flows through a fuel line into an engine driven fuel pump and from there directly to the engine carburetor. Should the engine fuel pump fail in operation, the speed of the booster pump can be increased in order to deliver liquid fuel directly to the carburetor of the aircraft engine, either through the inoperative fuel pump or through a by-pass therearound. Any increase in the rotating speed of the impeller will produce a proportionately higher discharge pressure through the pumping chamber. It has been found in high altitude operation of aircraft that a pressure in the discharge side of the booster pump up to a certain value is sufficient for insuring the flow of liquid fuel to the engine carburetor. A maximum discharge pressure can be predetermined for insuring delivery of a full volume of liquid fuel constantly to the engine driven fuel pump or, if the engine driven fuel pump is inoperative, directly to the engine carburetor. In order to eliminate the necessity for careful control of the speed at which the pump is driven in order to attain the predetermined pump pressure, a pressure relief mechanism is provided. This relief mechanism is so regulated as to effect the desired discharge pressure even though the impeller speed is increased to a value which would normally result in a much higher discharge pressure.

As shown in the figures in the drawing, a plurality of pressure relief valves **36** are provided around the inlet throat ring **20**. Each relief valve includes a seat formed by the inner edge of an outwardly tapered aperture **37** through the lower leg **21** of the throat ring. An enlarged aperture is provided in the other leg **22** of the throat ring in axial alignment with the aperture **36** for receiving a cup-shaped valve member **38**. The valve member **38** has a reduced base **39** at its inner end for receiving one end of a coil spring **40**. The outer end of the valve member has an enlarged bore **41** for loosely receiving therein a ball **42**. The ball **42** is normally held against the valve seat by the spring **40** thereby holding the pumping chamber **14** out of flow communication with the ports **25**.

As shown, the valve members **38** are maintained within the leg **22** of the throat ring by a centrally apertured plate **43** overlying the horizontal portion of the leg **22** and clamped thereon by cap screws **44**. These cap screws **44** can also be used to extend through the feet F of the cone legs L to bolt the cone on top of the pump assembly.

It is preferable, although not necessary, that the leg **22** be recessed to provide a shoulder **45** adjacent the inlet aperture for seating the plate **43** flush with the outer face of the leg **22**.

It is to be noted that the opening **37** is so positioned in the lower leg **21** of the throat ring that it connects for fluid flow the pumping or volute chamber **14** and the ports **25** between the spaced legs of the throat ring.

The pressure exerted by each of the coil springs **40** is predetermined as this pressure is the maximum discharge pressure of liquids pumped through the volute chamber by the impeller assembly. When the speed of rotation of the motive power of the pump impeller assembly is increased, the discharge pressure of liquids pumped by the pump impeller into the volute chamber will increase proportionately. When the discharge pressure in the volute chamber exceeds the pressure of the coil springs **40**, the latter collapse and the balls **42** are urged away from their valve seats. Liquid under pressure within the volute chamber will then circulate through the openings **37** and the ports **25** into the fuel tank **10**. Consequently, the pressure exerted by the coil springs **40** determines the maximum discharge pressure of liquids pumped by the impeller assembly through the volute chamber and into the discharge line **34**. Obviously, this maximum pressure may be changed as desired, either by regulating the compression of the coil springs **40** or by changing the size thereof.

It is to be noted that the bore **41** of the valve member **38** is sufficiently large to loosely receive the ball **42** while the bore **39** is smaller in diameter to limit the inward movement of the ball. Furthermore, the valve member projects into the space between the legs **21** and **22** to loosely hold the ball **42** in proper alignment with its valve seat. This eliminates any possibility of the ball being laterally displaced in the ports **25** and into the interior of the tank **10**.

It will be apparent from the foregoing that in a centrifugal pump of the type described, the discharge pressure thereof will vary up to a predetermined value as the speed of the impeller is increased. As soon as this predetermined value is reached the discharge pressure of the pump remains substantially constant. Since the pressured liquid is freed from bubbles of gas and vapor by the agitating mechanism of the pump, liquid and not gas pressure controls the operation of the relief valves.

While a particular embodiment of this invention only has been illustrated, it will, of course, be understood that the invention should not be limited thereto, since many 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. In a centrifugal type pump including a casing having a central inlet throat opening into a source of fluid supply and a peripheral volute chamber, an impeller with pumping vanes between said throat and said volute chamber for pumping fluids received from said source through the throat into the volute chamber, said inlet throat having a relief passageway joining said volute chamber with said source, and means normally closing said passageway sensitive to a predetermined pressure in the volute chamber for opening the passageway whereby the pressure in the volute chamber is limited to a predetermined value.

2. In a centrifugal type of pump having a casing defining an inlet opening and a discharge volute chamber, a throat ring in said inlet opening having spaced legs connected by a curved web portion, one of said legs overlapping said discharge volute chamber, the space between said legs and the inlet of said pump opening into a source of fluid supply, an impeller with pumping vanes between said throat ring and said volute chamber receiving fluids from said source through the throat and pumping the fluids into the volute chamber, at least one opening through said overlapping leg of the throat ring connecting the discharge volute chamber and the source of fluid supply to flow therebetween, a ball seated on a seat defined by the edge of said opening on the side of said one leg opposite the side overlapping the volute chamber, and a coil spring normally maintaining said ball on the seat to close said opening, said ball being urged away from said seat when the pressure in said volute chamber exceeds the pressure of said spring whereby the volute chamber is vented through the opening into the source of fluid supply.

3. In a centrifugal type of pump having a casing defining an inlet and a discharge volute chamber, a circular throat ring of U-shaped section formed by spaced legs and a curved connecting web, one of said legs being seated in said inlet and overlapping said volute chamber, the inlet opening of said throat ring defined by said curved web and the space between said legs both opening into a source of fluid supply, sealing means between said one leg and said inlet, an impeller with pumping vanes between said throat ring and said volute chamber receiving fluids from said source through the inlet opening and pumping said fluids into said volute chamber, openings through said one leg spaced around said throat ring for connecting the space between said legs and the volute chamber to fluid flow, a ball for each of said openings seatable on the side of

said one leg opposite the side overlapping said volute chamber, and a coil spring for each ball having one end seated on a ball and its other end seated in a recess in the other leg of said throat ring for normally maintaining the opening in said one leg closed, said ball being urged away from said opening when the pressure in said volute chamber exceeds the pressure of said coil spring whereby pressure in the volute chamber is released into the space between said legs.

4. In a pump having a casing defining an opening, a hollow throat ring arranged to be seated in said casing opening, said throat ring having spaced superimposed legs connected by a curved web whose inner surface defines a flared inlet for the pump, one of said superimposed legs being sized to seat within said casing opening, an annular groove in the periphery of said one leg, a resilient member seated in said groove for sealing engagement with said casing opening, spaced radially extending legs on the other of the superimposed legs on said throat ring, said radially extending legs overlapping said pump casing, spacers between said radially extending legs and said casing, and means for connecting said radially extending legs and spacers to said casing, the space between said radially extending legs defining ports communicating with the space between the superimposed legs of the throat ring.

5. A throat ring construction comprising a hollow ring member having spaced radially extending legs connected at their inner ends by a curved web, radially extending legs spaced circumferentially around one of said legs for connecting the ring member to a support, aligned openings in said legs, and a valve mechanism in an opening in one of said legs for normally closing an opening in the other of said legs, said valve mechanism including a cup-shaped member inserted in said opening of said one leg and opening toward said opening in the other leg, a ball, and spring means carried by said cup-shaped member for normally urging said ball against the edges of said opening in the other leg to close the same.

6. A throat ring construction comprising a hollow ring member having spaced radially extending annular legs connected at their inner ends by a curved web defining a flared surface extending axially through the ring member, circumferentially spaced apertured legs on one annular leg adjacent the flared end of the ring member, pairs of aligned openings through said spaced legs, the openings in the other annular leg being tapered away from said one leg, a ball for each tapered opening in said other leg and being sized for seating on the edges of the opening at its largest end, a cup-shaped member in each opening in said one leg extending into the space between said legs, said cup-shaped member opening toward the aligned tapered opening in said other leg and having a bore at its outer end for loosely receiving said ball, a coil spring in said cup-shaped member for normally maintaining said ball against said tapered opening to cover the same, and a ring plate seated on and connected to said one leg for maintaining said cup-shaped members in the openings therein.

7. In a pump construction having a central inlet throat adapted to communicate with a pond of liquid and a peripheral pumping chamber communicating with said throat and adapted to receive liquid therefrom, the improvements of communicating relief passageways adapted to join said pumping chamber with the pond of liquid feeding the inlet throat to discharge liquid from the pumping chamber back into the pond at a point radially outward of the inlet throat, and valve means controlling flow through said passageways.

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