March 24, 1959 R. A. GILBERT 2,878,889

APPARATUS FOR DE-AERATION OF LIQUIDS

Filed April 19, 1955 2 Sheets-Sheet 1

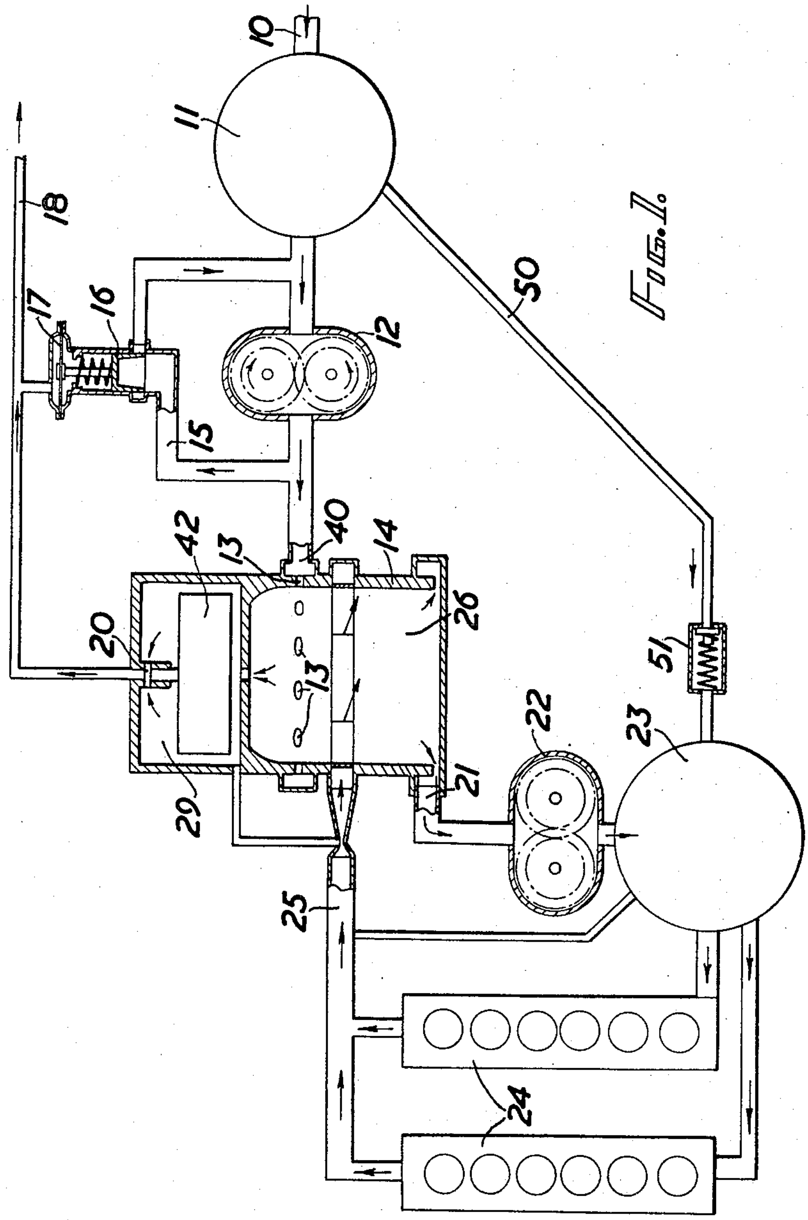

FIG. 1.

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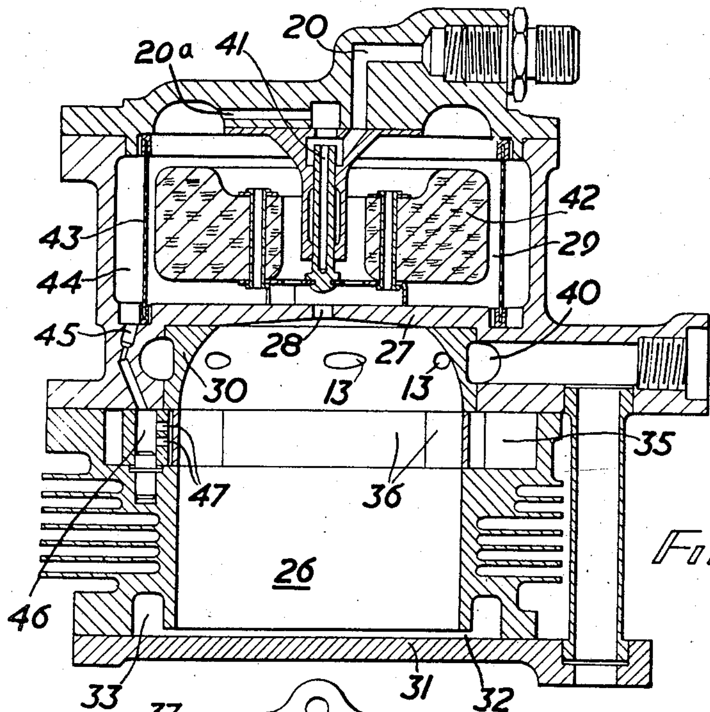

FIG. 2.

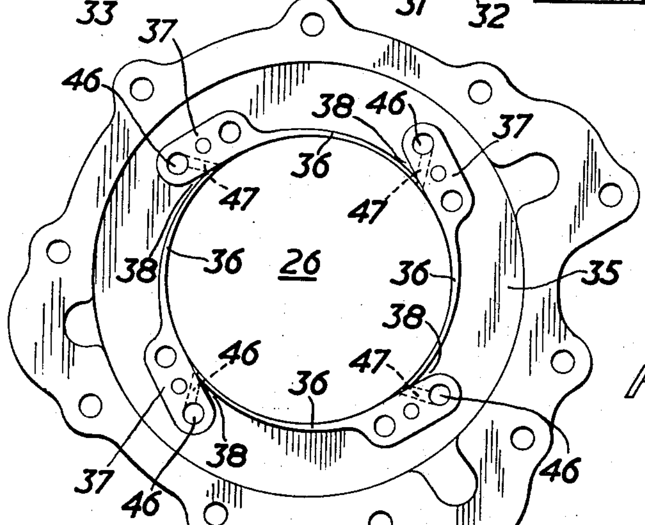

FIG. 3.

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APPARATUS FOR DE-AERATION OF LIQUIDS

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Claims priority, application Great Britain April 26, 1954

3 Claims. (Cl. 183—2.5)

This invention relates to the apparatus for de-aeration of liquids and it is an object of the invention to provide improved apparatus for the purpose.

According to the invention a centrifugal separator for de-aerating liquid comprises a separator chamber, preferably in the form of a hollow body of revolution, means for withdrawing air from the upper end of the separator chamber, and for withdrawing de-aerated liquid from the lower end thereof, and means for supplying aerated liquid to the chamber comprising at least one inlet passage arranged with a substantial tangential component of direction, so as to impart rotary motion to the liquid within the chamber, at least one of the walls of the inlet passage being movable and being resiliently urged towards the opposite wall of the passage, so as to restrict the cross-sectional area of the passage when the pressure of liquid in the passage falls, and thus to tend to maintain a high velocity of flow through the passage and consequent high rotary velocities in the chamber, even when the volumetric rate of flow through the passage falls.

Preferably the movable wall of the passage is constituted by a leaf spring, and the leaf spring is preferably pre-stressed with its end in close contact with the opposite wall of the passage when there is no flow through the passage.

According to another preferred feature of the invention the separator includes an upper air-separation chamber, arranged above the main chamber, and means for returning the de-aerated liquid from the upper air-separation chamber to the main chamber comprising a conduit leading from the air-separating chamber and emerging into the inlet passage at a point adjacent the throat thereof formed between the movable wall and the opposite wall.

In such case the separator preferably includes a float-controlled valve in an upper part of the air-separation chamber arranged to open when the level of liquid in the chamber falls to a predetermined level due to the accumulation of air therein.

The separator may include means for admitting additional liquid to the main separator chamber, preferably through one or more make-up passages above the level of the inlet passage.

The invention is particularly applicable therefore to fuel supply systems of internal combustion engines of the fuel injection type. In such engines it is customary for fuel to be delivered to the fuel injection pumps from the main fuel tanks and for excess fuel to be returned from the injection pumps to an auxiliary tank where air separation occurs, or through an air separator to the main fuel tanks. It is a further object of the invention to provide an improved fuel system which will obviate the necessity for providing a return fuel line for the aerated fuel.

According to another aspect of the invention therefore a fuel system for an internal combustion engine of the fuel injection type comprises a fuel injection pump, an air-liquid separator, a circulating pump arranged to receive de-aerated fuel from the separator and to supply fuel under pressure to the injection pump, and means for returning excess fuel (which is liable to be aerated) from the fuel injection pump to the separator, and including means for supplying make-up fuel to the circulatory system from a fuel tank.

The separator is preferably as outlined above.

The fuel system moreover preferably includes a fuel delivery pump between the fuel tank and the separator, a by-pass return conduit between the two sides of this fuel delivery pump, and a control valve in said by-pass conduit arranged to open only when the pressure on the outlet side of the pump reaches a predetermined value, so as to maintain a substantially constant pressure in the main separator chamber.

The invention may be performed in various different ways but one specific embodiment as applied to the fuel supply system of a compression ignition fuel injection type, internal combustion engine, constituting the power unit of an aircraft will now be described by way of example with reference to the accompanying drawings in which

Figure 1 is a diagrammatic view of the complete fuel supply system,

Figure 2 is a sectional side elevation through the air separator unit, and

Figure 3 is a plan view on the lines III—III of Figure 2 with the upper part of the unit removed.

The fuel system includes normal main fuel tanks (not shown) from which fuel is delivered to a main supply line **10** by a booster pump (not shown) arranged to maintain a pressure of (say) 10 lbs./sq. in. in the line. A primary fuel filter **11** is fitted in this main supply line, and having passed through this filter the fuel is then delivered to an engine driven fuel delivery pump **12** of the gear type, the outlet side of which is connected to make-up passages **13** leading into a centrifugal separator **14**. The inlet and outlet side of the fuel delivery pump **12** are interconnected by a by-pass return conduit **15** which includes a control valve **16** subject on one side to the pressure at the outlet side of the pump **12**, and connected also to a diaphragm **17** which is acted upon in the opposite direction by the air pressure in an air venting line **18**, and spring pressed into its closed position so as to maintain a pressure at the outlet side of the pump **12** of say 5 to 10 lbs./sq. in. above the pressure in the air vent line **18**.

The centrifugal air separator **14** is provided with an upper air escape port **20**, which communicates with the air vent line **18** referred to, and a lower de-aerated fuel outlet port **21** which communicates with a second engine driven circulating pump **22** (also of the gear type) the outlet side of which is connected to a secondary fuel filter **23** through which the de-aerated fuel is delivered to the injection pump or pumps **24** of the engine. Excess fuel (which is liable to be aerated) from the injection pump or pumps, is returned to the separator **14** through a return conduit **25**, and any air which may be separated in the secondary fuel filter **23** is fed also into this return conduit.

The centrifugal separator **14**, as shown in more detail in Figures 2 and 3, comprises a generally cylindrical main separator chamber **26** closed at its upper end by a plate **27** with a small central aperture **28**, which communicates with an upper air separation chamber **29** arranged directly above the main chamber **26**. The upper part of the cylindrical side wall of the main chamber is curved inwards to form a part-spherical head **30**, while the lower part of the side wall is spaced somewhat from the base **31** of the chamber to form an annular outlet port **32** which communicates with an annular gallery **33** through which de-aerated fuel is removed from the separator as described above.

Aerated fuel from the return conduit **25** is supplied under residual pressure to an annular inlet passageway **35** arranged at a height of approximately ⅔ of the full height of the main chamber **26**. The aerated fuel issues from the annular inlet pasageway **35** into the main separator chamber through four substantially tangential inlet passages **38**, so as to impart rotary motion to the fuel within the chamber and thus assist the separation of air. Each inlet passage is provided with a fixed wall and an opposite movable wall, the movable wall being constituted by the free end of a leaf spring **36**. Each leaf spring is formed with a length slightly less than a quarter of the circumference of the separator chamber and is secured or rigidly attached at one end to a fixed block **37** mounted adjacent the inner periphery of the annular inlet passageway. The free end of each leaf spring **36** is pre-stressed into contact with the inner face of the next block **37**, and the face of each block at the point where the free end of the next adjacent spring contacts it, is approximately tangential to the inner wall of the separator chamber. The leaf springs **36** may be tapered somewhat from their fixed to their free ends, and their resilience is arranged so as to maintain the pressure in the annular inlet passageway **35** at approximately 35 lbs./sq. in. above the pressure in the separator chamber **26**.

It will be realised that if the pressure in the inlet passageway **35** rises above this figure the leaf springs **36** will be deflected inwards so as to admit aerated fuel from the return conduit **25** into the separator chamber **26**. If the quantity of excess fuel returned from the injection pumps **24** rises, the leaf springs will be deflected further so as to increase the cross sectional area of the throats of the inlet passages **38**, whereas if the quantity of fuel from the pumps falls the throats of the inlet passages will be reduced. The arrangement thus tends to maintain a substantial and approximately constant flow velocity through the throats of the inlet passages **38**, and consequent high rotary velocities in the separator chamber, even when the volumetric rate of flow falls, due for example to increased fuel consumption by the injection pumps.

Make-up fuel for the circulatory system including the separator circulating pump **22**, and fuel injection pumps **24**, is supplied to the main separator chamber **26** from the engine driven fuel delivery pump **12**. The make-up fuel is supplied to an annular make-up passageway **40** adjacent the upper end of the separator chamber, and above the annular inlet passageway **35**. A series of circumferentially spaced make-up passages **13**, which have a tangential component of direction, are provided in the wall of the separator chamber leading from the make-up passageway into the interior of the chamber in the part-spherical portion **30** of the side wall. The make-up fuel is thus caused to rotate with the main mass of fuel in the chamber **26** under the influence of the tangential streams issuing through the inlet passages **38**.

The upper air separation chamber **29** is provided, as mentioned above, with an air escape port **20** at its upper end having an intake portion **20***a* opening into chamber **29**. The flow of air through port **20** is controlled by an air escape valve **41** which is actuated by a float **42** mounted within the chamber. Both the main separator chamber **26** and the air separation chamber **29** are normally flooded under the pressure maintained by the fuel delivery pump **12**, and air which is separated in the main chamber rises in the central core of the vortex through the central aperture **28** in the upper closure plate and separates out into the upper part

of the air separation chamber **29**. When the float **42** falls to a predetermined position due to the accumulation of air in the upper chamber, the air escape valve is opened and air is discharged through the air escape port **20** into the air vent line **18**.

A cylindrical fine mesh filter screen **43** is provided in the upper chamber **29** surrounding the float **42** to exclude air bubbles from the annular space **44** surrounding the screen, and a series of passages **45** lead from this annular space downwards through the wall of the main separator chamber into vertical drillings **46** provided in the blocks **37** to which the leaf springs **36** are connected. Each vertical drilling **46** communicates with one or more outlet drillings **47** which emerge at the inner tangential face of the respective block **37** adjacent the point where the free tip of the next adjacent leaf spring **36** contacts this surface. This point is adjacent the throat of each inlet passage **38**, and by venturi effect the reduced pressure at this throat thus draws the deaerated fuel from the air-separation chamber **29** into the streams of fuel issuing through the inlet passages **38**.

The fuel supply system also includes a priming line **50** between the primary fuel filter **11** and the secondary fuel filter **23**, and a pressure relief valve **51** in this priming line arranged to open when the pressure in the main supply line **10** reaches a predetermined value. The engine driven circulating pump **22** is thus primed as soon as the pressure in the main supply line **10** reaches an appreciable value.

What I claim as my invention and desire to secure by Letters Patent is:

1. A centrifugal separator for de-aerating liquid comprising a hollow body defining a generally cylindrical main separator chamber, means for withdrawing air from the upper end of said chamber, means for withdrawing deaerated liquid from the lower end of the chamber, said body being formed with an annular inlet passageway around said chamber, said passageway being separated from the chamber by an inner peripheral wall between it and the chamber including a plurality of fixed wall portions and movable wall portions, said fixed and movable wall portions being relatively circumferentially spaced around said passageway and alternating with each other around said inner peripheral wall, said movable wall portions each comprising a leaf spring having a cylindrical curvature generally conforming to that of said chamber, said leaf spring being fixedly secured at one end to one fixed wall portion and having a free end extending therefrom circumferentially in overlapping normally contiguous relation with another fixed wall portion, said free end extending radially inwardly of said other fixed wall portion and cooperating therewith to define a generally tangentially projected variable size inlet passage from said annular passageway into the said chamber and said free end being resiliently radially inwardly yieldably responsive to said fluid pressure in said annular passageway to vary the size of said passage through said passageway, and thus to tend to maintain a high velocity of flow through the passage and consequent high rotary velocities in the chamber even when the volumetric rate of flow through the passage is reduced.

2. A centrifugal separator as claimed in claim 1 including an upper air-separation chamber, arranged above the main chamber, and means for returning the de-aerated liquid from the upper air-separation chamber to the main chamber comprising a passage leading from said air-separating chamber and emerging into said inlet passage at a point adjacent the throat thereof formed between said movable wall portion, and said fixed wall portion.

3. A centrifugal separator as claimed in claim 1, including means for admitting additional liquid to the main separator chamber, through a make-up passage above the level of said inlet passage.

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