Sept. 13, 1960 H. E. ADAMS 2,952,214

FUEL PUMP

Filed Jan. 25, 1957 7 Sheets-Sheet 1

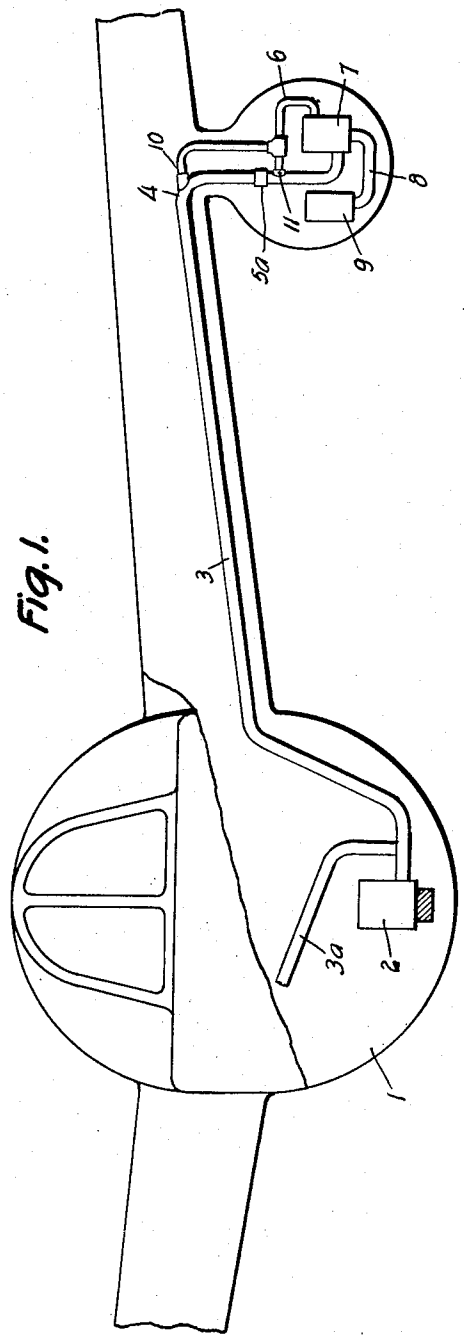


Fig. 1.

INVENTOR.
Harold E. Adams

BY

Moore, Hollt & Hollt
ATTORNEYS

Sept. 13, 1960 H. E. ADAMS 2,952,214

FUEL PUMP

Filed Jan. 25, 1957 7 Sheets-Sheet 2

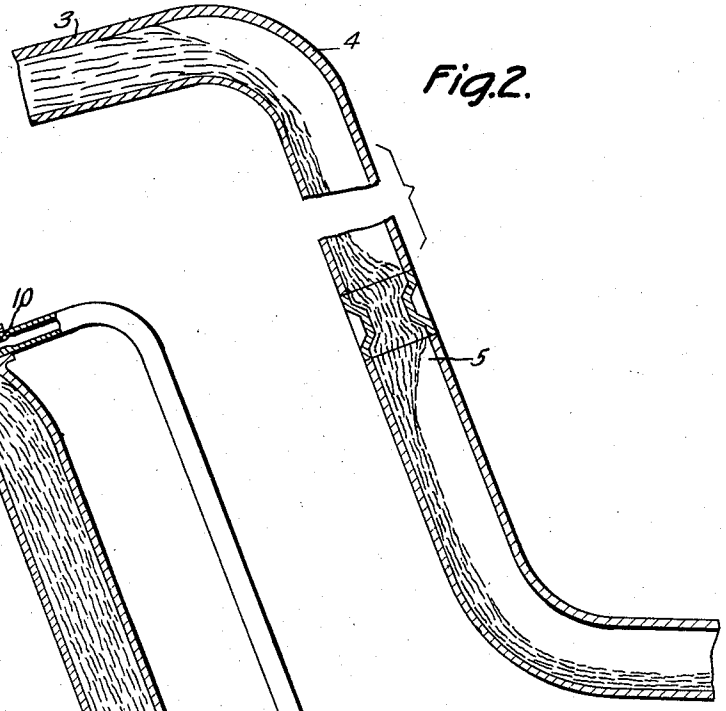


Fig. 2.

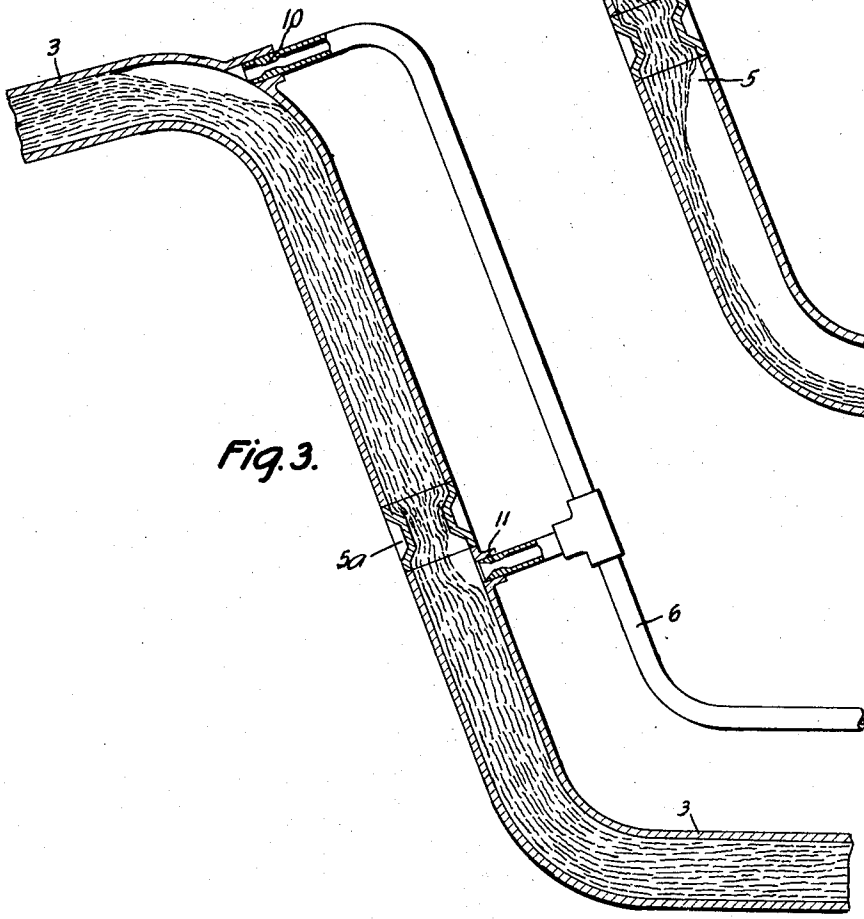


Fig. 3.

INVENTOR.
Harold E. Adams

BY

Mason, Nolte + Nolte
ATTORNEYS

Sept. 13, 1960 H. E. ADAMS 2,952,214

FUEL PUMP

Filed Jan. 25, 1957 7 Sheets-Sheet 3

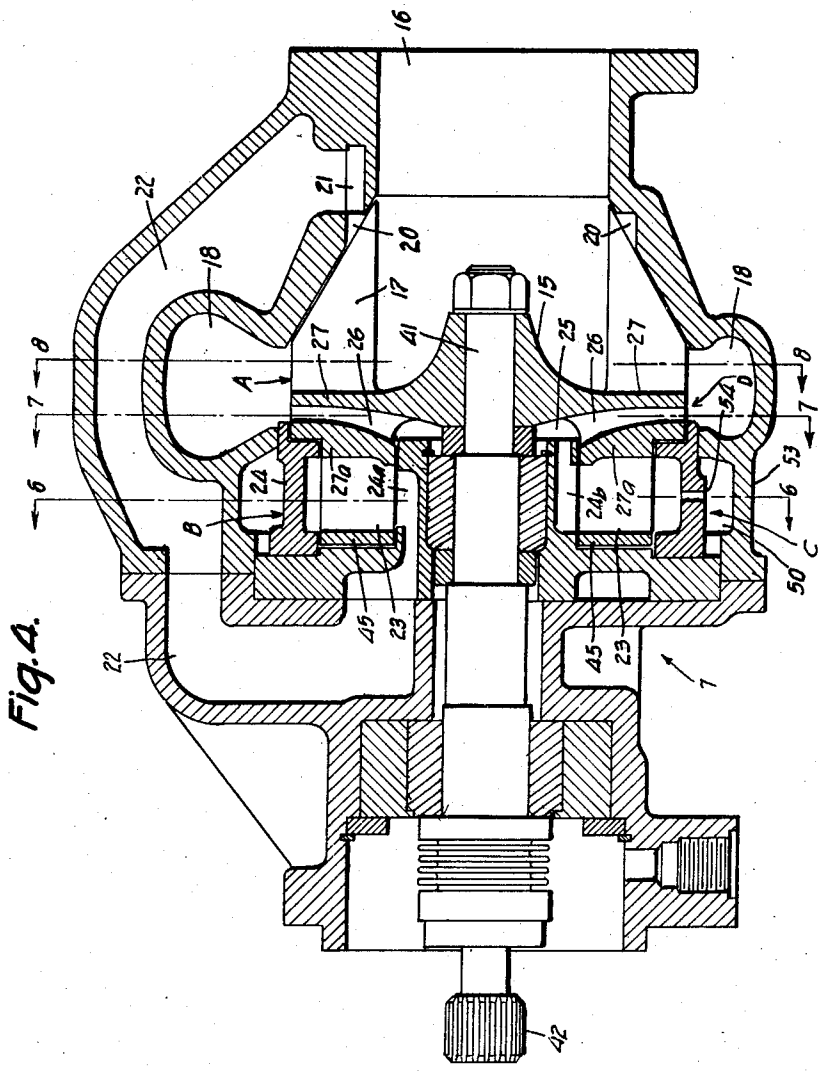


Fig. 4.

Inventor
Harold E. Adams.

By Mason, Nolte & Nolte

Attorneys

Sept. 13, 1960 H. E. ADAMS 2,952,214

FUEL PUMP

Filed Jan. 25, 1957 7 Sheets-Sheet 4

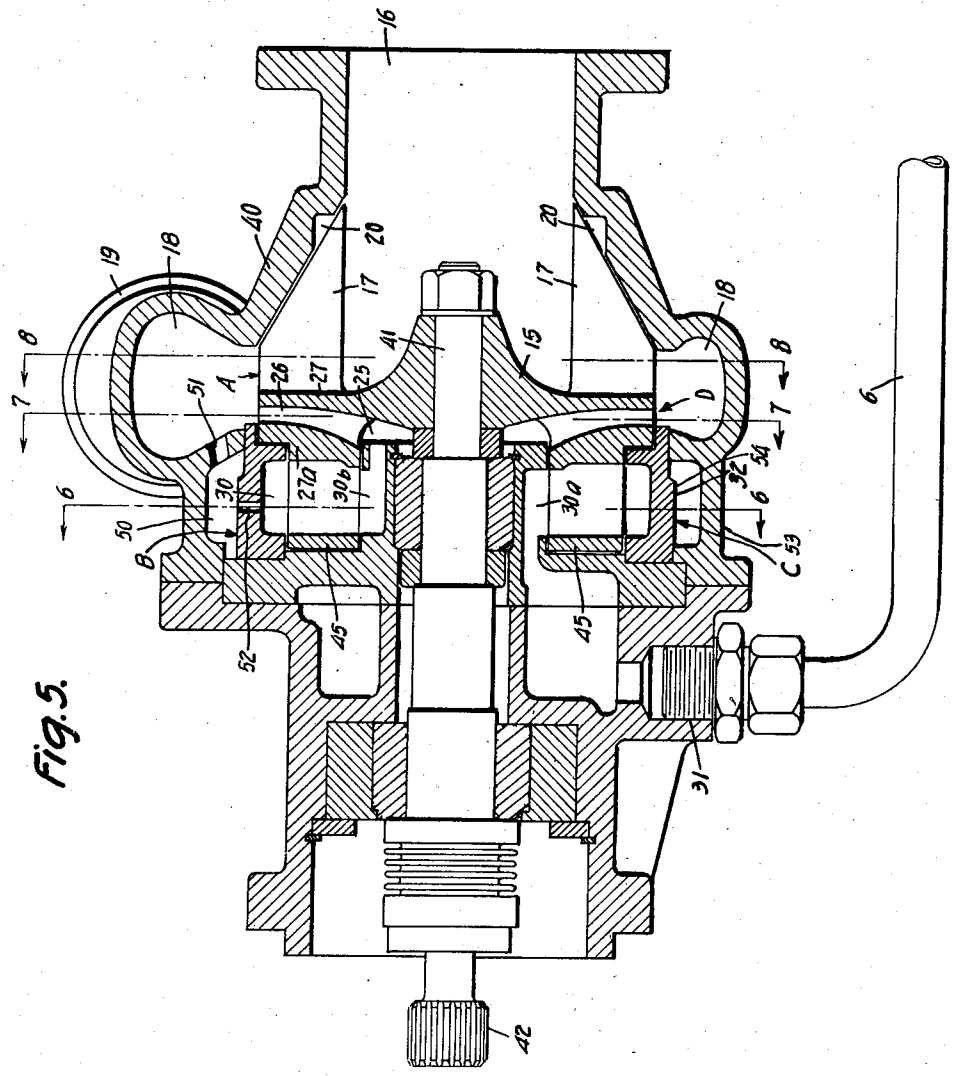


Fig. 5.

Inventor
Harold E. Adams

By Moses, Nolte & Nolte

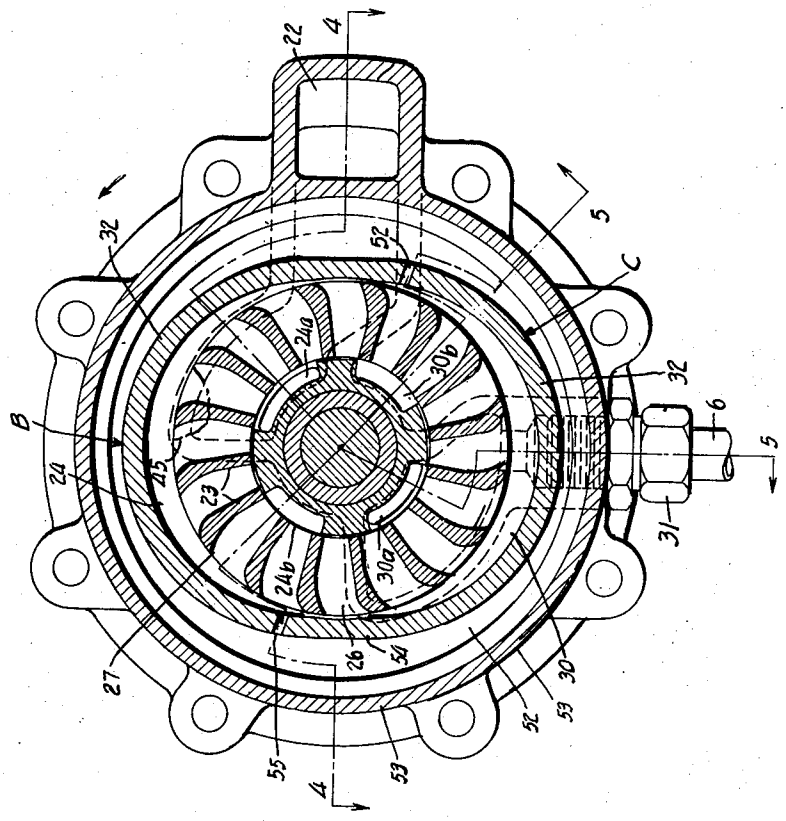
Attorneys

Sept. 13, 1960 H. E. ADAMS 2,952,214

FUEL PUMP

Filed Jan. 25, 1957 7 Sheets-Sheet 5

Fig. 6.



INVENTOR.
Harold E. Adams.

BY

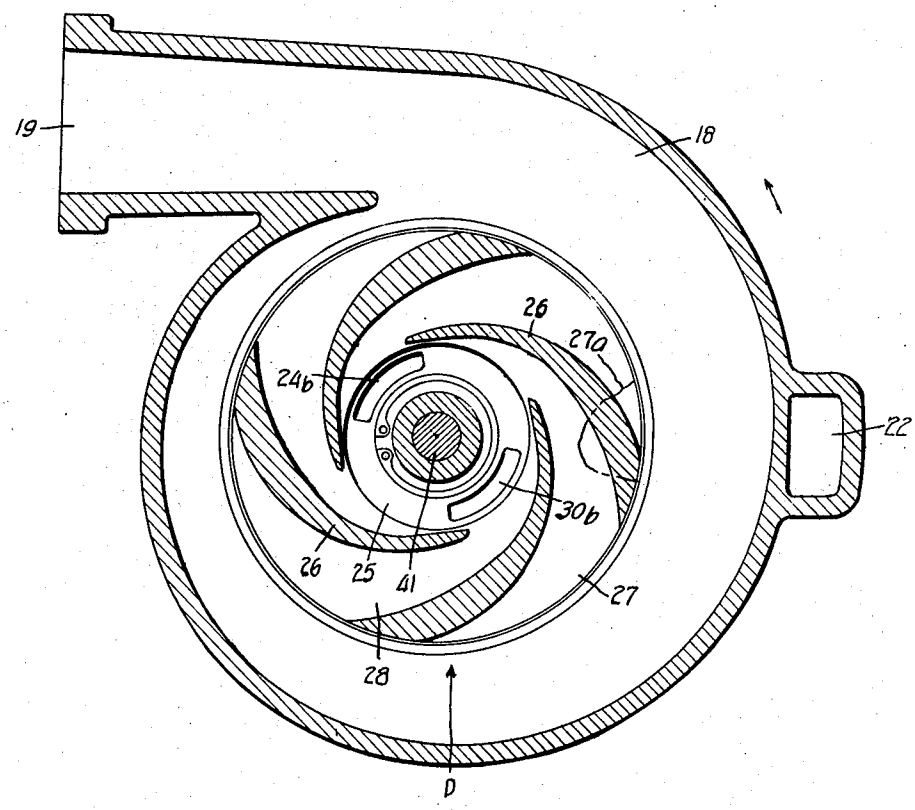
Moses, Holte & Holte
ATTORNEYS

Sept. 13, 1960 H. E. ADAMS 2,952,214

FUEL PUMP

Filed Jan. 25, 1957 7 Sheets-Sheet 6

Fig. 7.



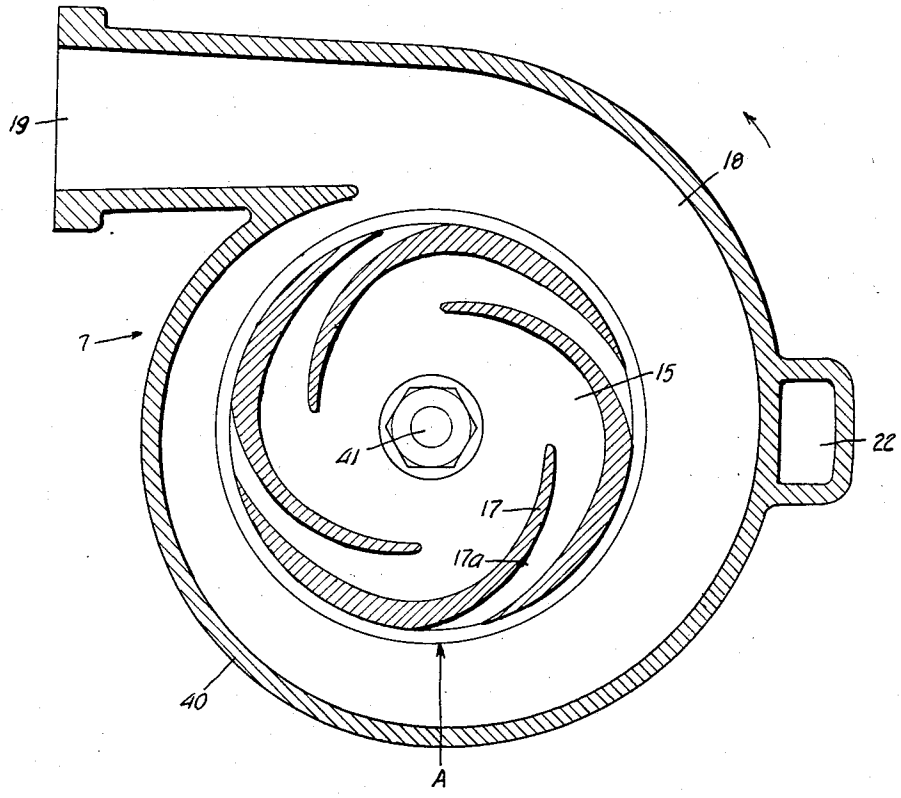
Inventor
Harold E. Adams
BY Mason, Molte & Molte
ATTORNEYS

Sept. 13, 1960 H. E. ADAMS 2,952,214

FUEL PUMP

Filed Jan. 25, 1957 7 Sheets-Sheet 7

Fig. 8.



Inventor
Harold E. Adams

BY Moses, Nolte & Nolte
ATTORNEYS

United States Patent Office 2,952,214
Patented Sept. 13, 1960

2,952,214

FUEL PUMP

Harold E. Adams, South Norwalk, Conn., assignor to Nash Engineering Company, South Norwalk, Conn., a corporation of Connecticut

Filed Jan. 25, 1957, Ser. No. 636,442

16 Claims. (Cl. 103—113)

The pump of this invention is constructed to handle multiple component liquid fuels near their boiling points through tortuous suction lines. The difficult nature of this operation is well known in the aircraft industry where fuel has to be transported within the airplane from fuel tanks located in the fuselage or in the wing, out to the main engine, which may be located at the outermost point of the wing or above or below the wing. The piping between the tank and the engine has to follow the airplane configuration. These piping conditions are usually so bad in relation to the gas and vapor forming characteristics of the fuel that it is impractical to draw the fuel through this piping by means of an ordinary pump located at the engine.

It is general practice to place an additional pump within the fuel tank to transport the fuel through the piping to the inlet of the main engine pump under a sufficient pressure to overcome the pressure drop of the piping and meet the inlet pressure requirement of the main engine pump. Such pumps in the art are known as tank mounted booster pumps.

By the use of novel features of my pump, I can place it at the engine and pump the fuel through the intervening suction lines without the continuous aid of the additional tank mounted booster pump.

The principal pumping difficulty is caused by the friction drop existing in the piping when fuel is flowing, which results in the evolution of gases and vapors in the pipe from the fuel. High spots or pockets formed by the piping allow the evolved gases and vapors to accumulate therein. In some cases these bubbles grow and gradually reduce the available pipe area for the flow of the liquid fuel, even to the point of causing the stoppage of all fuel flow, or the partial filling of the pump inlet passageway with gas or vapor, both of which will starve the pump and engine resulting in fuel flow stoppage. Such characteristics are often known in the art as "vapor lock."

Because of the aforementioned difficulty, it is common practice to supply a sufficient pressure or static head at the inlet to the piping system so that the pressure throughout the piping system is enough to prevent the coming out of solution of gases or vapors due to the friction drop, with a margin of pressure left to pressurize the inlet to the main engine pump. This pressure head is usually provided, on land installations, by raising the tank to a static height sufficient to give the desired pressure. This, of course, cannot be accomplished in an airplane, so the desired pressurizing of the piping system is usually obtained by means of a tank mounted fuel booster pump. In some cases, tanks are pressurized by air or gas to obtain this result, but this is not generally practised on aircraft because of the objectional weight penalty, etc.

In the case of airplanes dependent upon the pressurization of the fuel lines by tank mounted booster pumps, the airplane is vulnerable to the failure of the tank mounted booster pumps or any malfunction of this

pump or its driving motor. Such failure usually results in the necessity of the airplane to come down to a much lower altitude to obtain a higher ambient absolute pressure, such that the fuel will not evolve gases or vapors. The main engine pump, or its booster pump, located at the engine, generally has very limited performance, even at the reduced altitude and speed, without the assistance of the tank mounted booster pump. This, of course, is not a desirable situation and it is the purpose of my pump to enable the airplane to continue normal flight at a high altitude, in the event of the failure of the tank mounted booster pump.

When the fuel is being pumped from the fuel tank through the fuel piping system under conditions of reduced pressure approaching saturated gas conditions, or where the absolute pressure in the pipe line nears the vapor pressure of the fuel, there occurs the evolution from the fuel of the saturated air and gas, plus the vaporization of some of the lighter, more volatile constituents of the fuel. This evolved gas and vapor will accumulate in the high points or pockets in the fuel line. These gas pockets grow, to the point where it breaks the syphon effect of the piping and imposes an additional lift on the pump. It may be carried over in gulps if the flow velocity is great enough, or, under low velocity, the gas-vapor pocket may grow until it reaches the pump inlet. At this point, the pump only has the gas-vapor to work on and there results a serious interruption in the delivery of fuel to the engine.

My novel application to an airplane fuel system is shown herein as typical of the type of work for which my pump is well suited but it can be used on many other difficult two-phase pumping problems and I do not intend that it be limited merely to the application shown. A high point or gas collecting pocket may be deliberately added to the suction line above and ahead of the pump inlet to collect evolved gases for the gas removal element to handle. This pocket may also be deliberately connected to a large chamber to serve as a surge and separating chamber in the case of the two-phase liquid-gas flows involving severe slugging and other turbulent conditions which would be difficult to pump with either a positive or a centrifugal type pump.

In my novel pump, I provide built-in means to independently and continuously withdraw the gas and vapor from the pocket or pockets in the pipe line as they form. By thus continuously withdrawing this gas and vapor, the suction line ahead of the inlet of the pump is kept relatively free of large intermittent bubbles and gulps of air, which would otherwise interrupt the pumping action. This additional vapor and gas removal provides a denser head of liquid at the entrance of the pump, which, of course, gives a better inlet condition for the pump itself and thus further aids in the efficient handling of the fuel.

This novel auxiliary vapor-gas removal feature, which is built into my pump, is in addition to several other features which will subsequently be described and which are included to give a self-contained novel pumping unit for problems of this kind.

Other features and advantages will hereinafter appear.

In the drawings which form part of the specification:

Fig. 1 is an elevation of an airplane showing the invention applied thereto;

Fig. 2 is a view on a larger scale showing part of the piping system of Fig. 1;

Fig. 3 is a view similar to Fig. 2 showing how the parts function when my invention is employed;

Fig. 4 is a vertical longitudinal section taken on the line 4—4 of Fig. 6 looking in the direction of the arrows;

Fig. 5 is a vertical longitudinal view in section taken on the line 5—5 of Fig. 6;

Fig. 6 is a vertical section taken on the line 6—6 of Fig. 4 looking in the direction of the arrows;

Fig. 7 is a vertical section taken on the line 7—7 of Fig. 4 looking in the direction of the arrows; and

Fig. 8 is a vertical section taken on the line 8—8 of Fig. 4 looking in the direction of the arrows.

In the specification similar reference characters designate similar parts in each of the various views.

A typical arrangement of fuel piping on a modern airplane is shown in Fig. 1. In this arrangement, the fuel is carried in one of the fuel tanks **1** from which it is pumped by the booster pump **2**, through the fuel lines **3** and **3***a*, which lead across the wing structure to the engine pylon mounting. Then the fuel piping leads to the lower end of this mounting to the engine driven booster pumps **7** of my invention only one of which is shown.

It will be noted from this view that there is a high spot in the pipe line at **4**, at which a bubble may form. There is also indicated a fitting **5** in the line, which is typical of a valve, heat exchanger, strainer, etc., which will produce a local pressure drop point immediately beyond it and where additional bubble formation is likely to occur. An auxiliary suction pipe **6** is run from the pump **7** of the invention with connections to each of these gas forming locations at **10** and **11**. The booster pump delivers through its discharge line **8** into the main engine pump shown at **9** and fuel is delivered from there into the engine by the main engine pump.

A larger cross section illustrating typical flow conditions in the fuel piping system at the critical areas **4** and **5** is shown in Fig. 2. It will be noted that the gas bubble in Fig. 2 has grown to such an extent as to pretty much restrict the flow of fuel, as well as to break the syphon effect of the down leg of the pipe. There is only a small channel of fuel running along the lower part of the pipe. Under these conditions, the inlet to the pump is open to the gas, which would in itself result in failure of a normal centrifugal pump. Even a positive displacement pump cannot reach the fuel until it removes this air. All advantage of a possible static head of fuel assisting the pump on the suction side is also lost because of the channeling of the liquid in the pipe line instead of the pipe line being filled solid with liquid.

Fig. 3 shows the improvement in the flow conditions when my invention is applied in the manner prescribed. Local restrictions are placed at **10** and **11** to match the capacity of line **6**. It will be noted that the pipe line **3** is kept full of fuel, thus preventing gas and vapors from being drawn into the pump inlet and also providing a static head of fuel above the pump inlet for better pumping conditions.

The pump itself is shown in Figs. 4, 5, 6, 7 and 8. The main centrifugal pump impeller **15** is in accordance with the teachings of my Patent 2,461,865. This impeller, by its design, is capable of handling a liquid with a high percentage of gas and vapor present with the liquid. The impeller passageways **17***a* between impeller blades **17** are so proportioned as to centrifugally separate the gas and vapor from the liquid within the bladed portion of the impeller. The gas-free liquid is discharged against pressure through the volute **18** and main discharge of the pump **19**, while the separated gas and uncondensed vapor are directed towards an annular collecting groove **20** near to and surrounding the main inlet **16** to the impeller. From this collecting groove **20** one of the built-in liquid ring compressors **24** continuously withdraws the separated gas. It may be also noted that my said co-pending application, Serial 256,580, is designed for operation as an engine driven booster pump. Improvements of the present invention over this co-pending application will be readily observed from the following description.

In the present invention, I provide what amounts to four pumps with one unitary impeller **15**. The main suction of the pump is located at **16**. The fuel entering through this suction opening is picked up by the blades **17** of the vapor-gas separating portion of the impeller. The fuel and vapor or gas mixture picked up by these blades **17** are separated by centrifugal action within the casing as the blades rotate in a manner similar to that described in my Patent 2,461,865. Fig. 8 shows a cross section through these impeller blades **17**. The separated gas-free liquid is delivered through the volute passageway **18** and the final discharge **19**, while the separated gas and non-condensible vapors are directed to the collecting groove **20** near the entrance of the casing. At point **21** (Fig. 4) these gases and vapors collected in the groove **20** are withdrawn through passageway **22** (Figs. 4 and 6) to the inlet port **24***a* of one suction chamber **24** of a liquid ring compressor **32** provided on the opposite side of the impeller **15**, having blades **23** and the lobe casings **24** and **30**. The gases and vapors are compressed by the liquid ring compressor **32** and delivered through discharge ports **24***b* to the interior annular space **25** (Fig. 7). Fig. 4 is a cross section showing the above passageways. From here, the mixture of condensed vapors, gas and liquid are picked up by the intermediate blades **26** of the second stage centrifugal pump formed by these blades **26** and the two side walls **27** and **27***a* of the main impeller **15**. The mixture discharged by the liquid ring compressor **32** to chamber **25** is thus continuously picked up and centrifugally discharged through the blades passageways **28** to the volute chamber **18** into which the main liquid flow has been discharged by the previous mentioned set of blades **17**. Fig. 7 shows a cross section through the blades **26** of the second stage impeller.

In the process of suction and compression in the liquid ring compressor **32** the vapors are condensed and most of the free gas is absorbed at the higher discharge pressure at **25** from the liquid ring compressor. They are further pressurized by the action of the intermediate centrifugal **26** and the liquid delivered to the same terminal pressure as that developed by the main impeller blades **17**. The introduction of the intermediate blades **26** of the present invention allows the liquid ring compressor **32** to operate over a normal compression range rather than having to operate over abnormally high compression ranges, as is the case with my co-pending application, Serial 256,580, where it has to deliver the compressed mixture either against that developed by the main impeller or against the reduced regulated pressure from the main impeller.

Another feature distinguishing this invention, which is shown in Fig. 5, is the provision of a separate lobe **30** which is used to maintain a suction through connection **31** and pipe **6** to the vapor-forming pockets **10** and **11** in the suction line **3**, as previously outlined. Vapor and gas are withdrawn from these pockets through connection **31** into the port **30***a* of the liquid ring compressor lobe section **30**. The suction and compressive action in this lobe **30** are entirely independent of the suction and compressive action of the other lobe **24** used for scavenging the main impeller **15**. The vapors and gas removed from the pipe line pockets are compressed in the liquid ring compressor **30** and discharged through ports **30***b* into the same annular chamber **25** that receives the discharge from the impeller scavenging lobe **24**. The discharges of the two liquid ring compressor lobe sections **24** and **30** are therefore combined at this point and both are pumped to the higher volute pressure **18** by the common second stage impeller blades **26**.

It will be noted that the gas-vapor phase is handled in two stages. The first stage is a liquid ring compressor using the pipe line liquid as the liquid piston. This liquid is continuously replenished by liquid drawn in with the gas and vapor. In the liquid ring pump, the mixture is compressed to an intermediate stage pressure and in so doing, the vapors are condensed and the gases are reabsorbed back in the liquid so that little, if any, free gas or vapor is present in the discharge from the liquid

ring compressor. It is practically all liquid. After this work of compression has been completed and to stabilize this liquid further, it is passed through the second stage centrifugal pump. Here it is brought up to the final pump discharge pressure and discharged into the common and final liquid discharge.

The liquid ring compressors are only required to have the compression ratio necessary to condense and absorb the vapors and gases removed from both the collecting pockets **4** and **5** and the main impeller entrance groove **20**. The second stage centrifugal impeller is furnished to deliver this liquid from the discharge of the liquid ring pump to the final discharge pressure of the main centrifugal pump.

From the above description it will be understood that I provide four pump portions A, B, C and D with one unitary impeller **15**. Pump portion A has the property of centrifugally separating the entrained gas and liquid arriving at its inlet, and serves to discharge the liquid separately through a discharge connection, and to reject the separated air and vapor to a separate port, where it will be handled by pump portion B.

The parts which make up pump portion A include the vanes **17**, Figs. 5 and 8 in cooperation with the enveloping casing **40** and the volute **18** formed therein. Vanes **17** are integral with the central driving shroud **27**, which is driven by the main shaft **41**, this shaft being driven by a motor, not shown, through the coupling member **42**. The casing **40** also forms the main inlet to the pump **16**, the air vapor collecting groove **20** with its connection **21** for removal of the separated air and vapor and the final discharge connection **19**.

It will thus be seen that the function of pump portion A is to pump the liquid from the system **3** to which it is connected, pressurizing it and delivering it to higher pressure through the discharge connection **19**.

Pump portions B and C are included in casing **32**. This casing surrounds a rotor formed by blades **23**, attached to an extension **27***a*, Fig. 4, and driven by the central driving member **27** through blades **26**. This rotor also has an external shroud member **45** enclosing the ends of the blades **23**. These pump portions B and C are of double lobed liquid ring compressor type. Pump portion B of this double lobed liquid ring pump is defined by one lobe **24**, as shown in Figs. 4 and 6, together with central inlet port **24***a* and discharge port **24***b*.

The function of pump portion B is to continuously remove the separated gas and vapor directed to the annular groove **20** and the take-up point **21**, removing this mixture from the pump portion A through conduit **22** and inlet port **24***a*. A further function of pump portion B is to compress the gas and vapors so removed. In this process it condenses the said vapors and causes the gas to be absorbed by the liquid of the liquid ring portion in lobe **24**, delivering the excess liquid upon final compression through the discharge port **24***b*, from which port it is picked up by pump portion D to which I shall refer later.

Pump portion C is defined by the opposite lobe **30**, Figs. 5 and 6, of the liquid ring pump, and is provided with inlet port **30***a* and discharge port **30***b*. The function of this pump portion C is to remove gas and vapor from high collection points formed in the suction line piping attached to the main pump at **16**, this suction being maintained through connection **31** and pipe **6**, the purpose being to continuously remove gas and vapor collecting in the high points of the suction line, withdrawing them into the liquid ring pump through inlet port **30***a*, and compressing this mixture and discharging the condensed mixture through the discharge port **30***b* to the inlet **25** of the aforementioned pump portion D.

Pump portion D is a centrifugal liquid pump formed by the intervening blades **26** extending between the drive shroud member **27** and the opposite shroud member **27***a*, and is shown in cross section in Fig. 7. The purpose of this pump is to take the discharge from pump portions B and C, through suction connection **25**, and centrifugally pressurizing this mixture and delivering it to the volute **18** at the higher pressure maintained in volute **18** by pump portion A, thus removing this work of delivering to the higher pressure from the compressor pump portions B and C, so that they can operate in their normal compression range. The output from pump portion D is thus combined with the outlet from pump portion A in the main collecting volute **18**, from which it is discharged through the final discharge connection **19**.

Briefly stated, I provide a vapor separating centrifugal pump or booster equipped with an individual vapor removal pump portion, which constantly removes separated vapors and gas from the interior of the main pumping element and these elements are also combined with a separate and independent vapor removal element to continuously remove the evolved gases as they collect at remote high points in the suction line ahead of the main pump, and the vapor-gas removal pump portions compress and condense these vapors and absorb the gases, discharging both with other liquid to the common discharge of a second stage centrifugal, which then discharges this combined mixture with the liquid discharge of the main centrifugal impeller element.

The four combined pumping elements are thus designed to work together for the efficient delivery of pressurized, stabilized liquid from a suction line flowing with this liquid in a separated two-phase and unstable condition.

The liquid ring compressor pump portions B and C are supplied with liquid for the sealing ring of these compressors by the normal amount of entrained liquid coming to them with the gas and vapors removed from the impeller collecting ring **20** and the vapor removal line **6**, respectively. There are times, however, when the proportion of gas-vapor in the suction line **3** might be such as to preclude the possibility of liquid being carried over to the compressor pump portions B and C with the removed gas and vapor, in which event the liquid ring compressor pump portions B and C might exhaust the supply of sealing liquid therein and thereafter become inoperative because of the loss of the liquid ring and subsequent gas or vapor binding of the compressor.

To insure the continued maintenance of the liquid ring in this compressor, I provide means for supplying liquid from the pressurized portion of the volute **18** to the lobes of the compressor pump portions B and C. In addition to the liquid in the volute there will be the liquid available in the pipe line **8** or, should a special situation develop, where additional seal liquid might be required to be on tap, I provide an additional auxiliary storage chamber connected to the volute or the seal supply chamber **50** for this purpose.

The sealing liquid auxiliary supply chamber **50** is shown in Figs. 5 and 6 and is an annular chamber formed by the outer casing **53** and the inner casing **54** of the liquid ring compressor, as shown in Fig. 4.

Seal liquid supply for chamber **50** is fed from the volute **18** through feed hole **51**.

The liquid seal feed hole **55** for compressor B is shown in Figs. 4 and 6 and the liquid seal feed hole **52** for the compressor pump portion C is shown on Figs. 5 and 6. It will be noted that these seal feed holes are located in the lobe at the point of highest pressure built up within the lobe casing, that is, at a point near the final discharge from the lobe. These holes are placed so as to enter the casing at the highest pressure point of the compressor casing. This pressure, however, is less than the pressure in the volute by the difference between the pressure built up by the intermediate second stage pump portion D. Under these circumstances, a small amount of liquid only would be supplied to the compressor lobes, as would occur with the pressure differences noted. If,

however, the liquid ring pump should start to run out of seal, with resulting lessened pressure within the respective lobe casings, the reduction in pressure at this point would result in a greater pressure difference across the seal feed holes 52 and 55, with resultant increase in delivery of liquid to the liquid ring casing to restore the liquid ring to its full depth.

In the manner above shown, I provide for a continuous supply of liquid for the liquid ring compressor, even though the inlet connections to each respective compressor handle gas and vapor alone. In this way, the operation of the liquid ring compressor is maintained under such dry inlet conditions to keep up the efficient handling of vapor and gas under most critical main inlet conditions.

I have described what I believe to be the best embodiments of my invention. I do not wish, however, to be confined to the embodiments shown, but what I desire to cover by Letters Patent is set forth in the appended claims.

I claim:

1. In combination, a first pump portion having a liquid discharge connection and a separate gas and vapor discharge port, said first pump portion including a first rotary element having vanes and a casing having a volute formed therein for cooperating with said vanes and leading to said discharge connection to centrifugally separate the liquid from the gas and vapor entrained therein, to pressurize said liquid and to deliver the liquid to said liquid discharge connection and the gas and air to said separate gas and vapor discharge port, second and third pump portions constituting a double lobe liquid ring compressor including wall means defining a substantially elliptical chamber and a second rotary element rotatable therein, said second pump portion having a discharge port and an inlet connected to said vapor discharge port to continuously remove the said separated gas and vapor from said separate gas and vapor port of said first pump portion, and to compress the gas and vapor so removed, and to cause the said gas and vapor to be absorbed by the liquid of the liquid ring portion of said compressor and to deliver the said liquid to its said discharge port, said third pump portion having a separate discharge port and an inlet extending to the exterior of said third pump portion for connection to an external suction line to continuously remove gas and vapor from said suction line and to compress the said gas and vapor so removed, and to cause the said gas and vapors to be absorbed by the liquid of the liquid ring portion of said compressor, and deliver the said liquid to its said separate discharge port, and a fourth pump portion, said fourth pump portion including a third rotary element arranged to take the discharge from the discharge ports of said second and third pump portions and to centrifugally pressurize this mixture and deliver it at the higher pressure into the discharge connection of said first pump portion.

2. The combination of claim 1, in which each of the rotating elements is comprised in a unitary impeller structure.

3. The combination of claim 1, in which each of the rotary elements is comprised in a unitary impeller, said impeller comprising a central driving shroud, said first pump portion comprising vanes integral with said driving shroud and extending from one side of said shroud, said second and third pump portions comprising blades extending from the other side of said shroud, and said fourth pump portion comprising blades intervening between said last-mentioned blades and said shroud.

4. In a fuel system including a fuel tank, an engine fuel pump removed from said tank, fuel piping from said tank to said fuel pump, said piping having a pocket in which evolved gas and vapors from the fuel accumulate, the improvement comprising a booster pump installed in said fuel piping, said booster pump comprising a first pump having its inlet connected to said fuel piping and having a liquid discharge connection and a separate gas and vapor discharge port, said first pump portion including a first rotary element having vanes and a casing having a volute formed therein for cooperating with said vanes and leading to said discharge connections to centrifugally separate the liquid from the gas and vapor entrained therein, to pressurize said liquid and to deliver the liquid to said liquid discharge connection and the gas and air to said separate gas and vapor discharge port, second and third pump portions constituting a double lobe liquid ring compressor, including wall means defining a substantially elliptical chamber and a second rotary element rotatable therein, said second pump portion having a discharge port and an inlet connected to said vapor discharge port to continuously remove the said separated gas and vapor from said separate gas and vapor port of said first pump, and to compress the gas and vapor so removed, and to cause the said gas and vapor to be absorbed by the liquid of said compressor and to deliver the said liquid to its said discharge port, said third pump portion having a separate discharge port and an inlet extending to said piping in the location of said pocket to continuously remove gas and vapor from said fuel piping and to compress the said gas and vapor so removed, and to cause the said gas and vapors to be absorbed by the liquid of the liquid ring portion of said compressor, and deliver the said liquid to its said separate discharge port, and a fourth pump portion, said fourth pump portion including a third rotary element arranged to take the discharge from the discharge ports of said second and third pump portions and to centrifugally pressurize this mixture and deliver it at the higher pressure into the discharge connection of the said first pump portion.

5. The combination of claim 4, in which each of said first, said second, and said third and fourth pump portions include a rotating element formed into a unitary impeller.

6. The combination of claim 5, wherein said impeller comprises a central driving shroud, said first pump portion comprising vanes integral with said driving shroud and extending from one side of said shroud, said second and third pump portions comprise blades extending from the other side of said shroud, and said fourth pump portion comprises blades intervening between said last-mentioned blades and said shroud.

7. The subject matter of claim 1, in combination with means for supplying liquid to the lobes of the second and third pump portions.

8. The subject matter of claim 7, in which the said means comprises means constituting an auxiliary supply chamber and connections from said chamber to said second and third pump portions.

9. A pump comprising a rotatable main impeller, casing wall means defining a central fluid inlet and a peripheral volute discharge for said impeller, a rotatable liquid ring compressor rotor, said casing wall means including a centrally located rotor inlet and rotor discharge and a substantially elliptical ring in which said rotor is rotatable and including a connection between a location in the vicinity of said fluid inlet and the central portion of said rotor to deliver air and vapor from said impeller to said rotor for compression and condensation of liquid thereby, and an intermediate impeller having a central inlet connecting said rotor discharge and positioned to discharge peripherally into said volute discharge.

10. A pump according to claim 9, wherein said casing wall means includes portions at the center of said rotor defining two inlets one of which is connected to receive air and vapor from a location exteriorly of said pump.

11. A pump comprising a casing having a central inlet opening and an annular discharge passage, a continuously rotated main shaft, a triple function impeller rotor affixed to said shaft including impeller means positioned adjacent said inlet and arranged to discharge fluid radially

to said discharge portion, said casing including a substantially elliptical chamber and conduit means connecting a portion of said casing in the vicinity of said inlet with the central portion of said elliptical chamber, said impeller means including a liquid compressor rotor portion affixed to said shaft for rotation in said elliptical chamber, and an intermediate impeller portion affixed to said shaft and having a central inlet in communication with the central portion of said elliptical chamber and arranged to discharge radially to said discharge portion.

12. A pump according to claim 11 including conduit means in said casing connecting the central portion of said chamber to the exterior of said casing for connection to an external fluid line.

13. A pump according to claim 11 wherein said impeller means is of unitary construction.

14. In a pump system comprising a fuel reservoir, and a suction line extending above said reservoir and having a suction therein, said suction line including a portion in which gas and vapors evolved from the fuel tend to accumulate, the improvement comprising a pump connected to said suction line, the pump including a rotatable main impeller, casing walls defining a central fluid inlet connected to said suction line and a peripheral volute discharge, wall means defining a substantially elliptical chamber, a rotatable liquid ring compressor rotor arranged for rotation within said chamber and air and vapor discharge port defined in said casing adjacent said inlet, means connecting said port with the central portion of said elliptical chamber to deliver air and vapor from said impeller to said rotor for compression and condensation of liquid thereby, means connecting the gas and vapor accumulation portion of said suction line to the central portions of said elliptical chamber, and an intermediate impeller having a central inlet connecting said rotor discharge and positioned to discharge peripherally into said volute discharge.

15. In a fuel system including, a fuel tank, an engine fuel pump removed from said tank, fuel piping from said tank to said engine fuel pump, said piping having a pocket in which gas and vapors evolved from the fuel accumulate, the improvement comprising the addition of a booster pump located in the vicinity of said engine pump, said pump having a main inlet connected to said piping and a discharge connected to deliver fuel to said engine pump, said pump including a liquid compressor portion having a separate compressor portion inlet connected to the gas and vapor pocket of said piping to continuously remove gas and vapors from said piping and including rotating means to cause said gas and vapor to be absorbed by the liquid of said compressor portion.

16. In a fuel system according to claim 15, impeller means connected to said compressor portion, and arranged to continuously receive liquid therefrom and deliver it at increased pressure to the discharge of said booster pump.

References Cited in the file of this patent

UNITED STATES PATENTS

1,983,131	Hume	Dec. 4, 1934
2,018,110	Auter	Oct. 22, 1935
2,278,397	Scheibe et al.	Mar. 31, 1942
2,306,841	Adams	Dec. 29 1942
2,500,227	Adams	Mar. 14, 1950
2,500,228	Adams	Mar. 14, 1950
2,581,828	Adams	Jan. 8, 1952
2,737,897	Dewees	Mar. 13, 1956
2,845,871	Compton	Aug. 5, 1958

FOREIGN PATENTS

345,973	Great Britain	Sept. 27, 1929
511,305	Great Britain	Aug. 16, 1939

UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 2,952,214 September 13, 1960

Harold E. Adams

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 7, line 75, after "pump" insert -- portion --.

Signed and sealed this 20th day of June 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents