Feb. 15, 1949. H. E. ADAMS 2,461,865

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Filed July 6, 1943 4 Sheets-Sheet 1

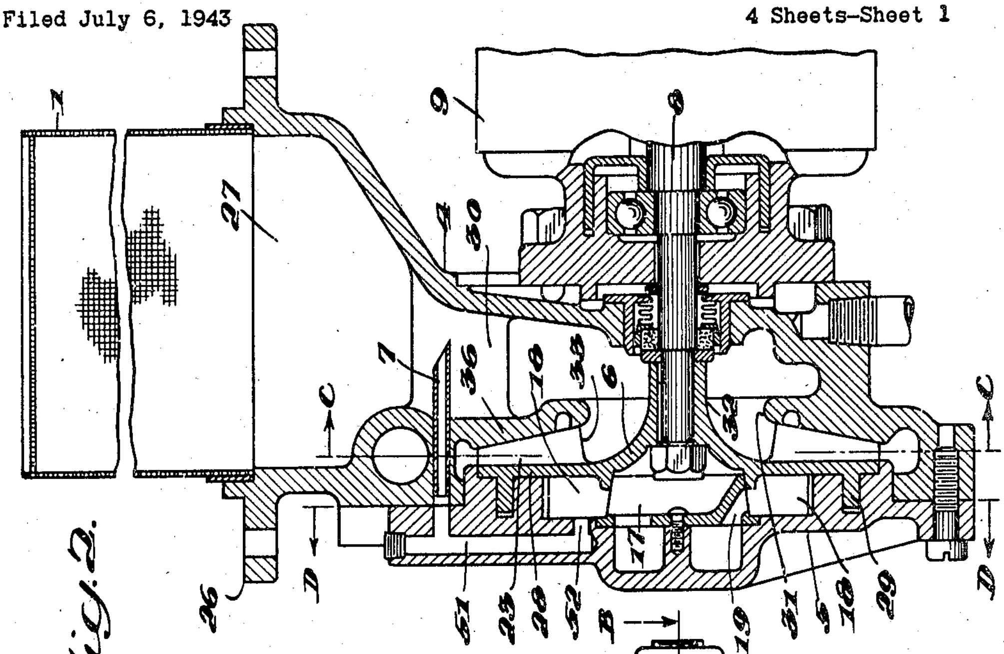

Fig. 2.

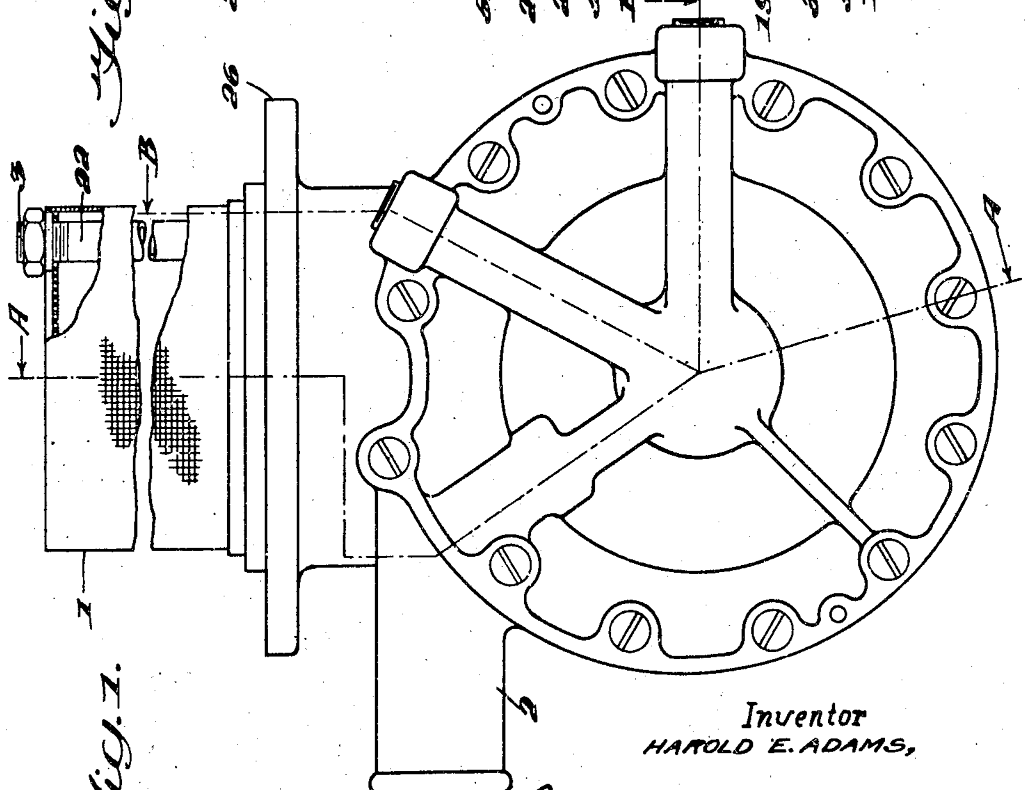

Fig. 1.

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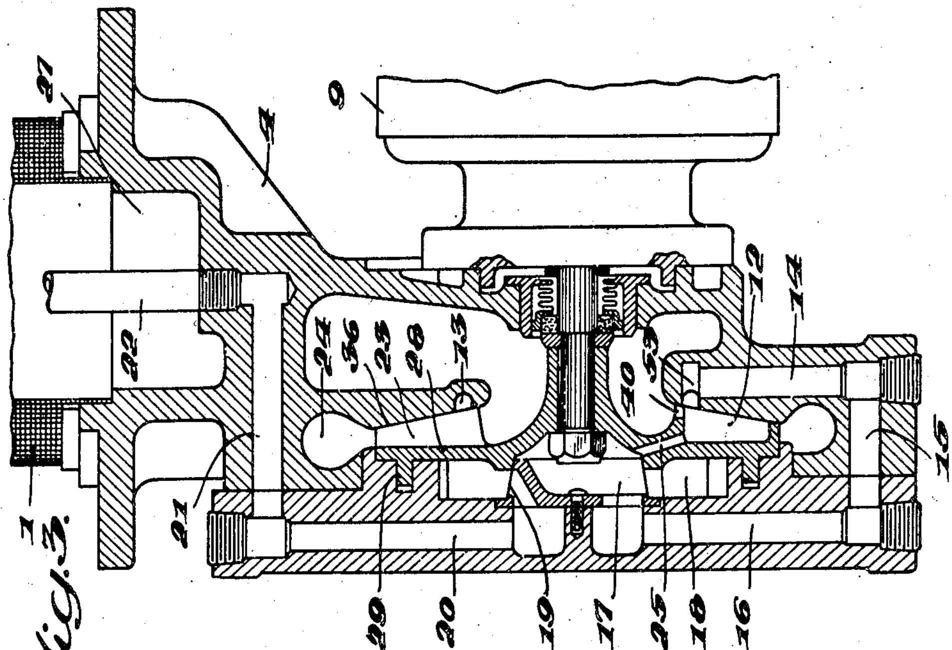

Fig. 3.

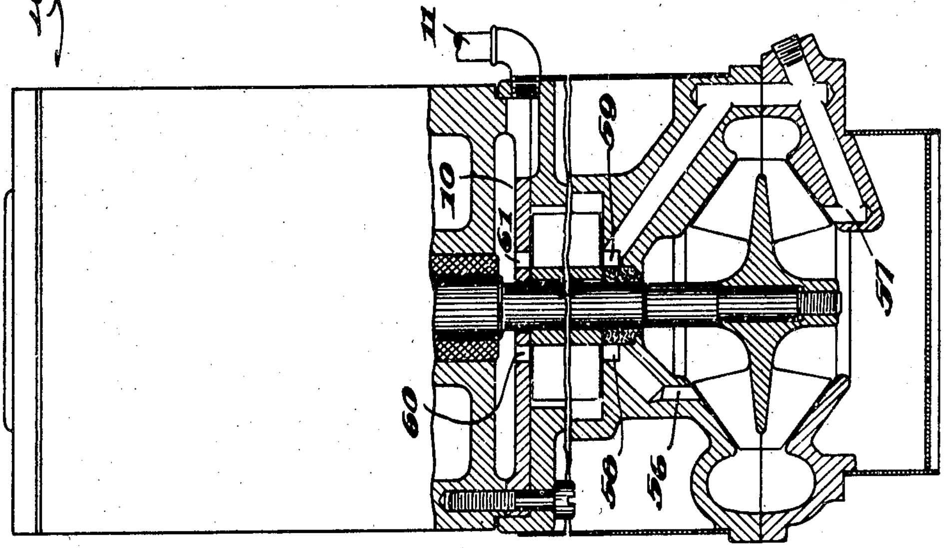

Fig. 6.

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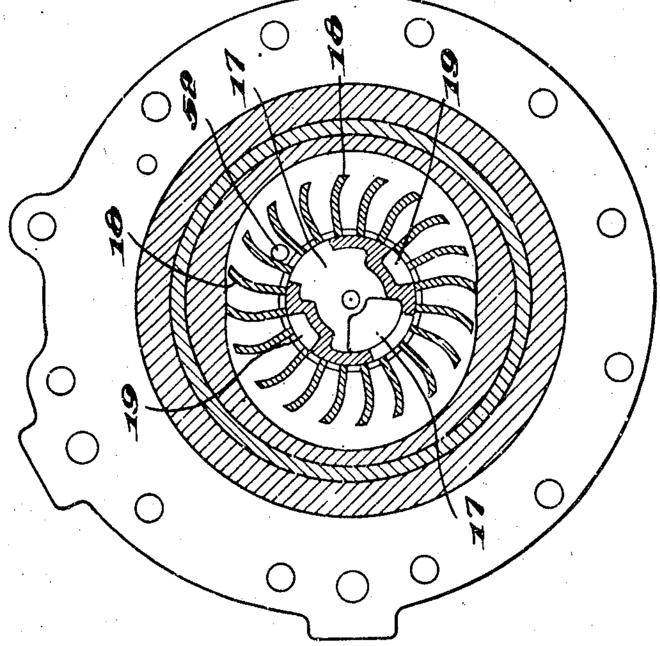

Fig. 5.

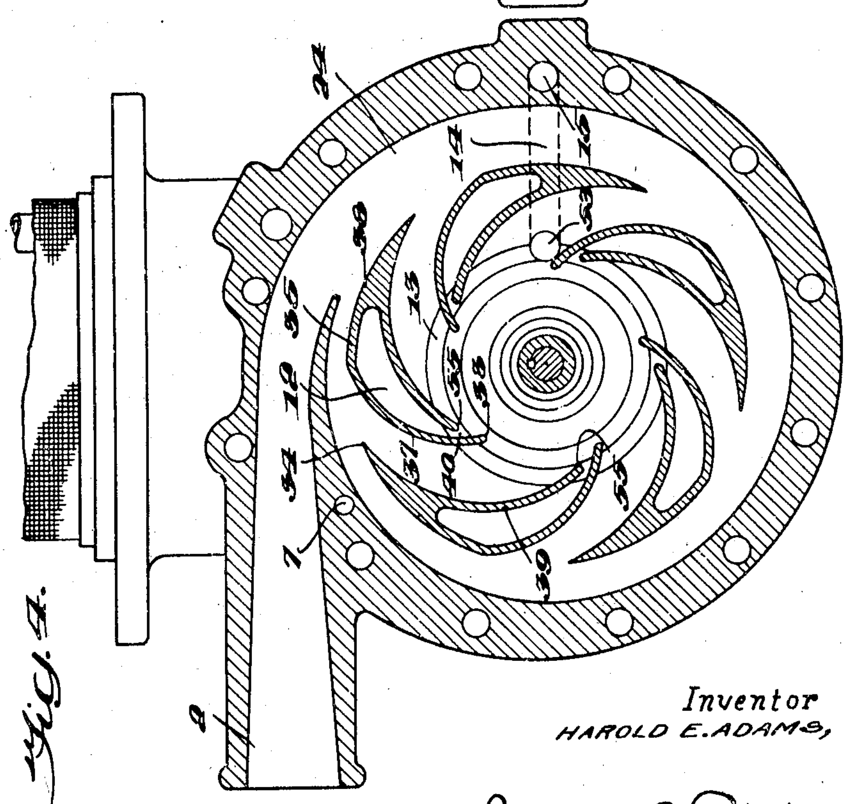

Fig. 4.

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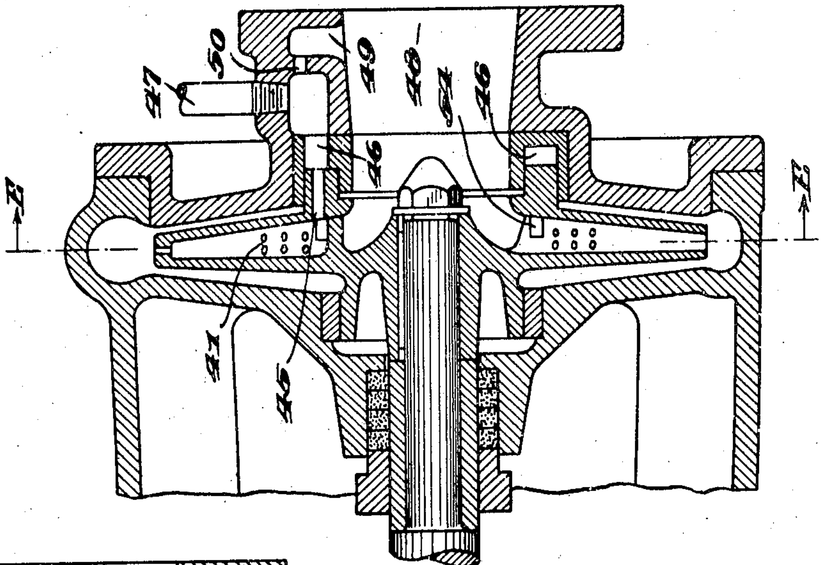

Fig. 7.

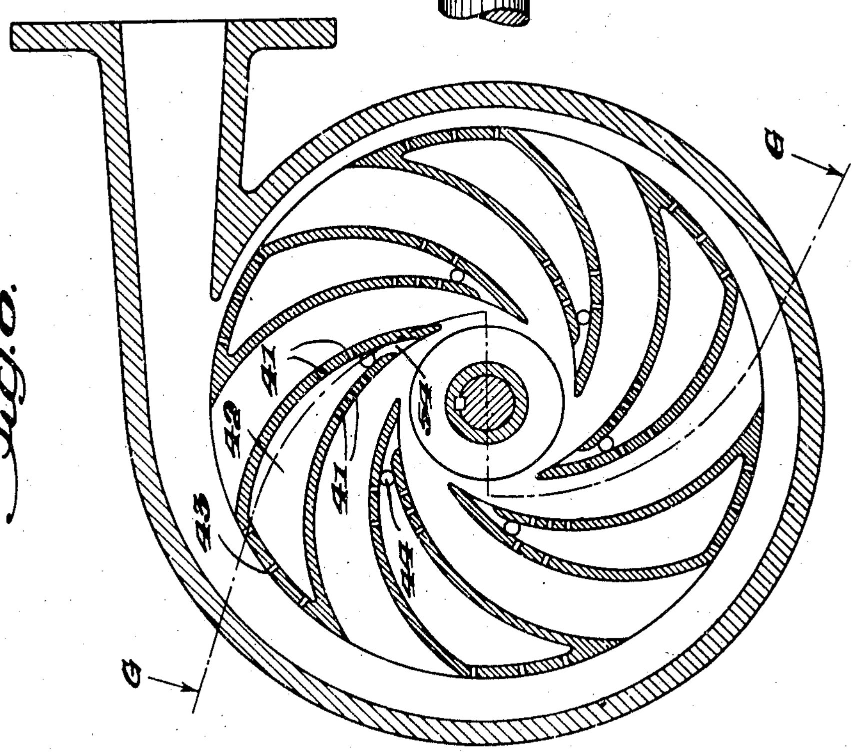

Fig. 8.

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Patented Feb. 15, 1949

2,461,865

UNITED STATES PATENT OFFICE

2,461,865

PUMP

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Application July 6, 1943, Serial No. 493,662

21 Claims. (Cl. 103—113)

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This invention relates generally to the pumping of highly volatile or effervescing liquids. The problem of fuel delivery from aircraft tanks to the engine carburetor is a specific application.

This problem of vapor lock, as it is known, developed early in the advent of high altitude and fast climbing airplanes. The reduction in absolute pressure on the vented fuel tank during high altitude flight causes boiling of the more volatile constituents of the fuel and also the release of absorbed air. Violent ebullition in the tank occurs during the rapid climb rates. The presence of resultant bubbles in the suction line of the main engine fuel pump results in the failure of the engine fuel pump to deliver the required amount of liquid fuel to the carburetor.

Attempts to overcome this difficulty have met with partial success by the use of what is termed a fuel booster pump. This is generally some form of a centrifugal pump mounted directly on the bottom of, or even inside of, the aircraft fuel tank, to deliver fuel under pressure to the inlet of the standard engine fuel pump. The booster pump is operated when vapor lock is likely to occur, such as when rapidly climbing from sea level with hot gasoline in the tanks or when climbing to relatively high altitudes with gasoline of so-call normal temperature.

These devices, which endeavor to deliver bubble-free gasoline to the engine fuel pump inlet, are good only for comparatively moderate rates of climb and fuel temperatures, and it is recognized that a better booster pump is required to handle higher temperature, more volatile gasoline during faster plane acceleration and to still higher elevations, also to operate with a minimum static head of liquid on the pump inlet.

It is, therefore, one object of this invention to further increase the capabilities of the fuel booster pump to operate under extremely adverse fuel temperature, pressure and inlet head conditions and deliver bubble-free liquid fuel to the engine pump at the maximum attainable rate of climb, and altitude of present and future aircraft.

There are many other problems involving the pumping of effervescing liquids or of gas-laden and ebullient liquids, also liquids at the boil point, and this invention provides improved means for the handling of these difficult pumping problems. It is well known in the art that a sufficient static head on the suction of a centrifugal pump must be provided when pumping liquids at the boil point. It is often inconvenient to provide for this necessary static head above the pump inlet. With

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the means of the present invention I can reduce this static head very substantially, pumping from the container directly.

Carbonated or other gas-laden or ebullient liquids of this nature can likewise be handled by means of this invention. It is further the object of this invention to provide improved means for application to the priming of centrifugal pumps to provide more efficient and quicker evacuation of the casing and to get them into full operation in less time than by conventional methods.

A further object of this invention is to provide a type of centrifugal that is constantly self gas and vapor purging.

A further object of this invention is to provide a unitary self-devaporizing centrifugal of minimum weight, size and horsepower.

A further object of this invention is to provide collecting means within a centrifugal liquid pump to trap and collect gas and vapor from an ebullient liquid after it passes through the inlet of the centrifugal impeller in order that it may be then drawn off by vapor removal means.

A further object of this invention is to provide a unitary impeller and associated casing to provide separating, collecting and discharge means for removing gas and vapors from an ebullient liquid that is being pumped so that only solid liquid is delivered and the removed vapors are returned to the source.

Another object of this invention is to provide unitary centrifugal pumping means capable of delivering vapor and gas-free liquid from an ebullient liquid source.

Further objects and uses of this invention will be apparent from the following description.

In the drawings:

Fig. 1 shows an end elevation of the invention;

Fig. 2 is an irregular cross section of the pump taken in the plane A—A of Fig. 1;

Fig. 3 is another irregular cross sectional view of the pump taken in the plane B—B of Fig. 1;

Fig. 4 is an end cross sectional view taken through the volute and impeller of the centrifugal pump in the plane C—C of Fig. 2;

Fig. 5 is a cross sectional view taken through the vapor removal end of the pump in the plane D—D of Fig. 2;

Fig. 6 is a cross sectional view of another form of the invention;

Fig. 7 is a cross sectional view taken thru the plane G—G of Fig. 8 and showing the vapor collecting feature as applied to a separate centrifugal;

Fig. 8 is an end cross sectional view taken through the volute and impeller in the plane E—E of Fig. 7.

The pump illustrated in Figures 1, 2, 3, 4 and 5 is designed for mounting on the bottom or lower side of aircraft fuel tanks with the inlet strainer 1 projecting up into the tank, and the pump secured by studs engaging the mounting flange 26. The liquid fuel is discharged from the centrifugal impeller 23 through the collecting volute 24 and the discharge nozzle 2. Suitable flexible hose connections are made at this point to the fuel line leading to the engine fuel pump.

The driving motor 9 is directly mounted on the body 4 of the centrifugal pump and the complete assembly may be secured in any position on the fuel tank or connection thereto that provides for free gravity flow from the tank into the pump suction 27.

The booster pump itself is an embodiment of many of the features of the impeller-rotor wet vacuum pumping apparatus disclosed in my U. S. Patents #2 306,841 and #2 306,988, also copending application Serial No. 349 953, filed August 2, 1940, for Pumps, now matured into U. S. Patent No. 2,362,954 of November 14, 1944.

While I employ the same liquid-gas handling unitary rotor in one form of this invention as in the aforementioned patents and application, I have made numerous novel provisions in the related pump structure for the specific handling of ebullient liquids, whereas, the aforementioned references are for pumping previously separated liquids and gases.

Referring to Fig. 2, the combination impeller-rotor or liquid-gas pumping element 6 is provided with the common driving disc and rotating partition 28, on one face of which are located special liquid handling impeller blades 23 and on the opposite side of which are located the gas pumping rotor blades 18, the sealing ring 29 and the liquid seal supply duct 7, 51 and 52.

The impeller-rotor is secured to the drive shaft 8 by a conventional impeller nut and key. The liquid impeller blades 23 operate in a manner similar to conventional liquid centrifugal pumps and the rotor blades 18 operate in a manner similar to liquid ring pumps, in the body 5.

There is thus provided in this unitary impeller-rotor the essential elements for pumping liquid fuel and for pumping gas and vapors and by the combination of this device with the later disclosed novel means for separating bubbles of gas and vapor from the ebullient liquid within the impeller wheel and volute casing, I obtain a compact, efficient pump for this service, as will be further described.

The highly volatile and ebullient liquid flows by gravity through the strainer 1 into the suction connection 27 down through inlet conduit 30 to the eye or annular entrance of the impeller defined by the stationary annular ring 31 and the rotating impeller hub 32. The preferred position of the pump is with the strainer 1 above the eye 31 so that most of the bubbles entrained in the liquid may have an opportunity to rise counter to the slow downward flow of fuel and thus escape to the surface of the fuel in the tank. Some of these bubbles, however, are entrapped with the liquid passing through the eye of the impeller and will be engaged by the leading edges 33 of the impeller blades 23. In addition to the bubbles already carried through the eye with the entering liquid, there will be bubbles evolved when this volatile liquid strikes the revolving edges of the blades 33.

It is well known in the art that the presence of air or gas bubbles in any appreciable volume will break down the action of a centrifugal pump. This is due to the lowering of the average density of the fluid in the impeller by the presence of these vapors, with the result that sufficient head cannot be generated by the impeller to fulfill its normal discharge head requirements.

The impeller pumping rate diminishes approximately as the overall density of the fluid in the impeller is reduced by the presence of bubbles and it may continue to reduce to the point where all pumping ceases at a given head. In the case of the aircraft application, the presence of bubbles delivered into the main engine fuel pump suction is detrimental to the latter pump's action and the mere presence of the bubbles alone may cause failure of the main engine fuel pump before the actual reduction in pumping volume of the fuel booster pump just referred to.

In my invention I provide for the continuous separation, collection and removal of these bubbles from the passages of the impeller itself so that the required density of liquid therein will be sufficient to insure flow and operation of the centrifugal pump. This procedure differs from other known methods which usually attempt to remove or reduce the bubble formation prior to its actual entrance into the confined passages of the impeller.

I will first describe the method of bubble separation and removal that I employ as it applies to the fuel booster pump structure illustrated in Figs. 1, 2, 3, 4 and 5.

A typical impeller passage is that formed between the revolving disc 28, the stationary side wall 36 of Fig. 3 and the two adjacent blade walls defined by 55, 39 and 34 and 33, 37 and 35 of Fig. 4. The driving force causing the rotation and flow of the liquid is exerted by the leading face 33, 37 and 35 of each impeller blade. As a result of this driving force, there is a concentration of pressure in the vicinity of this leading edge over that of other portions of the impeller passage. There is a corresponding lowering of pressure along the trailing edges 55, 39 and 34. This results in the setting up of a circulating movement within the passageway in addition to the radial flow therethrough.

When gas bubbles are entrained in the liquid being pumped, these gas bubbles are urged toward the trailing edge by this circulating movement, and by the action of differential pressure between these two faces tending to squeeze out the bubbles from the high pressure region. There is also the effect of centrifugal force tending to separate out the gas bubbles and to force these bubbles centripetally to the central portion of the impeller while at the same time allowing the more solid liquid to pass along the pressurized leading face of each impeller blade.

The result of the above forces is a concentration of separated gas at the entrance of each impeller passageway with the greatest concentration of gas on the following side of each trailing edge of the blade.

In my method of operation I provide means for withdrawal of this accumulated gas by providing a collecting groove 13 and/or a gas pump suction connection 53, connecting directly to this region or to the collecting groove located in this same region. The gas thus centripetally accumulated within the confines of the impeller passages is drawn off by the suction action of an auxiliary gas pump at a rate equal to the formation or accumulation of gas in this region. By so withdrawing the gas at this point, I prevent it from filling up the impeller passageways and the resultant entrainment of this gas in the delivery of the pump or the ultimate stoppage of all delivery by the pump because of the lowered overall density within the impeller passageways caused by excessive accumulation of gas therein.

My method of gas removal from a gas-laden liquid to be handled by the pump is more positive and more complete in its action than other means of separation exerted prior to the entrance of the mixture into the impeller passages themselves.

There are many variations by which this can be accomplished, such as by the use of open impellers or by totally enclosed impellers, also the means of withdrawal of gas from these regions, and I do not wish to be limited to the specific forms of construction shown in this application as there are obviously many ways in which this can be done by anyone skilled in the art.

In Figs. 1, 2, 3 and 4, I show only one collecting ring and one gas pump connection but there can be more than one collecting ring or none at all, and more than one gas pump connection to the centripetal region or to the ring or rings.

Another variation of the method of gas withdrawal is shown in Fig. 3 where the gas pump suction passages **53**, **14** and **15** and **16** which are shown in the stationary casing, may be replaced or augmented by suction passages which rotate with the impeller and are a part thereof with connecting conduits **25** leading from the collecting chambers, later referred to, or from the centripetal region of the impeller passages directly to the suction chamber **17** of the vacuum or gas removal pump.

As a further means of accumulating gas within the impeller and directing it centripetally to the gas take-off point, I employ a series of chambers **12** spaced between each of the impeller passages, a typical chamber being defined within the boundaries of the impeller surfaces **33**, **37**, **35**, **38**, **39** and **55**, the driving shroud surface **28** and the stationary side wall **36**. In each of these chambers **12** gas, which leaks through the clearance spaces between the following edge **39** and the stationary side wall **36**, also gas bubbles which are squeezed together with liquid between the clearance of the leading edge **37** and the same side wall **36**, is accumulated and because of the relative lack of radial flow in each of these chambers, this gas is quickly separated out by centrifugal force from the liquid leaking in with it and the gas is directed centripetally to the innermost portion of the chamber which passes adjacent to and opens into the gas collecting ring **13** and/or opening **53**, as each pocket passes this point. In addition to the gas collected within the chambers **12**, as above described, there is additional gas drawn into these chambers through the slot opening **40** which connects the innermost portion of each chamber with the previously mentioned accumulation of gas following the trailing edge of each blade and the innermost portion of each impeller passage.

The liquid which is trapped with the gas in each of these separating pockets is centrifugally separated and allowed to leak off by the pressure built up at the periphery of each pocket, this leakage occurring through the clearance spaces provided by the peripheral wall **35**, **38** and the stationary side wall **36**. The clearance at this point may be adjusted to take care of any liquid thus accumulated in each pocket. There is therefore provided between each impeller liquid passage a collecting chamber where centrifugal separation of gases trapped in each pocket may more effectively take place than in the main impeller passageways, and these gases are in turn directed to the gas collecting point near the center of the impeller.

Another feature still further distinguishing this structure from that shown in my U. S. Patents #2,306,841 and #2,306,988, also copending application Serial No. 349,953, above-mentioned, is the fact that the discharge from the vacuum pump portion of the impeller-rotor is directed back to the inlet chamber from which the effervescing liquid is being pumped rather than being discharged to some point of higher pressure. This results in the reduction in power because the differential to be overcome in pumping back to the same inlet source is only that due to frictional losses in the system rather than appreciable static pressure differences.

The discharge is made through the discharge port **19** and the discharge passages **20** and **21**, and the discharge pipe **22**. This pipe **22** is carried sufficiently high in the source of supply so that the gases discharged therefrom will not be entrained in the liquid immediately adjacent to the entrance **27** of the pump.

The combining of the features of the impeller-rotor, the positive method of gas removal and the discharge back to the suction, all result in a compact efficient unit requiring the minimum of power for its operation. These factors, of course, are vital in aircraft applications where weight, space and power are at a premium.

In Fig. 6 I show a form of double suction centrifugal for greater capacity and the same methods of gas separation and removal are employed but a liquid ring gas pump in a separate casing driven by the common drive shaft is shown. In this particular application, which is for aircraft fuel tanks, the entire pump and motor are shown inside the tank and submerged in the gasoline itself.

In this double suction application there are two gas take-offs located at the innermost portion of each side of the casing and designated as **56** for the upper take-off and **57** for the lower take-off. These separate gas take-offs each go to separate inlet ports **58** and **59** and separate lobes or displacement chambers in the gas pump. The gas is discharged thru upper ports **60** and **61** in the gas pump to gas discharge chamber **10** and said gas is directed upward into the source of supply through the discharge pipe **11**. It is thus seen that in this application, one lobe or displacement chamber of the typical Nash liquid ring pump is used for withdrawing gas from the upper entrance to the double suction impeller and the other lobe or displacement chamber is employed for withdrawing separated gases from the lower inlet to the double suction impeller.

This practice is distinguished from the usual practice in liquid ring pumps of this type where suction connections are usually combined to draw from one source. By separating these suction connections as I have done, I provide the equivalent of separate vacuum pumps for each side of the double suction pump thus obtaining definite removal from each, whereas, because of the differential static conditions between each side of the double suction impeller, a common suction connection might draw most of the gas from one side of the impeller at the expense of the other side.

There can of course be many variations to the above pumps, as any one skilled in the art can make, and I do not wish to be limited to the specific constructions shown herein.

Another form of my invention is illustrated in Figs. 7 and 8. This is a more general case showing the application of one feature of my invention to what is known in the art as an enclosed type centrifugal pump as compared to the open type centrifugal previously illustrated as an aircraft fuel booster pump. In this form of construction, small openings 41 are provided in the following and leading face of each impeller blade, these serving the purpose of collecting gas squeezed into the pockets 42 in a manner similar to that described previously.

Slotted openings 54 are provided to connect each pocket with the impeller passageway at the point of greatest gas accumulation in each passage, that is, at the trailing edge of the blade near the entrance.

The openings 43 in the periphery of each pocket 42 provide for the escape of excess liquid as heretofore described. The size and number of these openings can be proportioned to give the desired separation of gas in the pockets 42 and the escape of excess liquid through openings 43. The openings 44 at the innermost point of each pocket 42 connect through rotating conduits 45 into the stationary annular chamber 46. This chamber 46 is connected to suitable gas removal means through the pipe 47. Gases or vapors trapped in the pockets 42, as previously described, are centrifugally separated out in these chambers and are collected in the innermost portions of each pocket where they are withdrawn by any type of vapor or gas removal apparatus through the rotating conduits 45, the collecting chamber 46 and the suction pipe 47. The collection of a portion of the gas in the liquid entering the suction connection 48 of the pump is also provided for in a conventional way through the pocket 49 placed on top of this opening and the conduit 50 leading into the vapor collecting chamber 46.

The structure as shown presents an improvement over present means of priming liquid centrifugal pumps as well as means for handling effervescing or ebullient liquid pumps. The provisions made by the rotating gas collecting pockets 42 provide additional effective means over present conventional priming methods for the rapid removal of air or gas initially trapped in the casing during the priming operation or even in the efficient removal of subsequent air leakage that occurs in the flow during normal operation from leaks in the suction line.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. In a centrifugal liquid pump, intermediate gas collecting and separating chambers placed between the liquid passages of the impeller and rotating with said impeller, said rotating chambers having openings near their central extremities connecting to stationary suction chambers for the purpose of withdrawing gas from said rotating chambers by gas pumping means, and having their radially outer sections walled to limit discharge of liquid from said chambers radially outwardly into the main discharge passage of said pump.

2. In a centrifugal liquid pump, intermediate gas collecting and separating chambers placed between the liquid passages of the impeller and rotating with said impeller, said rotating chambers having openings adjacent to said impeller liquid passages for the collection of gas entrained in the liquid passing through said impeller, and having their radially outer sections confined by peripheral walls rotatable with said impeller, said walls having openings for the discharge of liquid separated out in said rotating chambers, said chambers having openings near their central extremities for the purpose of discharging gas separated within said rotating chambers to a stationary suction chamber which is connected to a vacuum pump for final removal of said separated gases.

3. A pump assemblage comprising a housing adapted for communication with a source of ebullient liquid supply and having an outlet, a rotor in said housing having a partition dividing said housing into a pair of adjoining pump chambers, said rotor forming in combination with one of said chambers a centrifugal liquid pump discharging to said outlet and forming in combination with the other chamber a gas pump, means in said centrifugal liquid pump for separating the gas from the liquid in the pumping chamber of said liquid pump and for collecting said gas, and conduit means for withdrawing the collected gas and delivering it to the inlet of the gas pump.

4. A pump assemblage comprising a housing adapted for communication with a source of supply and having an outlet, an impeller rotor for forcing a liquid through the housing and formed with a pocket substantially closed at its outer periphery by a wall rotatable with said rotor, and opened near its radially inner side, said housing having an annular gas collecting groove on its inner face communicating with the radially inner opened side of said pocket, means adjacent the impelling surface of the rotor to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, means for centrifugally discharging the separated liquid from the pocket, and conduit means for discharging the collected gas from said groove.

5. A pump assemblage comprising a housing adapted for communication with a source of supply and having an outlet, an impeller rotor for forcing a liquid through the housing and formed with a pocket having a confining wall at its outer periphery rotatable with said rotor, means adjacent the impelling surface of the rotor to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, means for centrifugally discharging the separated liquid from the pocket, and means for centripetally discharging the separated gas from said pocket, said housing having a stationary annular collecting ring for receiving the centripetally discharged gas.

6. A pump assemblage comprising a housing adapted for communication with a source of supply and having an outlet, an impeller rotor for forcing a liquid through the housing and formed with a pocket, said rotor having an opening leading from the impelling surface thereof into said pocket to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, said rotor further having an opening adjacent its periphery leading from the pocket for centrifugally discharging the separated liquid from the pocket,

and means for centripetally discharging the separated gas from said pocket.

7. A pump assemblage comprising a housing adapted for communication with a source of supply and having an outlet, an impeller rotor for forcing a liquid through the housing and formed with a pocket, said rotor having an opening leading from the impelling surface thereof into said pocket to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, said rotor further having an opening adjacent its periphery leading from the pocket for centrifugally discharging the separated liquid from the pocket, and means for centripetally discharging the separated gas from said pocket, said centripetally discharging means including an annular passage from said pocket adjacent the inner periphery thereof.

8. A pump assemblage comprising a housing adapted for communication with a source of supply and having an outlet, an impeller rotor for forcing a liquid through the housing and formed with a pocket, said rotor having an opening leading from the impelling surface thereof into said pocket to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, said rotor further having an opening adjacent its periphery leading from the pocket for centrifugally discharging the separated liquid from the pocket, and means for centripetally discharging the separated gas from said pocket, said centripetally discharging means including an annular passage from said pocket adjacent the inner periphery thereof and further including a stationary annular collecting ring in the housing in continuous communication with said passage.

9. A pump assemblage comprising a housing adapted for communication with a source of supply and having an outlet, an impeller rotor for forcing a liquid through the housing and formed with a pocket, means adjacent the impelling surface of the rotor to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, means for centrifugally discharging the separated liquid from the pocket, means for centripetally discharging the separated gas from said pocket, and means for receiving the centripetally discharged gas and returning it to said source of supply.

10. A pump assemblage comprising a housing, a rotor within the housing dividing the interior thereof into a liquid pumping chamber and a gas pumping chamber, gas pumping means within the gas pumping chamber, means adapting the liquid pumping chamber for communication with a source of liquid supply, said liquid pumping chamber having an outlet, an impeller carried by the rotor for forcing liquid through the housing and formed with a pocket, means adjacent the impelling surface of said impeller to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, means for centrifugally discharging the separated liquid from the pocket, and means including a passage to the gas pumping chamber for centripetally discharging the separated gas from said pocket.

11. A pump assemblage comprising a housing, a rotor within the housing dividing the interior thereof into a liquid pumping chamber and a gas pumping chamber, gas pumping means within the gas pumping chamber, means adapting the liquid pumping chamber for communication with a source of liquid supply, said liquid pumping chamber having an outlet, an impeller carried by the rotor for forcing liquid through the housing and formed with a pocket, means adjacent the impelling surface of said impeller to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, means for centrifugally discharging the separated liquid from the pocket, means including a passage to the gas pumping chamber for centripetally discharging the separated gas from said pocket, and means for conducting the gas pumped through the gas pumping chamber to said source of liquid supply.

12. A pump assemblage comprising a housing, a rotor within the housing dividing the interior thereof into a liquid pumping chamber and a gas pumping chamber, gas pumping means within the gas pumping chamber, means adapting the liquid pumping chamber for communication with a source of liquid supply, said liquid pumping chamber having an outlet, an impeller carried by the rotor for forcing liquid through the housing and formed with a pocket, said pocket having an open side closely spaced from a wall of the housing to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, means for centrifugally discharging the separated liquid from the pocket, and means including a passage to the gas pumping chamber for centripetally discharging the separated gas from said pocket.

13. A pump assemblage comprising a housing, a rotor within the housing dividing the interior thereof into a liquid pumping chamber and a gas pumping chamber, gas pumping means within the gas pumping chamber, means adapting the liquid pumping chamber for communication with a source of liquid supply, said liquid pumping chamber having an outlet, an impeller carried by the rotor for forcing liquid through the housing and formed with a pocket, means adjacent the impelling surface of said impeller to provide for restricted pressure leakage into the pocket for centrifugal separation of liquid from gas entrained in said leakage, means for centrifugally discharging the separated liquid from the pocket, and means including a passage to the gas pumping chamber for centripetally discharging the separated gas from said pocket, said passage from the pocket to the gas pumping chamber including a stationary annular collecting ring formed in said housing.

14. In combination, a source of liquid supply, a centrifugal liquid pump, a connection from said source of supply to the inlet of said pump, a rotary gas pump separate from said liquid pump, means in said liquid pump for centripetally separating the gases entrained in said liquid and conducting them to the inlet of said gas pump, and including a gas collecting annular chamber communicating with the liquid pump chamber and encircling the inlet of said liquid pump, and a discharge connection from said gas pump to said liquid supply.

15. In combination, a shaft, a pair of pump chambers having respective inlets, a liquid pump impeller on said shaft in the first chamber, a gas impeller on said shaft in the second chamber, an annular gas collecting chamber distinct from said inlets and in communication with the interior of said first chamber, said gas collecting

chamber extending around the axis of said shaft means for centripetally separating the gas entrained in the liquid in said first chamber and conducting it to said gas collecting chamber, and a connection distinct from said inlets and extending between said gas collecting chamber and the inlet of said second chamber.

16. In combination, a shaft, a casing, a rotatable disc mounted on said shaft for rotation therewith, and separating said casing into two adjoining pump chambers having respective inlets, a liquid pump impeller mounted on one side of said disc in one of said chambers for rotation with said shaft, a gas pump impeller mounted on the other side of said disc in the other chamber for rotation with said shaft, an annular gas collecting chamber distinct from said inlets and in communication with the interior of said one of said chambers, said gas collecting chamber extending around the axis of said shaft means for centripetally separating the gas entrained in the liquid in said latter chamber and conducting it to said gas collecting chamber, and a connection between said gas collecting chamber and the inlet of said other chamber.

17. A centrifugal pump comprising a pump casing defining a pump chamber, and having a peripheral outlet and an axial inlet, a shaft, a plurality of impeller vanes secured to said shaft and defining a series of gas separating liquid trapping pockets having side walls and outer peripheral walls, and liquid pumping passages between the side walls of said pockets in communication with said peripheral outlet at their radially outer ends, said pockets having openings near their radially inner ends through which the liquid with entrained gas is admitted, a gas collecting chamber, and passage means between said pockets near their radially inner ends and said gas collecting chamber.

18. A centrifugal pump comprising a volute casing having a central inlet and a peripheral outlet, a pump impeller in said casing, said casing having on its inner side an annular gas collecting groove extending around the axis of said impeller and located radially outwardly from said central inlet and a substantial distance radially inwardly from said peripheral outlet, said groove connecting with the pumping chamber defined by said casing, and conduit means connecting said groove with the inlet of a gas pump distinct from said pump impeller for removal of gas collected in said groove.

19. In combination, a centrifugal pump for handling gas laden liquids comprising a volute casing having a central inlet and a peripheral outlet, a pump impeller in said casing, said casing having on its inner side a circular gas collecting groove extending around and coaxial with the axis of said impeller, said groove being located radially outwardly from said central inlet and a substantial distance radially inwardly from said peripheral outlet, and connecting with the pumping chamber defined by said casing, a gas suction connection communicating with said groove and means including a gas pump connected to said gas suction connection and distinct from said centrifugal pump for discharging the gas collected in said groove.

20. A centrifugal pump comprising a volute casing having a central inlet and a peripheral outlet, a pump impeller in said casing open on the side thereof adjacent to the wall of said casing and defining radial liquid passageways in the pump chamber, said casing wall having on its inner side an annular gas collecting groove extending around the axis of said impeller and located radially outwardly from said central inlet and a substantial distance radially inwardly from said peripheral outlet, said groove connecting with the open-side of said impeller and thereby with said radial passageways, and conduit means connecting said groove with the inlet of a gas pump distinct from said pump impeller for removal of gas collected in said groove.

21. In combination, a shaft, a casing, a rotatable disc mounted on said shaft for rotation therewith and separating said casing into two adjoining pump chambers, a set of liquid pump impellers mounted in one of said chambers for rotation with said shaft, a set of gas pump impellers mounted in the other chamber for rotation with said shaft, said casing having an annular gas collecting groove in communication with the interior of said one of said chambers and extending coaxially with the axis of said shaft, means for centripetally discharging the gas entrained in the liquid in said latter chamber and conducting it to said gas collecting groove, and comprising one or more pockets substantially closed at their outer periphery by a wall rotatable with said disc, and opened near their radially inner side, the radially inner opened side of said pockets communicating with said ga collecting groove and a connection between said gas collecting groove and the suction side of said other chamber.

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