

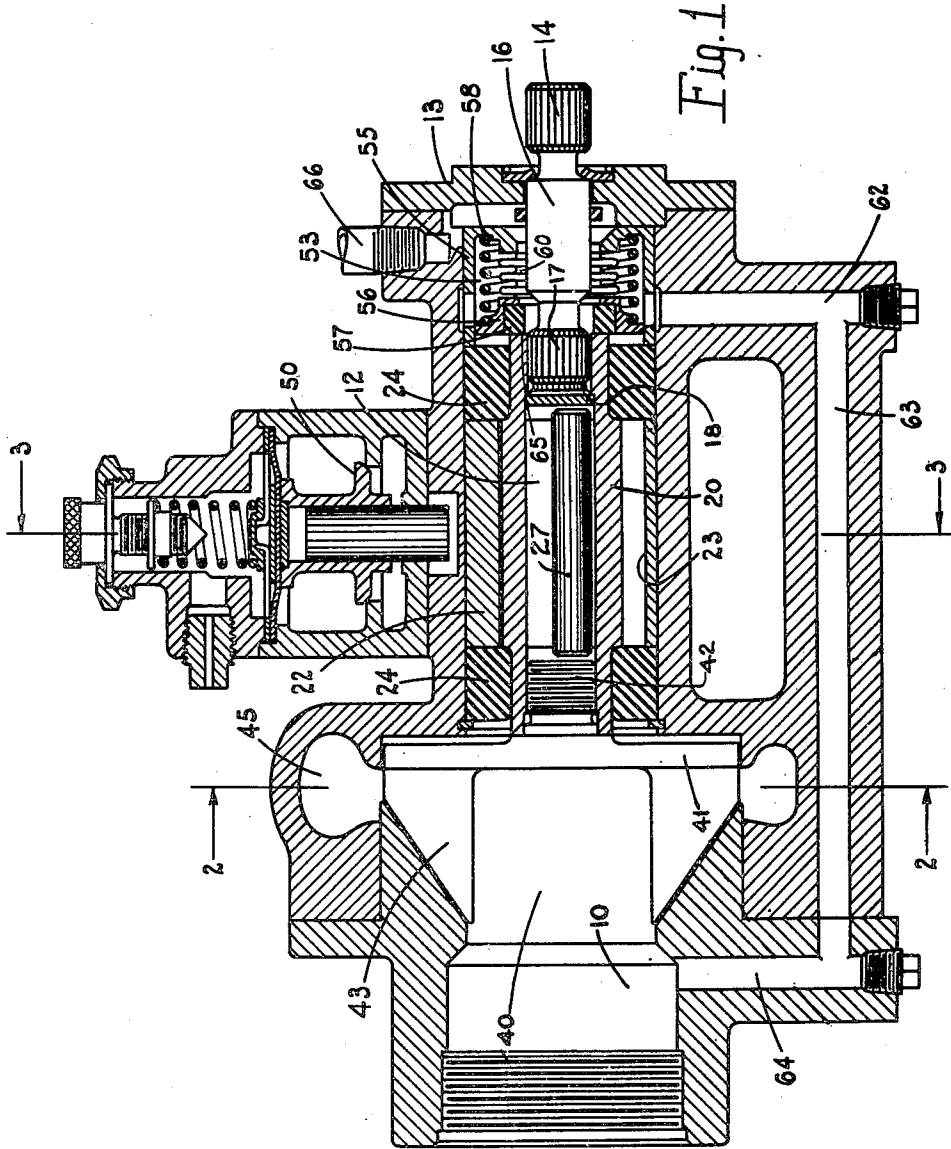
March 14, 1950

H. E. ADAMS
LIQUID PUMPING UNIT

2,500,227

Filed Jan. 18, 1946

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

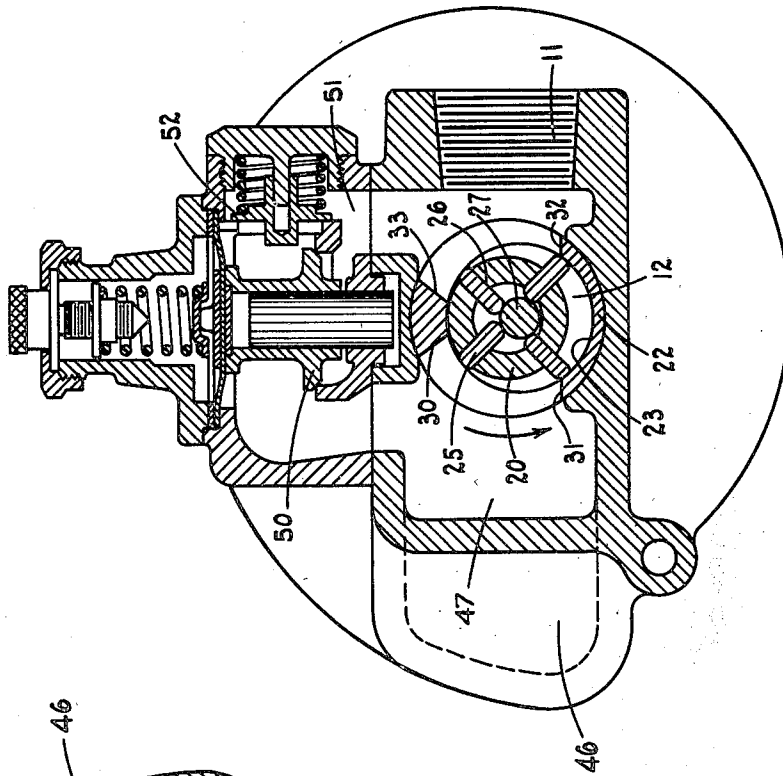


Fig. 3

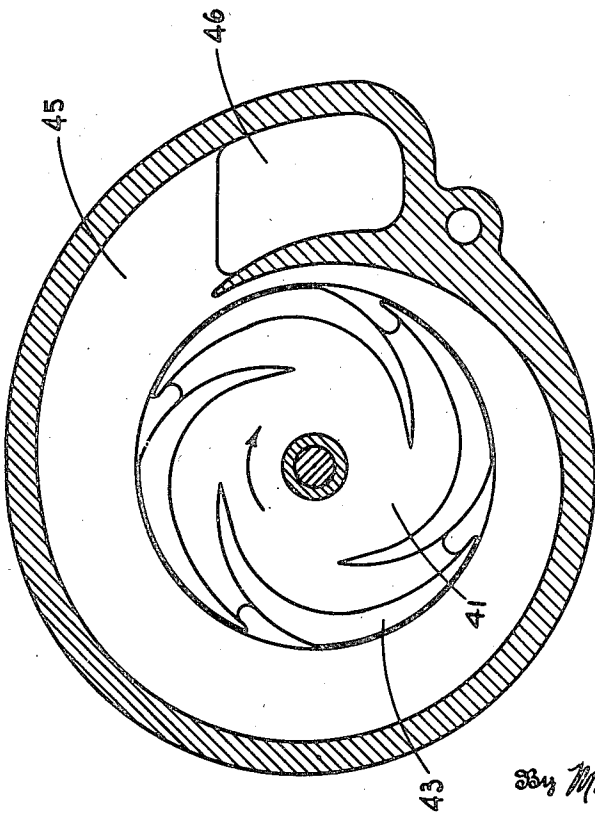


Fig. 2

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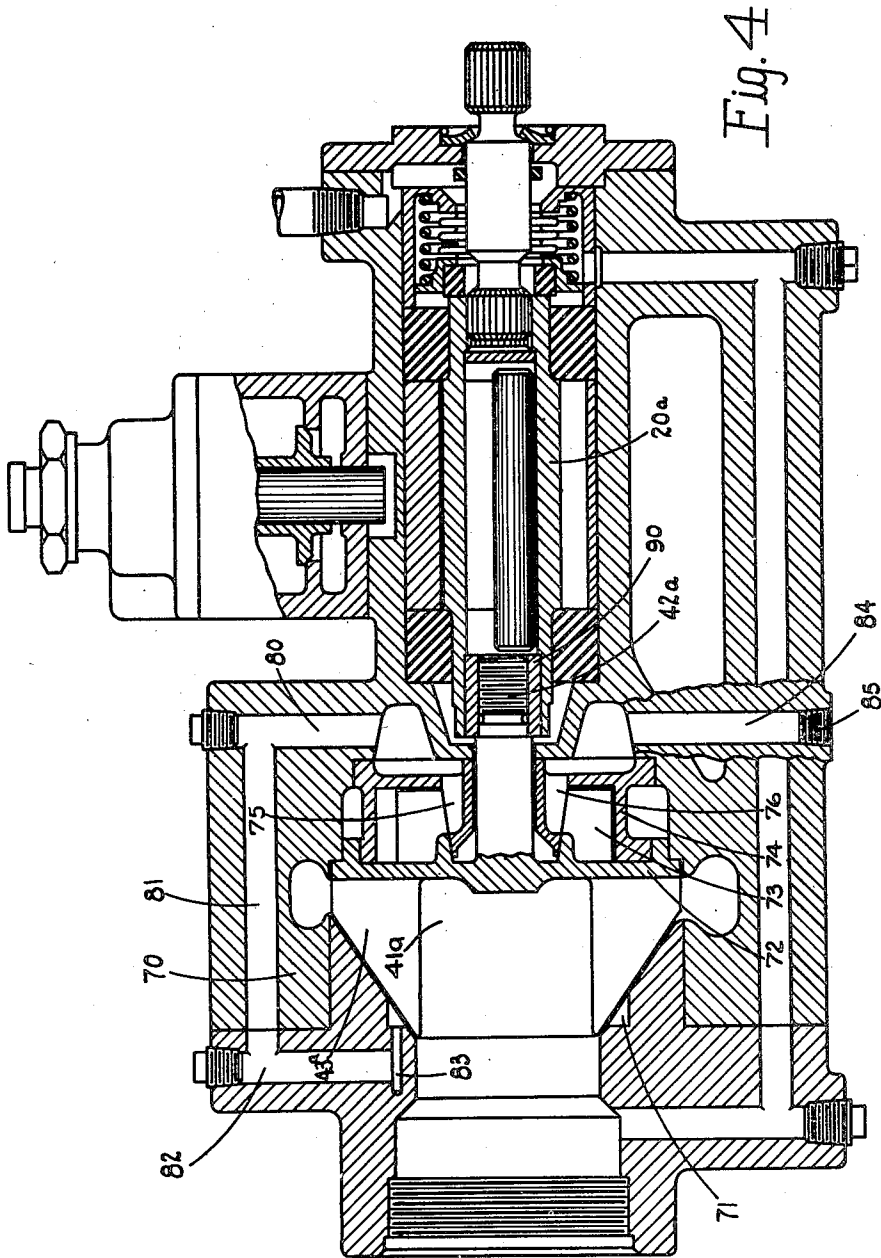
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UNITED STATES PATENT OFFICE

2,500,227

LIQUID PUMPING UNIT

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Application January 18, 1946, Serial No. 642,000

12 Claims. (Cl. 103-5)

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The present invention relates to a liquid pumping unit of the general type described in my co-pending application, Serial No. 617,360.

One object of the invention is to provide a pumping unit of this type, combining the characteristics of a self-priming centrifugal pump with a positive type rotary pump, and affording a compact relatively high speed efficient pumping unit effective to deliver liquid against relatively high pressures. Although such a pump unit has a wide range of utility, it is particularly suitable for delivering fuel to the engine carburetor or atomizing fuel nozzles of reciprocating type engines, or to revolving gas turbine driven engines.

A suitable application of the pumping unit of the present invention is in the art of jet propulsion. Gas turbines employed in this type of propulsion require fuel to be delivered to the atomizing burner nozzles at relatively high pressure, such as 300 to 1000 p. s. i. For this purpose, high pressure fuel pumps of the gear or piston type, or of the multi-stage centrifugal type, are normally employed, as exemplified in my co-pending application, Serial No. 555,444, now Patent No. 2,438,104.

Another suitable application of the pumping unit of the present invention is as the main fuel pump driven from a reciprocating type aircraft engine, or as a motor-driven auxiliary fuel pump for the main fuel pump, especially in cases where a rotary vane type fuel pump has been used for that purpose.

In carrying out the features of the present invention, I combine a positive displacement rotary pump, which heretofore has only been suitable for relatively low pressure service, such as 35 to 65 p. s. i., with a centrifugal pump to deliver fuel against high pressures such as 350 p. s. i. or higher. The centrifugal pump which pressurizes the liquid at the inlet to the positive displacement rotary pump is mounted coaxially with said latter pump, and is driven in unison therewith from a motor by a direct shaft coupling.

As another feature of the present invention, a new and improved sealing arrangement is provided for the shaft of the positive displacement rotary pump, equalized in pressure to avoid the high pressures at the outlet of said pump.

In one embodiment of the invention, there is

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incorporated with the centrifugal pump as an additional feature, means by which the vapor in the fuel is removed when handling volatile fuels, such as aviation gasoline.

Various other objects, features and advantages of the invention will be apparent from the following particular description, and from an inspection of the accompanying drawings, in which:

Fig. 1 is a longitudinal section of one form of pumping unit embodying the present invention;

Fig. 2 is a transverse section of the pumping unit taken on line 2-2 of Fig. 1;

Fig. 3 is a transverse section of the pumping unit taken on line 3-3 of Fig. 1; and

Fig. 4 is a longitudinal section of another form of pumping unit incorporating as an additional feature vapor removal means for the centrifugal pump, and embodying the present invention.

Referring to the form of the invention shown in Figs. 1-3 of the drawings, the pump unit may be of the type which is completely submerged in a fuel tank of an aircraft, and which is mounted on the bottom or side wall of the tank.

The pump unit has a suction inlet 10 threaded for the detachable connection thereto of an inlet pipe, and an outlet 11 threaded for the detachable connection of a discharge pipe. Between the inlet 10 and the outlet 11 is a positive displacement rotary pump 12 and a centrifugal pump 40. The pump unit is arranged for attachment to the driving engine or electric motor by a connection to a flange 13, and the pump 12 is driven from said engine or motor through a splined coupling connection, the male spline member 14 of which is mounted on the driven end of a floating shaft 16 having a similar male spline 17 at its other end engaging a female spline 18 constituting an integral part of the rotor 20 of the positive displacement pump 12.

The positive displacement pump 12 is desirably of the vane rotary type, and comprises a casing 22 having a cylindrical bore 23 placed eccentrically with the pump shaft 16, and a hollow rotor 20 in said bore splined to said shaft by spline connections 17, 18, as already described, and journalled in end bearings 24. The vane pump 12 is of the sliding vane type having four vanes 25 arranged in quadrant relationship, with each set of two diametrically opposed vanes sliding in radial slots 26 in the rotor 20. In the central

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portion of the rotor 20 is located a pin 27 which maintains each opposite pair of vanes in close proximity to the wall of the cylindrical bore 23 in the casing 22. This is a general type of vane pump well known per se. There are many variations of this general type of positive rotary pump, and as far as certain aspects of the invention are concerned, any one of these variations may be employed for the purpose of the present invention. Also, as far as certain aspects of the invention are concerned, gear pumps, piston pumps or other positive displacement type machines may be employed.

The pump rotor 20 eccentrically mounted in the casing 22 operates counterclockwise, as viewed in Fig. 3, to afford displacement characteristic in the delivery of fuel from the suction port defined by the casing walls 30 and 31, to the discharge port defined by the casing walls 32 and 33.

One characteristic of the type of positive rotary pump described is that its operational range is limited by two general factors. When operating at low speed, the maximum pressure obtainable with this pump is low, because of the slippage by the blade clearance in the pump. As the pump rotational speed is increased, it is capable of higher pressure, because the increased speed allows less time intervals for slippage past each vane or blade 25.

The pump 12, by its nature, has a fixed displacement per revolution, and as the speed is increased to obtain higher differential pressure across the pump, its pumping capacity tries to increase at the same proportionate rate. It soon reaches a point where it is trying to pump liquid faster than the liquid in the suction line can get into the displacement spaces through the suction part of the pump. At this stage in the pump operation, the suction caused by this greater displacement lowers the absolute pressure at the inlet to the pump to a point where it approaches or goes below the vapor pressure of the liquid it is handling. The pump under these conditions, develops noise and loses liquid capacity and its pressure capability.

Pumps of this nature have been used in the aircraft industry as fuel pumps for a long time and their limitation has always been set at around 35 p. s. i. differential and a speed of about 2500 r. p. m. Beyond this speed and pressure, the objectionable noise and rapid disintegration of the pump occurs, so that these units have never been visualized as capable of service for higher pressure operation, such as 200 to 300 p. s. i. differential. Because of this limitation in the operation of the general vane type of rotary pump, in their stead there have been used gear pumps or piston type pumps which can operate at a low speed and at low capacity, and which can deliver the low viscosity liquids against the higher pressures required. Even with pumps of this type, however, they operate at higher pressures to better advantage with high viscosity liquids.

In accordance with my invention, I place the inlet of the vane type rotary pump 12 under pressure so as to enable it to operate at high speeds, and thus obtain high differential pressures, such as 300 p. s. i. and 3500 r. p. m. The pressurizing of the liquid on the inlet side of the rotary pump 12 prevents cavitation normally experienced at these high speeds, and completely charges the inlet of said pump with liquid fuel below the vapor pressure point of the fuel.

For pressurizing the inlet of the pump 12, I provide a centrifugal pump 40 having a pump

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impeller 41 driven by the vane pump rotor 20 through the direct male threaded engagement of the impeller shaft 42 with corresponding female threads on said rotor.

The impeller 41 has impeller vanes 43 of the vapor handling type described in my co-pending application Serial No. 652,633, but as far as certain aspects of the invention are concerned, these impeller vanes need not be of this type, but may be of the conventional type, especially if the liquid being handled is not at the point of vaporizing or not containing gas or vapor bubbles that would be detrimental to the normal action of a centrifugal pump.

The liquid fuel entering the suction inlet 10 is pressurized by the impeller rotating vanes 43 and delivered into the centrifugal pump volute 45. From this volute 45, the fuel is discharged through the port 46 into the inlet chamber 47 of the vane pump portion of the unit.

Incorporated in the pump unit is means for adjusting the discharge pressure. This adjusting means is shown in the form of a by-pass valve 50, which by-passes liquid from the discharge chamber 51 back to the inlet chamber 47 in accordance with the adjustment of said valve and the pressure relationship desired.

Incorporated also in the pump unit is a by-pass valve 52 which allows the flow from the inlet chamber 47 to the discharge chamber 51 through said by-pass valve when the pump 12 is stationary or inoperative.

The shaft 16 is sealed by a device 53 of the mechanical type shown comprising a seal housing 55, an axially slidable sealing ring 56 with a bushing 57 urged in sealing contact with the end of the journal of the rotor 20 by a coil spring 58, and a metallic bellows 60 between one end of said housing and said sealing ring encircling said shaft. The shaft sealing device 53 does not have to seal against the full discharge pressure of the vane pump 12. To that end, the leakage between the bearing 24 and the journal of the rotor 20 is drawn off and equalized to the suction pressure of the pump unit through equalizing drain conduit 62, 63 and 64 between the inside of the seal housing 55 and the suction inlet 10, so that the pressure differential across the sealing faces 65 between the journal of the rotor 20 and the bushing 57 is nearly that obtained between atmosphere and the pressure within the suction inlet 10. Any leakage beyond these sealing faces 65 is drained off through a drain connection 66 to atmosphere.

Fig. 4 shows another form of pump unit including vapor removal means similar to that shown in copending application Serial No. 493,662, now Patent No. 2,461,865. In this modified construction, the centrifugal impeller 41a is enclosed in a pump casing 70 having an annular gas collecting groove 71 near the entrance to the passageways defined in said impeller by the impeller vanes 43a. These impeller vanes 43a are connected to one side of a web 72, the other side of which is equipped with the rotor blades 73 of a liquid ring pump which operates in an elliptical casing 74, and which has stationary inlet ports 75 and outlet ports 76. The inlet ports 75 of the liquid ring pump are connected through conduits 80, 81, 82 and 83 to the annular gas collecting groove 71. The outlet ports 76 communicate with an outlet conduit 84 leading to a threaded discharge connection 85. From this discharge point 85, the separated vapors may be returned to the source of supply or to waste.

The vapors and gases in the fuel operated upon by the centrifugal pump impeller 41a are centrifugally directed to and collected in the groove 71, withdrawn from said groove by the liquid ring pump, compressed by said latter pump, and discharged through outlet 85.

The impeller 41a is driven from the vane pump rotor 20a through the threaded engagement of the impeller shaft 42a with a bushing 90 firmly secured desirably by brazing to the interior of said rotor.

As many changes can be made in the above apparatus, and many apparently widely different embodiments of this invention can be made without departing from the scope of the claims, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In combination, a positive displacement rotary liquid pump of the slide vane type having a hollow rotor and a member in said rotor for determining the radial slide position of the vanes, a drive shaft extending into one end of said rotor with a coupling connection therewith, and a centrifugal pump for pressurizing the liquid at the inlet of said positive displacement pump having an impeller shaft extending into the other end of said rotor with a coupling connection, said member being disposed between said shafts.

2. The combination as recited in claim 1, in which said drive shaft has a spline connection with said rotor.

3. The combination as recited in claim 1, in which said impeller shaft is threaded into said rotor.

4. The combination as recited in claim 1, in which said drive shaft has a spline connection with said rotor, and said impeller shaft is threaded into said rotor.

5. In combination, a positive displacement rotary liquid pump of the slide vane type, a centrifugal pump for pressurizing the liquid at the inlet of said positive rotary pump, a pump for removing the vapor from the liquid in said centrifugal pump, mounted between said positive displacement pump and said centrifugal pump, and means connecting all of said pumps for simultaneous operation.

6. In combination, a positive displacement rotary liquid pump of the slide vane type, a pump casing, an impeller therein having a partitioning web dividing said casing into adjoining pump chambers, and having pumping elements extending from opposite sides of said web into corresponding pumping chambers to define a centrifugal pump and a vapor removal pump, means for collecting the vapors in said centrifugal pump, conduit means for leading the collected vapors from said centrifugal pump to the inlet of said vapor removal pump, conduit means from the outlet of said centrifugal pump to the inlet of said positive displacement rotary liquid pump for pressurizing the liquid at the inlet of said latter pump, and means connecting all of said pumps for simultaneous operation.

7. In combination, a positive displacement rotary liquid pump with a single outlet adapted, a centrifugal pump for pressurizing the liquid at the inlet of said positive rotary pump and having a gas collecting chamber separate from the inlet of said centrifugal pump and from the inlet of said positive rotary pump, a pump for removing the vapor from the liquid in said centrifugal pump

mounted between said positive displacement pump and said centrifugal pump, passage means separate from the inlet of said centrifugal pump extending from said collecting chamber to the inlet of said vapor removing pump, and means connecting all of said pumps for simultaneous operation.

8. In combination, a positive displacement liquid pump, a centrifugal pump for pressurizing the liquid at the inlet of said positive rotary pump, a pump for removing the vapor from the liquid in said centrifugal pump mounted between said positive displacement pump and said centrifugal pump, and means mounting and connecting all of said pumps coaxially for operation in unison.

9. In combination, a positive displacement rotary liquid pump, a pump casing, an impeller therein having a partitioning web dividing said casing into adjoining pump chambers, and having pumping elements extending from opposite sides of said web into corresponding pumping chambers to define a centrifugal pump and a vapor removal pump, means for collecting the vapors in said centrifugal pump, conduit means for leading the collected vapors from said centrifugal pump to the inlet of said vapor removal pump, conduit means from the outlet of said centrifugal pump to the inlet of said positive displacement rotary liquid pump for pressurizing the liquid at the inlet of said latter pump, and means mounting and connecting all of said pumps coaxially for operation in unison.

10. In combination, a positive displacement liquid pump of the slide vane type having a rotor, a pump casing, an impeller therein having rigid therewith a shaft connected to one end of said rotor for rotation therewith, the other end of said rotor having drive means therefor, said impeller having a partitioning web dividing said casing into adjoining pump chambers, and having pumping elements extending from opposite sides of said web into corresponding pumping chambers to define a centrifugal pump and a vapor removal pump, means for collecting the vapors in said centrifugal pump, conduit means for leading the collected vapors from said centrifugal pump to the inlet of said vapor removal pump, conduit means from the outlet of said centrifugal pump to the inlet of said positive displacement rotary liquid pump for pressurizing the liquid at the inlet of said latter pump, and means connecting all of said pumps for simultaneous operation.

11. In combination, a positive displacement rotary liquid pump of the slide vane type normally operable with efficiency in the absence of inlet pressurizing means within a low speed range of a certain value to produce a low pressure differential within a predetermined range, a centrifugal pump having a single outlet for pressurizing and supplying the liquid to the inlet of said positive rotary pump, a pump for removing vapor from the liquid in the centrifugal pump, and means for driving said rotary liquid pump at high speed substantially greater than said value to obtain a substantial increase of pressure differential over said predetermined range with minimum of cavitation and noise, said driving means also serving to drive the other pumps.

12. The combination as described in claim 11, in which said rotary liquid pump is of the type normally operable in the absence of inlet pressurizing means at about 2500 R. P. M. and a pressure differential of about 35 pounds per square inch, and said driving means is capable of driving said rotary liquid pump at a speed of about

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3500 R. P. M. to produce a differential pressure
many times 35 pounds per square inch.

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REFERENCES CITED

The following references are of record in the
file of this patent:

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Johnson	Feb. 6, 1940
Robinson	July 28, 1942
Curtis	Dec. 4, 1945
Adams	Mar. 23, 1948
Adams	Feb. 15, 1949

Certificate of Correction

Patent No. 2,500,227

March 14, 1950

HAROLD E. ADAMS

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 5, line 69, strike out the words "with a single outlet adapted" and insert the same after "pump" in line 70, same column;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 20th day of June, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.