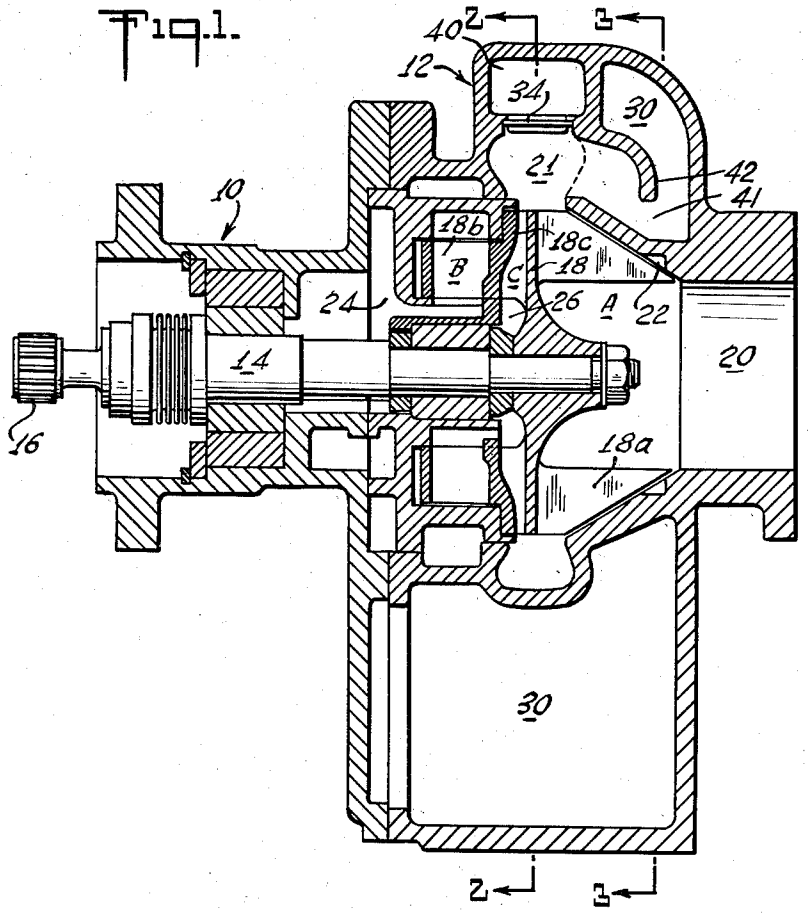
Sept. 3, 1963 H. E. ADAMS 3,102,491

COMBINED BOOSTER PUMP AND CENTRIFUGAL SEPARATOR

Filed Aug. 29, 1960 4 Sheets-Sheet 1

Fig. 1.



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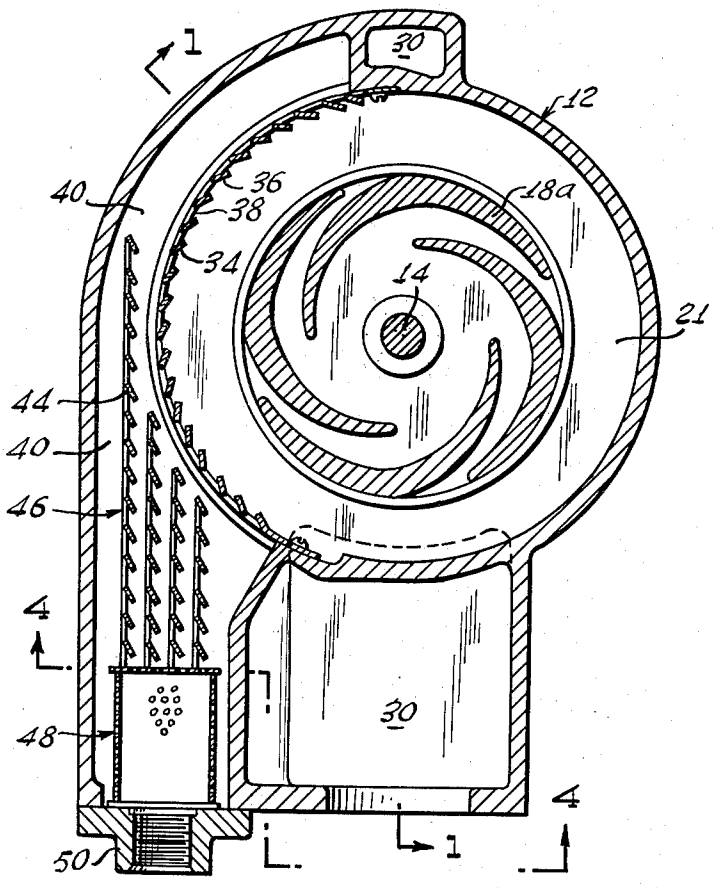
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COMBINED BOOSTER PUMP AND CENTRIFUGAL SEPARATOR

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Fig. 2.



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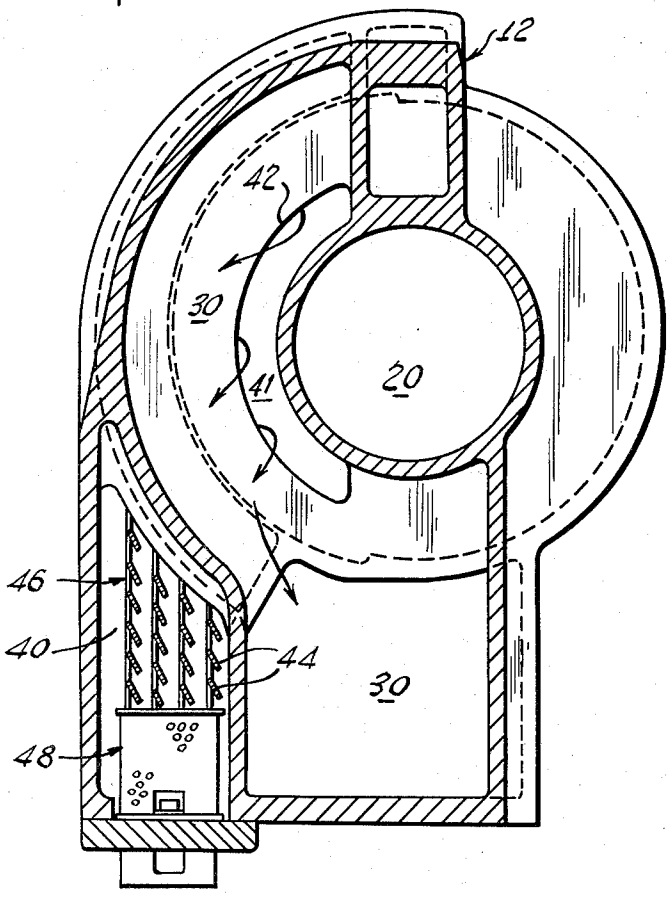
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COMBINED BOOSTER PUMP AND CENTRIFUGAL SEPARATOR

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Fig. 3.



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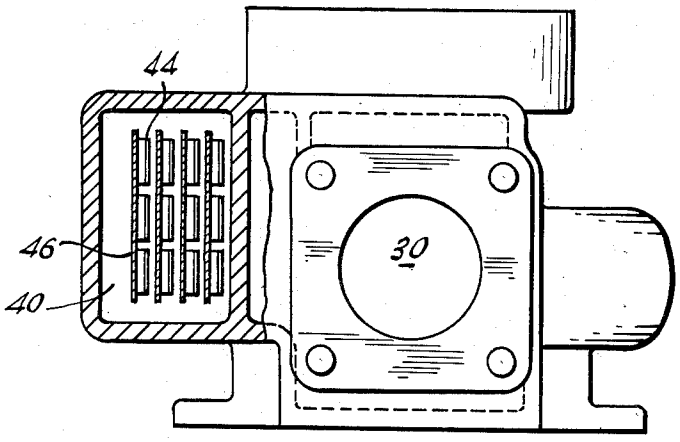
Moses, Nolte & Nolte
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Sept. 3, 1963 H. E. ADAMS 3,102,491

COMBINED BOOSTER PUMP AND CENTRIFUGAL SEPARATOR

Filed Aug. 29, 1960 4 Sheets-Sheet 4

FIG. 4.



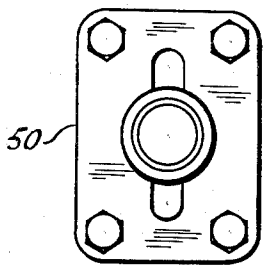


FIG. 5.

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United States Patent Office 3,102,491 Patented Sept. 3, 1963

3,102,491
COMBINED BOOSTER PUMP AND CENTRIFUGAL SEPARATOR

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

Filed Aug. 29, 1960, Ser. No. 52,690
9 Claims. (Cl. 103—113)

This invention relates in general to liquid circulating and filtering devices and in particular to a new and useful combined booster pump and centrifugal separator.

The present invention finds particular application for use in the fuel circulating system of aircraft jet engines. In such systems it is absolutely essential to insure that engines are continuously supplied with dirt-free and vapor-free fuel.

In present day practice it is usual to take great precaution in the ground handling of fuel for aircraft by passing the fuel through filters and water separators before the fuel is delivered to the airplane. The fuel is then pumped from tank to tank within the airplane, while in flight, by fuel transfer pumps and eventually to the engine by fuel booster pumps. The engine is provided with a positive type fuel pump for delivery of the fuel under relatively high pressure conditions to be atomized as it is sprayed into the combustion chambers of the gas turbine engines. The orifices of the atomizing units used in the engines, and more important, the close clearances involved in the fuel control system, demand that the fuel be passed through micronic filters to remove all dirt down to small micron sizes.

In spite of all the precautions taken in ground fueling, etc., the problem of dirt in the fuel has always been a critical one. Recently, and particularly with the advent of kerosene-type fuels, together with flights to still higher altitudes, additional fuel problems have been introduced by the presence of water in the fuel. Despite all precautions, water is sometimes accidently delivered into the airplane fuel tanks from the ground supply. In addition to this, water accumulates in the aircraft fuel tanks due to changes in temperature and pressure conditions in the fuel tanks. When at great altitudes, the fuel and the fuel tanks cool down to low temperatures. When the airplane comes down to land, the low temperature structure of the fuel tank and the fuel within the tank causes condensation of the humid air as the airplane approaches sea level. The tank becomes filled with the sea level air during the pressure equalizing process. Water entrained in the air is condensed in the fuel. Upon reascent to high altitudes the water in the fuel causes the formation of ice crystals and the thickening of the fuel, especially when operating over long periods of time at high altitudes. The thickened fuel and the ice crystals themselves are trapped in the aforementioned micronic filters. In very short order, the filters soon plug up so that the engine has to operate with the fuel going through a by-pass built into the filters. The dirty fuel with the entrained ice crystals goes directly into the engine fuel system control with obvious bad results.

Aside from the freezing problem the water is liable to be picked up in gulps, causing starvation of fuel delivery to the engine, and, in some instances, causing a flameout.

Many devices have been proposed to obviate the aforementioned problems. Devices consisting of more elaborate fuel filters and equipment for the heating of the fuel have been proposed. In some instances, separate centrifuges are provided in order to more adequately filter the dirt from the aircraft fuel. Such centrifugal separating equipment is expensive and difficult to maintain and it is difficult to justify the apparatus in consideration of its added weight, expense and power involved in the addition of the separate centrifuge and its driving motor. While a centrifuge is undoubtedly good for land usage where time and power are ample for clarifying a liquid in this manner, it is questionable whether such perfection can be obtained within the small limits of an airplane installation and whether the additional space and power requirements would be justified.

In accordance with the present invention there is provided a combination centrifugal separator and booster pump which operates to effectively remove the bulk of entrained dirt and water to deliver vapor-free fuel to the engine control system. The novel combination booster pump and centrifugal separator includes means to take out the large size dirt particles and is designed to operate in combination with other micronic filters to achieve final small size dirt particle filtering. The combination also includes means to separate out included water and deliver same to separate water separating means. The mechanism includes means for insuring that the vapor is continuously removed from the fuel, recompressed and condensed and combined with the discharge of the pump, and it further includes means for filtering the large size dirt particles from the fuel and for removing entrained water in the fuel as it is being pumped. By thus removing the bulk of the water and the large size particles, a considerable load is taken off the filters in the system and it is insured that they will not become plugged by the large size particles.

The combination booster pump and centrifugal separator includes means for applying some of the centrifugal forces that are already at work on a normal booster pump to obtain a degree of centrifugal separation of the heavier particles from the main stream as it is pumped through the pump. By removing the heavier particles which are entrained with the fuel as it is being pumped and diverting these particles into a separate trap, the time between cleaning and servicing of the main filter elements is prolonged and the fuel service requirements are improved.

The present invention includes a centrifugal impeller-type booster pump including means for continuously removing air and vapor from the liquid as it is being pumped and for thereafter recompressing and recondensing this vapor and combining it with the discharge of the liquid portion, and in addition, includes means for utilizing the same centrifugal force generated by the impeller of the liquid pump to throw out the heavier particles of dirt entrained in the fuel and catch them in a separate trap for later removal.

Accordingly, it is an object of this invention to provide a combined booster pump and centrifugal separator.

A further object of this invention is to provide a combined booster pump and centrifugal separator including means for impinging and trapping dirt particles in a separate by-pass discharge.

A further object of this invention is to provide a combined booster pump and centrifugal separator including a rotating liquid pumping impeller arranged to discharge liquid through an annular discharge which includes a by-pass passage having perforated baffle plates for trapping large size particles and including a filtering element in this passage for further removing impurities.

A further object of this invention is to provide a booster pump including means for continuously removing vapor from a liquid as it is being pumped and for compressing and recombining condensed vapor with the discharge of the liquid pump, and further including a separate by-pass discharge passage for removing separated water from the fuel, the passage including baffle elements for filtering out large size impurities.

A further object of this invention is to provide a combined booster pump and centrifugal separator which is

simple in design, rugged in construction, and economical to manufacture.

The various features of novelty which characterize the invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a longitudinal section taken on the line 1—1 of FIG. 2 of a combined booster pump and separator constructed in accordance with the invention;

FIG. 2 is a transverse section taken on the line 2—2 of FIG. 1;

FIG. 3 is a transverse section taken on the line 3—3 of FIG. 1;

FIG. 4 is a partial section and partial plan view taken along the line 4—4 of FIG. 2; and

FIG. 5 is a bottom plan view of the clean out plate.

Referring to the drawings in particular, the invention as embodied therein includes a combined booster pump and separator, including a cylindrical bearing support casing portion generally designated 10 and a pumping chamber casing portion generally designated 12. A main shaft 14 is journaled in each of these casing portions for rotation by a driving motor (not shown) which is connected through a splined portion 16 of the shaft. Affixed to the shaft 14 for rotation therewith is a triple duty impeller generally designated 18 which is arranged to rotate within three separate pumping portions on the interior of the housing 12; a liquid pumping portion generally designated A, a liquid ring compressor portion generally designated B, and a condensed vapor recombining portion generally designated C.

Liquid fuel or other vaporizable liquid enters through a central inlet opening 20 and it is discharged at increased pressure through an annular volute 21 by blades 18*a* of the tripple action impeller 18. The volute 21 includes an outer peripheral portion including stripper plate 34 and a sidewall portion 42, each to be described in greater detail herebelow. Entrained vapors and gases are picked up in an annular groove 22 and delivered by internal passages (not shown) defined in the housing portion 12 to an inlet 24 of the liquid ring compressor portion B.

Gas and entrained vapors which are delivered through the inlet 24 are compressed and condensed and delivered to an inlet 26 where blade portions 18*c* are effective to discharge the condensed vapors and entrained gases at higher pressure into the volute 21. The action of the triple action impeller 18 is more fully described in copending application Serial No. 636,442, filed January 25, 1957, now Patent No. 2,952,214 issued September 13, 1960, by the inventor of the present invention.

In accordance with the invention liquid which is delivered by the blade portions 18*a* and 18*c* of the pump is directed against a semiannular dirt and water stripper plate generally designated 34 which includes a plurality of outwardly bent members 36 (FIG. 2) which define openings or perforations 38 to permit the discharge of liquid therethrough into a dirt and water trap passage 40. The liquid is discharged at high centrifugal velocities from the impeller blades 18*a* and 18*c* into the annular chamber 21 and against the dirt and water stripper plate 34 and portions are passed through the perforations 38 and into the dirt and water trap 40. Portions of the liquid are directed against a centrifugal particle retaining wall 42 (FIG. 1) which deflects it inwardly through the arcuate opening 41 (FIGS. 1 and 3) and into the annular discharge passage 30.

The heavier particles entrained with the fuel are immediately thrown out to the periphery of the annular chamber 21 as they pass by the slotted openings 38 and some liquid is edged under the same centrifugal and tangential force into the dirt and water trap chamber 40. This liquid is trapped as it is discharged into the dirt and water trap 40 by the centrifugal particle retaining wall or barrier 42 which insures that the liquid is circulated several times around the periphery of the annular volute 21 before it is eventually discharged radially inward of the edge of the wall 42 through opening 41 and into the passage 30. During the travel of the liquid around in the volute 21 and into the water trap 40, the liquid which is trapped is subjected to centrifugal forces and there is sufficient time allowed for the heavier particles to be deflected to the outer periphery rather than being carried along with the fuel stream. Of course, some of the lighter particles being of insufficient weight and mass will be impinged on the bent members 36 and on a plurality of bent members 44 of a plurality of perforated baffle plates 46 which are placed in a position extending across the dirt and water trap passage 40. The baffle plates 46 tend to produce stagnation of water circulation and reduce turbulence in the dirt and water trap passage 40. At the bottom of the dirt and water trap passage 40, there is provided a perforated retainer or filter tube 48. The tube 48 includes a hollow interior which is filled with woven stainless steel wire mesh. The perforated filter tube 48 thus insures a further entrapment of the particles that have gone over into the dirt and water trap 40. Since water is also heavier than the fuel which is pumped, it will normally be directed into the trap 40.

At the bottom of the water trap passage 40, there is provided a water and fuel bleed-off connection 50 which is combined with a clean-out plate.

In operation, a continuous by-pass flow of liquid is maintained through the water and fuel bleed-off connection 50 and this by-pass flow is regulated in accordance with experience to obtain maximum entrapment of dirt and removal of water particles from the main flow through the pump. Periodically, the cleanout plate 50 is removed and the dirt retainer and baffle plates are either flushed out or replaced with a clean unit and the operation resumed. The dirt retainer 48 and baffles 46 can be cleaned out and made ready for the next inspection.

In actual use it has been shown that a large percentage of the sand and minute particles coming over with the fuel are thus separated and collected in the dirt and water trap 40, and, by removing these particles, a longer service life of the other filters in the system is effected. Water which is entrained in the fuel as it passes through the pumping process is similarly separated out and is directed into the dirt and water trap 40. The water, however, is not retained by the dirt retainer 48 but passes on through the water bleed-off connection 50. The bypassed water and fuel are then either fed into a separate water separating filter, or separating tank in accordance with individual requirements. The water from the water separator is bled off to waste and the fuel is returned to the fuel tank or the suction of the pump as design requirements indicate.

Thus, the invention provides a combination fuel booster pump and separator which includes a filter portion which is actuated by the centrifugal action of the pump and which is capable of removing, during the pumping operation, a major portion of the heavier particles entrained in the fuel being pumped. Thus, the invention includes both a pumping and separating device without requiring additional equipment and by utilizing the potentialities of existing pumping equipment.

While a specific embodiment of the invention has been shown and described in detail to illustrate the application of the invention principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. In a centrifugal pump including a casing having

a central inlet and an annular volute chamber, and an impeller rotatable within said casing for drawing liquid through said inlet and into said volute chamber, the improvement comprising a particle trap passage extending around at least a portion of the outer periphery of said volute chamber and in open communication with said chamber, a perforated stripper plate located in the opening between the particle trap passage and said volute chamber defining at least a portion of the periphery of said volute chamber, and a main pump discharge passage communicating with a side portion of said volute chamber radially inward from the outer periphery of said volute chamber.

2. A centrifugal pump according to claim 1, wherein said particle trap passage includes means to bleed liquid and particles from said passage.

3. A centrifugal pump according to claim 1 wherein said particle trap passage includes a plurality of perforated baffle plates.

4. A centrifugal pump according to claim 1 wherein said particle trap passage includes a cylindrical filtering element.

5. In a combination fuel booster and separating pump comprising a rotatable main impeller, casing wall means defining a central fluid inlet and a peripheral volute chamber 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 chamber, the improvement comprising a dirt and water trap extending around a portion of the outer periphery of the volute chamber and in open communication with said chamber, a perforated dirt and water stripper plate located in the opening between the dirt and water trap and said volute chamber, and defining a peripheral portion of said volute chamber, means to bleed water from said dirt and water trap, said casing wall means including a main volute discharge opening in a side portion of said volute chamber radially inward from said stripper plate.

6. A combination booster pump and centrifugal separator comprising casing wall means defining a liquid pumping portion, a liquid ring compressor portion, a central inlet, an annular volute chamber, an annular main discharge adjacent said volute chamber, and a wall extending radially inward from the periphery of the volute chamber between said volute chamber and said main discharge, said wall terminating in an arcuate edge portion defining in cooperation with the exterior of said central inlet an opening between said volute chamber and said main discharge, a triple acting impeller including means to take liquid in from said inlet and discharge it at increased pressure into said volute chamber, a liquid ring compressor rotor arranged to remove vapors from said inlet and said liquid pumping portion and compress and condense said gases and entrained vapors, and a condensed vapor pumping portion for recombining said condensed vapors and compressed gases into said volute chamber, wall means further defining a dirt and water trap passage extending around a portion of the outer periphery of said volute chamber and in open communication with said volute chamber, a dirt and water stripper plate located in the opening between said volute chamber and said water trap passage, and means to bleed a portion of liquid discharged into said volute chamber out through said water trap passage.

7. A combination fuel booster pump and separator according to claim 6 including a removable water and fuel bleed-off connection at the exterior of said dirt and water trap passage.

8. A combination fuel booster pump and separator according to claim 6 including a plurality of perforated baffle plates in said water trap passage.

9. A combination fuel booster pump and separator according to claim 6 including a cylindrical filtering element covering an outlet of said water and fuel bleed-off connection.

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