

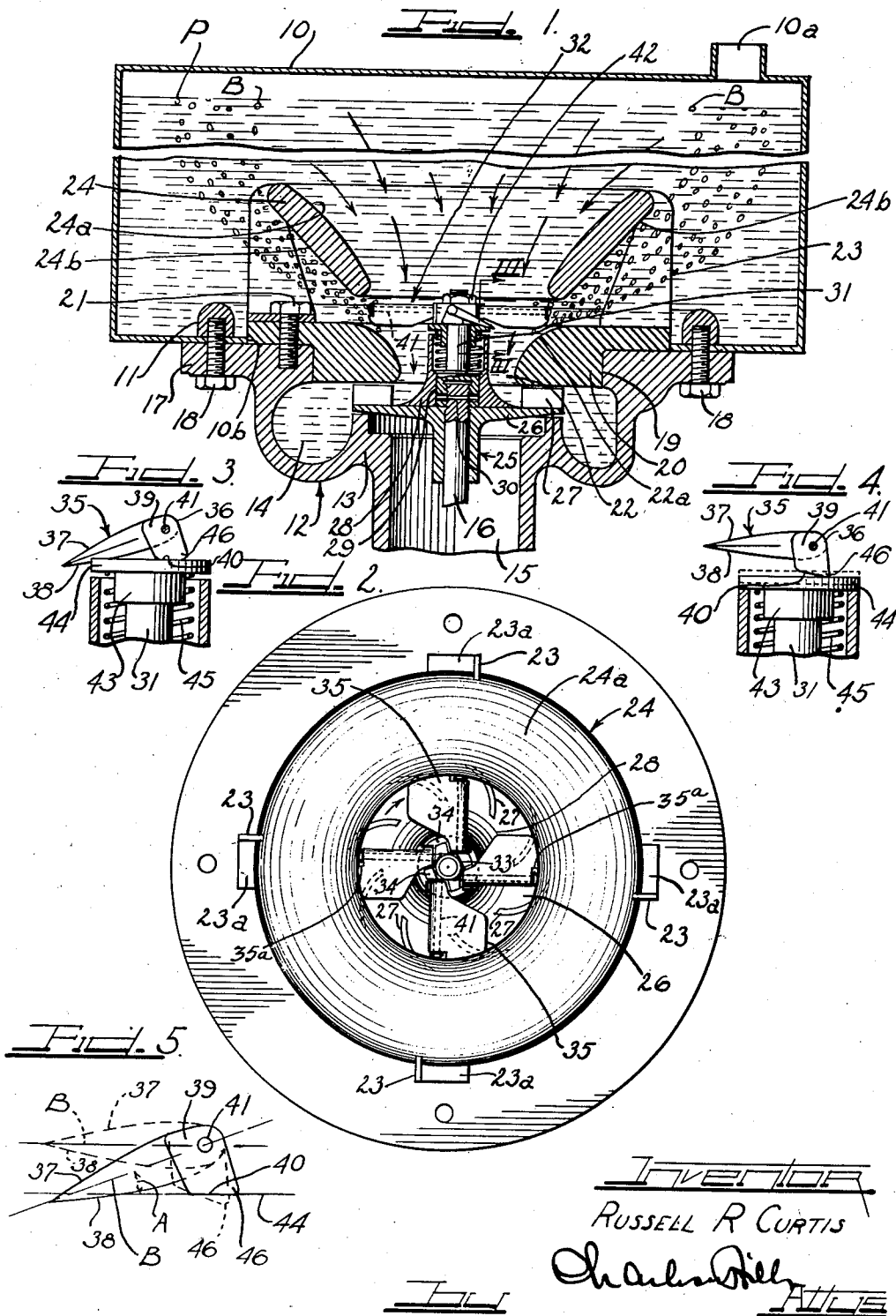
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BOOSTER PUMP WITH VARIABLE PITCH AUXILIARY PROPELLER

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BOOSTER PUMP WITH VARIABLE PITCH
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14 Claims. (Cl. 103—88)

This application is a continuation in part of my co-pending application Serial No. 409,647 filed September 5, 1941.

The present invention relates to pump assemblies especially adapted for use in high altitude aircraft fuel systems for efficiently separating gases and vapors from liquids so that only fully liquid material is pumped thereby.

More specifically, this invention relates to centrifugal booster pump assemblies having auxiliary agitators with automatically adjustable vanes, which feather down or flatten out when subjected to increased fluid resistance such as occurs when the agitators are speeded up. The agitators effect cavitation in the liquid in which they operate for aiding in the beating out of bubbles and gas from liquid. The pump assemblies include bell mouthed shaped guides for directing the liquid to be pumped to the agitators and for directing the separated gases and vapors out of the path of the incoming fluid and thus not only beat out, in bubble form, the occluded gases and vapors in the liquid but also induce, in the cavities or pockets behind the vanes, the formation of gas and vapor from the more volatile liquid ingredients.

In accordance with this invention, a pump casing is so mounted with relation to a source of liquid, such as a fuel tank, as to be below the hydraulic gradient of the liquid. The casing has an inlet throat communicating with the source of liquid and a volute chamber receiving pressured liquid from the throat. An impeller disk having pumping vanes thereon centrifugally pumps the liquid from the throat to the volute chamber. This impeller assembly also carries an agitating propeller in spaced relation from the pumping vanes and preferably at the inlet to the throat. A guide or shield is mounted in spaced relation from the inlet throat to direct liquid to the agitating propeller along a converging path. This path converges at a relatively high rate to a point spaced from the discharge end thereof and then converges from this point at a slower rate to the discharge end thereof. The resulting bell mouthed path has very high fluid flow capacity.

The agitating propeller effects the formation of bubbles from gas and vapor in the liquid and creates a radial flow of liquid which carries the bubbles radially outward through the space between the guide or shield and the inlet throat member.

In addition, the propeller raises the pressure in the area between the propeller and impeller and

starts the liquid to whirl so that when the liquid strikes the open edges of the impeller vanes, only a negligible amount of vaporization can take place.

5 The outer face of the shield directs bubbles of gas and vapor from the agitating propeller out of the path of the incoming liquid so that the bubbles are not entrained in the liquid entering the pump. At the same time the liquid is delivered to the agitating propeller at a minimum pressure so that bubble formation at the propeller is enhanced.

10 It is preferred that the centrifugal booster pump of the type illustrated and to be described herein be interposed in the fuel line of a fuel system between the source of liquid, such as a fuel tank, and an engine-driven fuel pump. During normal operation in such a system, the main function of the booster pump is to beat out the gases and vapors from the fuel and to merely pressure the beaten fuel sufficiently so that additional bubbles will not be formed in the fuel line. The fuel pump itself in such normal operation, even at high altitudes, will pressure the fuel to the engine. When, for any reason, the engine-driven fuel pump fails in operation, the centrifugal booster pump has the emergency duty of supplying the vehicle engine with fuel pumped either through the inoperative engine pump or by-passed therearound. In order to meet such an emergency, the centrifugal booster pump must be operated at higher speeds than for normal duty in order to produce higher discharge pressures.

35 It has been found that effective vapor separation for high altitude performance can be obtained when the blades of the propeller are set at a high pitch, even when the propeller is driven at low speeds. However, if the blade angle remains fixed as the speed is increased to produce emergency pressure, the power requirement for driving both the impeller and the propeller becomes excessive.

40 A variable pitch propeller is therefore provided in which the angle of the blades is automatically reduced as the propeller speed is increased.

45 It is, therefore, an object of this invention to provide a liquid pump with agitating means whose resistance to rotation in a liquid remains substantially constant during increases in the speed of rotation of the agitating means.

50 Another object of this invention is to provide a variable pitch agitating member for a centrifugal pump.

A further object of this invention is to provide a propeller for agitating a liquid having blades thereon whose pitch angle is automatically reduced with changes in the speed of rotation thereof.

A still further object of this invention is to provide a propeller for agitating a liquid having pivotally mounted blades and cam means associated with the blades for automatically reducing the pitch angle thereof when the speed of rotation of the propeller is increased.

Another and still further object of this invention is to provide a fuel pump with an agitating propeller having blades pivotally connected to a drive shaft and with spring pressed cams co-operating with the blades to regulate the pitch angle thereof in accordance with changes in resistance to rotation effected by changes in the speed of rotation of the blades by the shaft.

A further object of this invention is to provide a booster pump having a variable pitch propeller lying above the mouth thereof with a bell mouthed shaped annular fluid guide shield which discharges fluid to the agitating propeller and which guides gas and vapor bubbles from the propeller away from the pump inlet.

The novel features believed to be characteristic of the present invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and manner of construction, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in which:

Figure 1 is a broken and fragmental vertical cross-sectional view, with parts in elevation, of a booster pump, adjustable pitch propeller, guide shield, and fuel tank assembly all in accordance with principles of this invention;

Figure 2 is a plan view of the booster pump, adjustable pitch propeller and guide shield assembly shown in Figure 1;

Figure 3 is an enlarged fragmentary vertical cross-sectional view, with parts in elevation, as seen when taken substantially in the plane indicated by the line III—III of Figure 1 and showing the operative relation of a vane and a spring pressed cam for maintaining the pitch angle of the vane when the parts are either at rest or being rotated at a low speed;

Figure 4 is a view similar to Figure 3 showing the change in pitch angle of a feathered vane when the parts are being rotated at a high speed; and,

Figure 5 is a view somewhat similar to Figures 3 and 4 illustrating, in full lines, the pitch angle of the propeller blade when the propeller is being operated at normal speeds and, in dotted lines, the feathered position of the propeller blade when the propeller is being operated at high speeds for emergency duty.

In Figure 1, the reference numeral 10 designates a fuel tank, vented as at 10a, and containing a pond P of liquid fuel, such as gasoline. The bottom wall of the tank has a circular aperture 10b therein and a mounting ring 11 mounted in the tank on its bottom wall around the aperture.

A booster pump 12, of the centrifugal type, is mounted on the tank around the aperture in the bottom wall thereof. The booster pump includes a casing 13 defining a volute or pumping chamber 14 and a shaft housing 15. The casing 13 is connected with a source of motive power

(not shown) which drives the shaft 16 in the housing portion 15 of the casing. The casing has an outturned annular flange 17 for mounting on the bottom wall of the tank. The flange 17 receives screws 18 at spaced intervals therearound which are threaded into blind tapped wells in the mounting ring 11. The mounting ring may be welded, soldered, or otherwise secured to the bottom wall of the tank.

The casing has a circular opening 19 into which a throat ring 20 is seated. The throat ring 20 partially overlies the flange 17. Bolts 21, at spaced intervals around the throat ring, are threaded through the ring into the flanged portion 17 to mount the ring on the casing 13.

The throat ring 20 has a central aperture 22 therethrough for joining the interior of the tank 10 with the volute chamber 14. The aperture 22 flares outwardly as at 22a to provide an inlet mouth for the booster pump.

A plurality of standards or ribs 23, each having a foot portion 23a, are disposed around the throat ring and secured thereon by the bolts 21. The standards or ribs 23 are fixedly secured at their upper ends to a bell mouth annular shield 24. The ribs 23 carry the shield 24 in spaced relation above the throat ring 20.

The shield 24 has an inner face 24a which, as best shown in Figure 1, converges from the upper end of the shield at a relatively high rate to a point intermediate the top and bottom of the shield. The face then converges at a slower rate from this point to the bottom or discharge end of the shield. The inner face 24a has a smooth continuous curvature especially designed for a high fluid flow capacity without, however, unduly pressuring the fluid as the path converges to the discharge end. This particular curvature has greatly enhanced the pumping capacity of the booster pump since it flares outwardly at the inlet end thereof to receive fuel from the pond P over a relatively large area and then guides the fuel inwardly from this large area along a path having a relatively small vertical component to a point ahead of the discharge mouth of the shield. While the path continues to converge from this point it converges at a slower rate and thus does not materially increase the pressure of the fuel for any given velocity. The reduced height of the shield positions the inlet end thereof closer to the bottom of the tank so that the fuel even at low levels of the tank will enter the guide.

The booster pump has an impeller assembly 25 mounted on the drive shaft 16. This impeller assembly includes a disk or flange portion 26 spanning the inlet or aperture 22 in the throat ring and communicating freely around the periphery thereof with the inner rim of the volute chamber 14. Curved pumping vanes 27 are mounted on the flange 26 around the periphery thereof to underlie the throat ring 20. These pumping vanes 27 define, with the throat ring 20 and the flange 26, open ended pumping channels communicating at their outer ends with the volute chamber 14 and at their inner ends with the inlet of the throat ring.

A hollow cap or fairing member 28 is pressed on or otherwise suitably secured to a cup member 29 which has its inner periphery threaded for engagement with the threaded end of the shaft 16 and to which it is connected by means of a cross pin 30. In this connected position, the outwardly tapered cap member 28 seats on the impeller flange 26. The cup member 29 has

an upwardly extending shaft portion 31 for receiving at the top end thereof a propeller assembly 32.

As best shown in Figure 2, the propeller assembly includes a hub member 33 having substantially radially extending support portions 34 thereon. A propeller blade 35 is pivotally mounted on each of the support portions 34 to extend outwardly therefrom and normal thereto.

Each of the blades 35, as viewed from the free end thereof, has a rounded nose portion or leading edge 36 with the side surfaces 37 and 38 tapering toward the rear thereof and terminating in substantially a line edge. The inner ends of each of the blades 35 are of reduced width and thickened to provide a cam portion 39. A cam surface 40 is formed on the lower side of each of the cam portions 39 at such angularity to a longitudinal axial plane passed through a blade that the included angle therebetween is less than 90° for a purpose to be more apparent from the following description. The outer ends of each of the blades 35 are recessed at 35a to receive therein the head of a pivot pin 41 extending longitudinally through the blade and being threaded into or otherwise suitably secured to one of the support portions 34 of the hub member 33. Each of the blades 35 is thereby pivotally mounted on the hub member for rocking movement in a plane substantially right angularly disposed to the plane of rotation of the impeller assembly.

It will be noted that the rounded nose or leading edge 36 of each of the blades 35 faces in the direction of rotation of the propeller assembly.

As best shown in Figure 1, the hub member 33 and pivotally connected blades 35 are secured to the shaft portion 31 and held in place thereon by means of a nut 42 threaded to the free end of the shaft.

The blades 35 of the propeller are disposed in the space between the bottom of the shield 24 and the top of the throat ring 20. As shown in Figures 1 and 2, the blades 35 extend across the entire discharge mouth of the shield 24.

A sleeve member 43, having a radially extending flange 44 at one end thereof, is slidably mounted on the shaft portion 31. A coil spring 45 is interposed between the cup member 29 and the flange 44 of the sleeve 43 to embrace the shaft portion 31 and seat within the upper hollow portion of the cap member 28.

As shown in Figure 3, the coil spring 45 exerts pressure against the flange 44 to seat the flange against the angularly extending cam surface 40 on the end portion of each of the blades 35. With the parts so positioned, each of the propeller blades 35 is disposed at a relatively steep pitch angle.

As shown in Figure 1, the propeller blades 35 agitate the fuel flowing down through the shield 24 as soon as the fuel is discharged from the shield. The propeller beats out of bubbles B gases and vapors from the liquid fuel and throws these bubbles outwardly from the discharge mouth of the shield where they can rise in the pond P along a path between the shield and throat ring. The outer face 24b of the shield slopes upwardly and outwardly away from the throat ring so that the bubbles are guided away from the inlet to the shield. The bubble path widens out and the bubbles become larger as they approach the surface of the pond P. Upon reaching the surface of the pond P the bubbles burst

into the atmosphere and discharge their vapors or gases.

It should therefore be understood that the shield 24 serves two functions, namely, to increase the feed of liquid fuel to the pump and to guide the beaten out bubbles away from the incoming liquid fuel. The curvature of the inner face of the shield is designed so that the shield can be relatively flat, receive liquid from a large area, and discharge it out of a smaller area at minimum pressure, so as not to interfere with the bubble separation.

The bubble-free liquid enters the pump through the inlet mouth 22 of the throat ring. It is then pressured by the impeller assembly into the volute chamber.

It is preferred that the centrifugal booster pump illustrated and described operate at a comparatively slow speed for producing low discharge pressures found to be most desirable for beating out bubbles of gases and vapors from the liquid fuel and for pressuring the vapor-free fuel into the fuel line whereby an aircraft may be operated at high altitudes. The usual fuel system for an aircraft to be operated at high altitudes includes an engine-driven fuel pump which receives the liquid fuel discharged into the fuel line by the booster pump. Should the engine-driven fuel pump fail in operation, the speed of the booster pump must necessarily be increased in order to deliver liquid fuel directly to the carburetor of the aircraft engine, either through the inoperative fuel pump or through a by-pass therearound. This higher rotating speed of the propeller for producing higher discharge pressures necessitates an excessive power requirement for driving both the propeller and the impeller. This is due to the high pitch angle at which the blades of the propeller are set to effect the most efficient gas and vapor separation at low rotating speeds. Consequently, if the low pitch angle of the blades remains fixed as the speed is increased to produce emergency pressure, the power requirement becomes excessive.

This objection is eliminated by providing a propeller assembly which has a high blade angle at low speeds with an automatic and gradual reduction in the blade angle as the speed is increased. This high pitch angle is illustrated in Figure 5 at A, and at normal operation is less than 90°, and is the included angle between the seated cam surface 40 and the flat flange 44 and a longitudinal axial plane B passed through a blade. When the rotating speed of the propeller assembly 32 is increased over the normal speed, the inertia of the liquid to agitation as it flows downwardly from the shield exerts a pressure on the lower side 38 of the propeller blades 35. This pressure tends to feather the blades or, in other words, tends to move the blades to a horizontal position in which the resistance to rotation is decreased. As seen in dotted lines of Figure 5, the blade when feathered at high or emergency speeds is so positioned that the longitudinal axial plane B is parallel to the flat flange 44. When the resistance pressure as exerted against the surfaces 38 of the blades becomes higher than the compression of the coil springs 45, the blades rotate about their pivot pins 41 and the corner 46 of the cam portion 39 cams against the flange 44 of the sleeve 43. The resistance pressure exerted against the surfaces 38 of the blades will depend upon the speed of rotation of the propeller assembly in a fluid and will thereby determine

the pitch angle of the blades between the maximum limits illustrated in Figure 5. When the speed is such that the resistance pressure is greater than the compression of the coil spring 35, the propeller blades will gradually feather to a horizontal or flat position as illustrated in Figures 4 and 5. As soon as the rotational speed is decreased, the resistance pressure against the surfaces 38 will likewise decrease and the propeller blades will gradually assume their greatest pitch angle as illustrated in Figures 1 and 3.

It will be apparent from the foregoing that a booster pump construction is provided herein having a propeller assembly which is normally operated at low speeds to effect the most efficient gas and vapor separation from a liquid, while at the same time pressuring the liquid sufficiently to effect a continual flow of the liquid to the carburetor. When higher pressures of liquid flow are desirable, the speed of the impeller is increased. As the impeller and propeller have a common drive, the speed of the propeller assembly is likewise increased and the blades are so mounted as to automatically feather to eliminate an excessive power requirement for driving the propeller. In the present propeller assembly, the blades are so mounted that the pitch angle thereof is automatically regulated in accordance with changes in resistance to rotation effected by changes in the speed of rotation of the blades with the drive shaft.

While a particular embodiment of this invention only has been illustrated, it will, of course, be understood that the invention should not be limited thereto, since many modifications may be made, and, therefore, it is contemplated by the appended claims to cover all such modifications as fall within the true spirit and scope of the present invention.

I claim as my invention:

1. In a pump construction having an inlet throat, a shaft extending through said throat, a hub member on said shaft in the path of fluid to the throat, propeller blades, means pivotally mounting said blades radially on said hub to position the blades for acting on fluid before it enters the throat, a cam portion on each of said blades having an angular cam surface thereon, a cam member slidable on said shaft and having a surface for seating said cam portions of the blades, and spring means urging said cam member toward said hub and against the angular surface of said cam portions on the blades for normally maintaining each of the blades at a steep pitch angle, said blades being feathered to a reduced pitch angle when rotated at a speed whereby the fluid pressure on said blades is greater than the pressure exerted by said spring means.

2. In a pump construction having an inlet throat, a shaft extending through said throat, a hub member carried by the shaft on the inlet side of the throat and having radially extending support portions, propeller blades each having a rounded leading edge and tapering rearwardly therefrom, a pivot pin carried by each support portion for pivotally mounting each of the blades on the hub radially of the shaft to act on fluids entering the pump before the fluids become confined in the throat, said blades having their rounded leading edges facing in the direction of rotation, a cam on each blade having a surface thereon whose included angle with the longitudinal axial plane of the blade is less than 90°, a cam member slidable on said shaft toward said hub and having a surface thereon for engaging

said angular surfaces on the blades, and a coil spring embracing said shaft and exerting pressure against said cam member whereby said blades are normally maintained at a pitch angle defined by the angular surfaces on said blade cams, said blades being feathered to a reduced pitch angle when rotated at a speed whereby the fluid pressure on said blades is greater than the pressure exerted by said coil spring.

3. In a pump construction, a pump casing having an inlet throat, an impeller with pumping vanes underlapping the throat, a guide shield mounted in advance of the throat to define therein and therearound localized flow paths, and a variable pitch agitating propeller between said shield and said throat.

4. In a pump construction, a pump casing having an inlet throat, an impeller with pumping vanes underlapping the throat, a guide shield mounted in advance of the throat to define therein and therearound localized flow paths, a propeller between said shield and said throat for agitating liquid flowing to said throat, said propeller having independently movable blades, and cam means normally maintaining each of said blades at one pitch angle during rotation of the propeller below a predetermined speed, said blades being feathered to a reduced pitch angle when rotated at a speed whereby inertia of the liquid to agitation exerts a pressure on said blades sufficient to cause relative movement between said cam means.

5. In a centrifugal type pump having an inlet throat, an impeller for pressuring liquid received from said throat, an agitating member for effecting cavitation in the liquids being fed to the throat, and means for feathering said agitating member to vary the cavitation in the liquid.

6. In a centrifugal type pump having an inlet throat receiving liquid from a pond, an impeller for pressuring liquid received from said throat, agitating vanes adjustable relative to said impeller and rotatable therewith and positioned to act on that portion of the liquid in the pond adjacent the throat for effecting cavitation in the liquid to liberate bubbles of gas and vapor from the liquid into the pond, and means for moving said vanes relative to said impeller in response to changes in speeds of rotation of the impeller.

7. In a centrifugal type pump, an impeller for pressuring liquid, pivotally mounted agitating vanes co-supported with said impeller for effecting cavitation in a liquid being fed to the impeller, and pressure exerting means for adjusting said pivotally mounted vanes to vary the cavitation in the liquid.

8. In a centrifugal type pump having a drive shaft, an impeller rotatable with said shaft for pressuring liquid, agitating vanes pivotally mounted on said shaft and rotatable with the shaft for effecting cavitation in a liquid being fed to the impeller, and means for feathering said pivotally mounted vanes relative to said shaft for varying the cavitation in the liquid.

9. In a centrifugal type pump, an impeller for pressuring liquid, an agitator for acting on liquid being fed to the impeller, said agitator including a hub and vanes rotatable with and adjustable relative to the hub for effecting cavitation in the liquid in which they operate, and means for adjusting said vanes relative to said hub to vary the cavitation in the liquid.

10. In a centrifugal type pump having a drive shaft, an impeller rotatable with said shaft for pressuring liquid, agitating vanes pivotally

mounted on the shaft and rotatable therewith for effecting cavitation in the liquid being fed to the impeller, and spring urged cam means sensitive to pressure exerted on said vanes by the liquid being agitated for feathering the vanes in accordance with the exerted pressure.

11. In a centrifugal type pump having an inlet throat, a drive shaft extending through said throat, an impeller rotatable with said shaft and positioned for pressuring liquid from said throat, a hub portion on said shaft in spaced relation from said impeller, agitating vanes pivotally mounted on said hub and extending radially with respect to said shaft, said vanes being rotatable with said shaft for effecting cavitation in a liquid being fed to said throat, a member slidable on said shaft between said impeller and vanes, a coil spring for normally urging said slidable member toward said vanes, and a cam on each of said vanes engageable by said spring urged member, said slidable member, cams, and coil spring co-acting to feather said vanes in accordance with pressures exerted on the vanes by the liquid agitated thereby.

12. A pump construction comprising an inlet throat, pumping vanes on one side of said throat, agitating vanes on the other side of said throat, and means for feathering said agitating vanes.

13. A centrifugal pump construction comprising an inlet throat for receiving fluids there-through, an impeller adjacent the outlet side of said throat for pumping fluids received from the throat, vanes adjacent the inlet side of said throat for agitating fluids before entering the throat, means for co-rotating said impeller and said agitating vanes, and means for feathering said vanes in accordance with pressures exerted thereon by the fluids agitated thereby.

14. A centrifugal type pump construction comprising an inlet throat for receiving fluids there-through, a drive shaft extending through said inlet throat, an impeller rotatable with said shaft adjacent the outlet side of said throat for pumping fluids received from the throat, vanes rotatable with said shaft adjacent the inlet side of said throat for agitating fluids before entering the throat, said vanes being pivotally mounted on said shaft for rotation about their own axes, and pressure exerting means for feathering said vanes about their own axes in accordance with pressures exerted thereon by the fluids agitated thereby.

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