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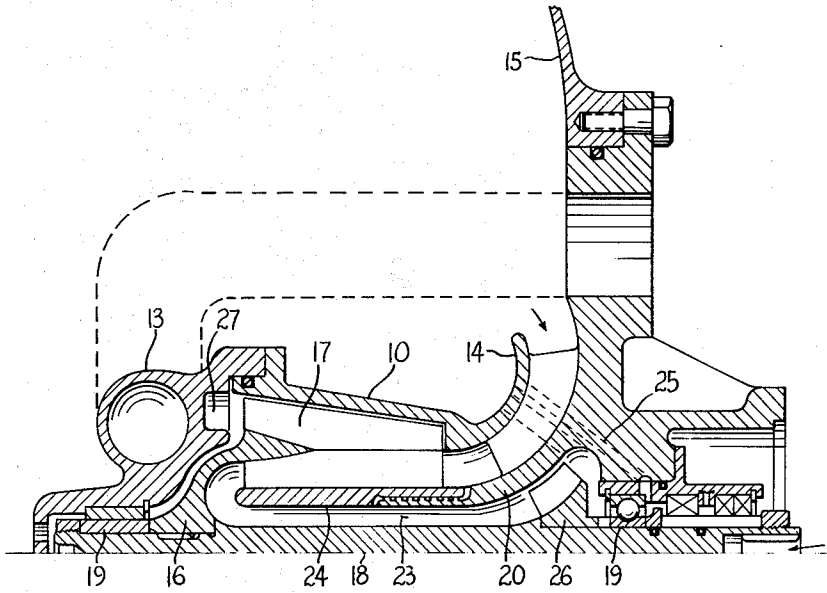


Fig. 1

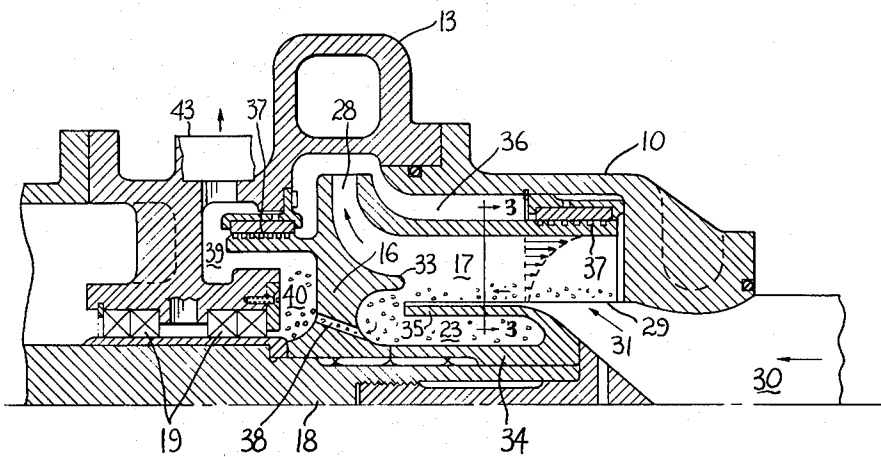


Fig. 2

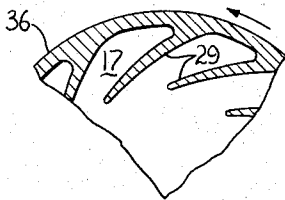


Fig. 3

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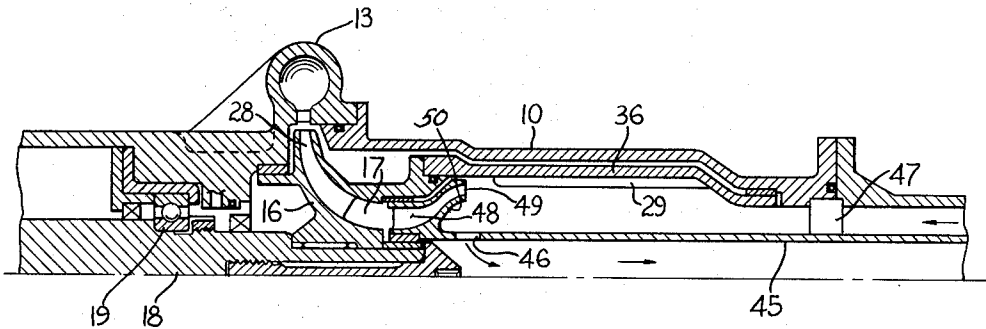


Fig. 4

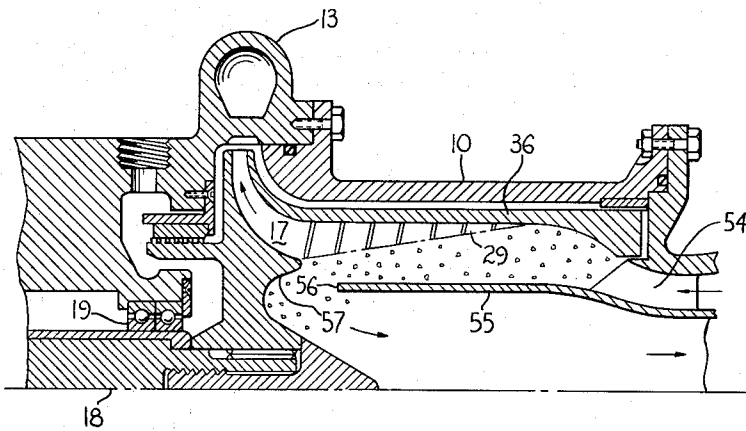


Fig. 5

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3 Claims. (Cl. 103—113)

This invention relates generally to pumps and more particularly to a high speed, high capacity pump having a vapor separating impeller.

As is well known, much research has been and is being done with the view of improving the cavitation performance of pumps because of the significant gains which could still be made. This is particularly true of rocket engine propellant pumps and is of particular importance because the closer to the boiling point of the propellant a pump will operate, the less propellant pressurizing gas is required. This in turn saves weight in two areas, namely, in the pressurizing gas container and in the propellant tanks.

Most efforts to improve the cavitation performance of pumps have centered on refining the vane geometry of the high solidity inducer. Some progress has been made, although with the non-cryogenic propellants it has not been significant, and indications are that it is still not desirable to operate at a suction specific speed much above 25,000. With the cryogenic propellants, it is possible to operate at higher suction specific speeds. Suction specific speed is calculated as follows:

$$SSS = N \frac{(Q)^{1/2}}{(NPSH)^{3/4}}$$

Where:

SSS=Suction specific speed

N=Shaft speed r.p.m.

Q=Volumetric flow—g.p.m. NPSH=Net positive suction head feet

If for example, in a rocket engine system the propellant is boiling, and a mixture of liquid and vapor is fed to a conventional vanned inducer, severe cavitation ensues accompanied by loss of head. As is well known, this problem of pump cavitation performance has resulted in the use of low speed inducers or impellers and step down gearing.

Accordingly, the main object of the present invention is to provide an improved pump which will obviate the above and other problems characterizing known structures.

An important object of the present invention is to provide an improved pump capable of operating at suction specific speeds approaching infinity with all fluids without cavitation problems.

Another important object of the present invention is to provide a high speed pump having highly improved cavitation performance and having a drastic reduction in size and weight.

A further important object of the present invention is to provide a large capacity pump which can be operated at a very low net positive suction head without losing discharge pressure enabling a higher permissible speed than for conventional pumps and requiring a smaller driving turbine.

A still further important object of the present invention is to provide an improved pump or inducer which separates the vapor bubbles entrained in a liquid from the liquid so as to markedly improve the suction characteristics of the pump.

Another important object of the present invention is to provide an improved pump or inducer which may be operated at any speed to eliminate the conventional re-

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quirement for low speed inducers and the step down gearing of pump drives, and to enable a direct drive turbopump to be used so that with the higher permissible speed, the turbine size may be reduced and the efficiency improved.

Other objects and advantages of the present invention will become apparent during the course of the following description.

In the drawings, I have shown four embodiments of the invention. In these showings:

FIGURE 1 is a fragmentary, central, longitudinal sectional view of one form of the invention showing the pump mounted in the bottom of a fuel or propellant tank;

FIGURE 2 is a similar view of another embodiment of the invention;

FIGURE 3 is a fragmentary, vertical sectional view of the impeller vanes to an enlarged scale taken on the line 3—3 of FIGURE 2;

FIGURE 4 is a fragmentary, central, longitudinal, sectional view of a further form of the invention; and

FIGURE 5 is a similar view of a still further embodiment of the invention.

In its broadest aspects, the invention contemplates the practical application in various embodiments of a pump of the principle that vapor bubbles entrained in a liquid rotating around an axis inside of a cylinder, will travel toward the axis as the mixture flows axially inside of the cylinder, at which area they may be collected and returned to their tank or source.

Referring to FIGURE 1 of the drawings, numeral 10 designates a pump casing having a volute section 13 and a pump inlet annulus 14. The pump in this embodiment is shown mounted in the bottom of a propellant tank having a wall 15.

An annular support or hub 16 for the impeller 17 is keyed to the pump shaft 18 which is rotatably mounted in the casing 10 by means of bearings 19. An annular portion 20 of the stationary casing 10 extends along and is spaced from the drive shaft 18 to define an annular chamber 23 therewith, the portion 20 of the casing including wear rings co-operating with those on the base or inner surface 24 of the impeller 17, the base further defining the annular chamber 23.

The annular chamber 23 communicates with the propellant tank by means of a conduit 25 and vapor and liquid which enters the chamber 23 will be returned to the tank by a small impeller 26 fixed to the drive shaft 18 and projecting into the annular chamber 23.

In operation, fluid at or near the boiling point enters the pump inlet annulus 14 and passes to the impeller 17 which imparts a forced vortex to the fluid mixture of liquid and vapor bubbles. This generates a pressure distribution which increases from the hub to the tip of the impeller 17. As a result, the vapor bubbles will flow inwardly to the lowest region of pressure in their axial passage across the impeller 17 as shown and into the annular chamber 23. The bubbles and liquid particles then return to the tank by the conduit 25 assisted by the impeller 26. The liquid propellant which flows to the outer portion of the casing and is free of vapor bubbles, passes through the passage 27 before entering the volute section 13 of the pump.

The form of the invention shown in FIGURES 2 and 3 embodies structural differences which improve and allow greater head rise. This is achieved in part by adding a centrifugal portion 28 to the impeller 17, similar parts of the various forms of the invention bearing similar numerals. The vanes 29 of the centrifugal impeller 17 (FIGURE 2) have no twist and the flow of mixed fluid enters the impeller 17 from an axial inlet position 30, flows radially outward as indicated by the arrow 31 rather than

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initially axially, and then flows axially to the beginning 33 of the centrifugal portion 28.

It is to be noted that an annular chamber 23 for the vapor bubbles is again provided but is defined in this embodiment by a portion 34 extending rearwardly from the hub or impeller support 16 and curved outwardly and forwardly to support and form the base 35 for the impeller blades 29, the chamber 23 being larger at its forward end so that vapor bubbles and liquid particles flowing along the inner portion of the impeller 17 may readily enter the chamber.

The impeller 17 and blades 29 are formed integrally with an enclosing drum or cylinder 36 whose aft outer periphery includes wear rings co-operating with similar rings on the inner surface of the pump casing 10. The axial flow feature of the structure, as before, ensures that the fluid mixture of liquid and vapor bubbles passing from point 31 toward the point 33 will seek the lowest pressure medium. This is directed towards the axis of rotation because rotation imparts a centrifugal pressure gradient in the fluid.

The vapor bubbles are consequently collected by passing at point 33 into the chamber 23 from where they pass by passages 38 into a chamber 39 assisted by impeller vanes 40 formed on the front of the main impeller hub 16. The vanes pull the bubbles through the passages and recompress them to liquid which joins the wear ring flow and is returned to the pump inlet through a conduit connection 43.

It will be apparent that large capacity pumps developing high heads and embodying the principles of the embodiments of the invention thus far disclosed, can be readily built and operated at a very low net positive suction head and with a boiling fluid. As a result, the permissible speed for the pump is higher than for conventional pumps and the turbine driving the pump can be made smaller.

The pump disclosure of the embodiment of FIGURE 4 is of a drum inducer capable of infinite suction specific speed with all liquid propellants or fuel. As seen, the fluid mixture of vapor bubbles and liquid enters the pump casing 10 axially along a stationary, central, vapor return tube 45 having radial inlet apertures 46 which is supported at one end as at 47 and at its forward end and terminating in a diffuser 48 having an intake annulus 49 adjacent the drum or cylinder 36. It will be noted that inner diffuser wall 50 acts as a deflector for directing the separated vapor and liquid particles to the inlet apertures 46 of the vapor return tube 45 from where they are ducted back to the supply tank.

The vanes 29 of this embodiment extend radially inward for a short distance to, as before, impart rotational movement more effectively to the fluid mixture as it enters the pump casing 10. The mixture picks up tangential velocity as it flows toward the stationary diffuser 48 at the exit and the rate at which the vapor bubbles travel inwardly toward the axis of rotation therefore increases. At the intake 49 to the diffuser 48, the liquid is free of bubbles and hence it can be bled off by the diffuser and discharged at a smaller diameter annulus to an axial or radial high pressure stage.

The embodiment of the invention disclosed in FIGURE 5 is similar although somewhat simpler to that of FIGURE 4 and, like all of the embodiments, employs the principles herein set forth. The fluid mixture enters the pump casing 10 axially through stationary vanes 54 along a stationary vapor return tube 55 which increases in diameter to conform generally to the shape of the rotating drum 36 and terminates at a point 56 spaced from the impeller 17 to form an inlet passage for the return flow of vapor bubbles and liquid particles. As the mixture flows

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axially through the drum 36, it picks up tangential velocity from the blades 29 which are tapered from the impeller 17 rearwardly to a point intermediate the length of the drum. The separated vapor and liquid particles are deflected into the tube 55 by the arcuate wall portion 57 while the liquid adjacent the drum which is free of bubbles, is discharged to the volute 13.

It will now be readily apparent that the present invention provides material advantages in that low speed inducers are not required, the propellant pumps may be operated at any speed thus eliminating the step down gearing heretofore required in pump drives, the driving turbine may be reduced in size, and the efficiency is greatly improved.

It is to be understood that the forms of the invention herewith shown and described are to be taken as preferred examples of the same and that various changes in the shape, size and arrangement of parts may be resorted to without departure from the spirit of the invention or the scope of the subjoined claims.

What is claimed is:

1. A pump for pumping fluid mixtures of vapor and liquid without loss of head comprising, in combination, a casing including a portion disposed for axial fluid flow, a drive shaft including an impeller fixed thereto journaled in said casing, an annular inlet communicating with said casing to direct pumped fluid axially along said impeller, impeller vanes arranged in said axial portion to impart rotation to the mixture upon rotation of said shaft to effect a separating flow of the lighter vapor components toward and of the heavier liquid components away from the axis of rotation, and a pair of annular, radially spaced walls formed on said impeller vanes defining separate inner vapor and outer liquid passages with said shaft and said housing and directing said separated components to separate discharge means of said casing.

2. The combination as recited in claim 1 wherein said impeller includes a centrifugal portion.

3. The combination recited in claim 1 wherein said vapor discharge means comprises an annular chamber, the inner side of which comprises said shaft, communicating with the radially inner side of said directing walls; a discharge conduit extends exteriorly of said casing; and an impeller is arranged in said annular discharge chamber to effect the movement of vapor therein to said discharge conduit.

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