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CENTRIFUGAL PUMPS

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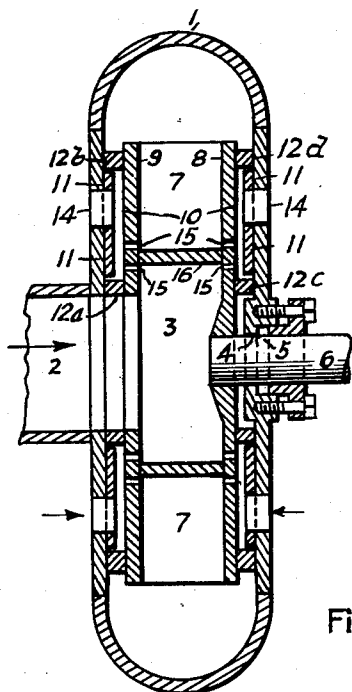


Fig. 1

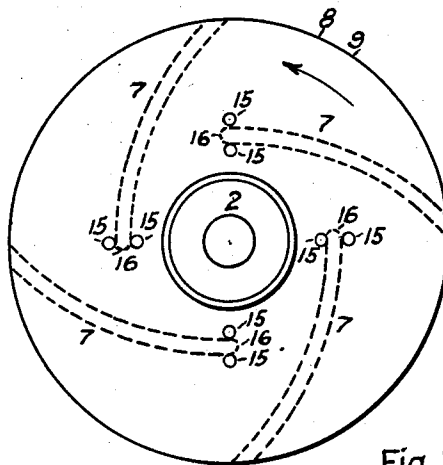


Fig. 2

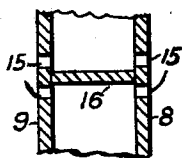


Fig. 3

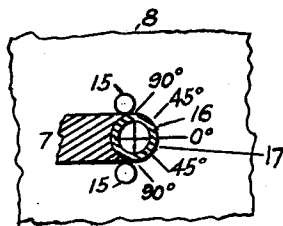


Fig. 4

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CENTRIFUGAL PUMPS

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This invention relates generally to centrifugal pumps and particularly to single suction pumps operating with high suction lifts.

The term cavitation as used herein refers to conditions that occur within the impeller channel when the absolute pressure on the vane surface near the intake end decreases abruptly and causes water vapor to form and displace the fluid. The area containing water vapor starts near the vane edge and extends along the vane surface until the vapor reaches a zone of higher absolute pressure when it suddenly condenses. This results in the destruction of the metal surface of the vane, where the condensation takes place; also causes pump vibrations, excessive popping noises, as well as affecting the pump output and hydraulic efficiency.

The object of my invention is to provide the impeller with a duct in its shroud through which water or other fluid can be injected on the vane where the vapor pocket exists and thereby dissipate the vapor, thus eliminating the cavitation and its effect upon the pump performance.

This is accomplished by means of such structure and relative arrangement of parts as will fully appear by considering the following specifications and claims.

In the drawings:

Fig. 1 is a sectional view of the pump case containing impeller.

Fig. 2 is a sketch of the impeller without the pump case as viewed from pump suction inlet and pump eye.

Fig. 3 is a fragmentary sketch of an impeller intake section near the vane end showing position of injection ducts in the shrouds.

Fig. 4 is a diagrammatic sketch showing preferred location of injection ducts with reference to vane surface and end of intake vane.

Referring now more particularly to the characters of reference on drawings, the pump, Fig. 1, is shown in a horizontal shaft position. A pump case is provided having the usual inlet opening 2, eye 3, and tangential discharge outlet, not shown. The casing 1 is provided with an opening 4 and stuffing box 5 opposite the inlet opening 2, for shaft 6. On the shaft 6 and within the casing 1 is mounted an impeller having four vanes 7 and back shroud 8 and front shroud 9. The clearance space 10, lying between the casing liners 11 and shrouds 8 and 9, serves as an annular reservoir and channel for collecting fluid and distributing same to ducts 15 in the impeller shrouds. 12b and 12d are annular rings made integral with pump case or impeller shrouds which serve as seal rings and outer reservoir boundaries. 12a is a similar structure serving as a seal ring and inner reservoir boundary. The ring structure 12c also serves as a seal ring and reservoir boundary. The stuffing box 5 for shaft 6 will serve the same purpose as 12c in defining the reservoir boundary. The omission of the liners will not alter the functions performed by the reservoir. 14 is an inlet duct extending through the casing wall and liner 11 serving the reservoir 10 from a supply source outside the case, not shown. Injection ducts 15 in the shrouds 8 and 9 are

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stationed near vane surface and vane edge 16 and receive fluid from the reservoir 10.

Fig. 2 is the conventional impeller with curved vanes 7. The vanes are made integral with the back shroud 8 and front shroud 9. The entrance edge 16 is rounded and makes a transition to the upper and lower vane surface at the beginning of the tangent. Injection and diffusion ducts 15 are contained by the shrouds 8 and 9, near the intake edge 16 of the impeller vane 7. The number of impeller vanes is not pertinent.

Fig. 3 further accentuates the relationship of vane surfaces and ducts 15 and shrouds 8 and 9.

Fig. 4 shows the preferred relative position of the ducts 15 near vane end 16. The pressure as maintained at positions indicated by 0°, 45°, and 90° is discussed later:

When the pump is operating the impeller draws the fluid into the pump eye 3 through inlet 2 where it is picked up by the revolving impeller vane 7. It then passes along the channels between the vanes, thence into the case and through the discharge outlet.

The fluid required by the ducts 15, Fig. 1, enters the case through the duct 14 and passes through the annular reservoir 10 and thence to the said ducts 15 near the vane edge 16 where it diffuses on the vane 7.

A brief discussion on the development of pressures imposed upon the leading edge of the impeller vane due to the contact of the vane with the fluid, will define the vane area first affected by cavitation and make clear the purpose of the invention. Surface pressures on the vane edge can be measured by the Pitot tube.

A Pitot tube when used to measure fluid velocities in a closed conduit or system is ordinarily held in a fixed position and the pressure created at the orifice is due to the velocity of the fluid impinging upon the same. The basic Pitot formula is $Velocity = C\sqrt{2gh}$. Obviously the same effect will be registered if the tube is in motion and the fluid stationary. However, the effective pressure h will be due to the difference in the relative velocity between the tube orifice and fluid, because the two may be moving at the same time in the same direction or counterwise.

A comparatively new type of Pitot tube referred to as the Pitot cylinder consists of a round tube with an orifice in the wall. This type of tube of tube is described in Patent 1,374,359. The original Pitot tube formula for translating velocity into pressure h also applies to the cylinder. The Pitot cylinder has the feature of being able to determine the pressures directly on the cylinder circumference by changing the position of the orifice. The trailing half of the Pitot comprising 180 degrees of the surface has practically a constant Pitot pressure, but a suction rather than a positive pressure effect. As an experiment it is therefore possible to merge half the tube with the vane edge, as in Fig. 4, and anticipate the pressure which occurs along the vane surface tangent to the curved surface at 90° as well as at 45° and 0°.

Continuing this line of reasoning, the Pitot cylinder 17, Fig. 4, is assumed to be combined with the entrance vane 7 in which one-half of the tube is embedded in the vane and the other half makes up the edge 16. When a Pitot orifice is at approximately 45° the Pitot effect h , as determined by the Pitot formula, is zero. This static pressure is the same for all vane velocities. The pressure at 0° can be determined by Pitot formula where $C=1.00$. At 90° the pressure h has been greatly decreased and is negative in value. That is to say, the Pitot effect at 0° is h plus and at 90° h minus with reference to the static pressure at 45°. The two h values are practically the same numerically as determined by experiment but one adds to the absolute pressure occurring at 45° and the other subtracts from the same.

This is of vital importance for in a relatively short

distance on the rounded edge surface the sudden drop in pressure that occurs is of such magnitude it causes cavitation to a degree depending largely upon the speed of the impeller and the absolute pressure existing in the impeller eye.

As a maximum theoretical cavitation effect, a vane edge velocity of forty-seven feet per second will create a suction pressure head of thirty-four feet of water, which of course produces vaporization. Obviously, when the pump is operating under a suction lift at the impeller eye the tendency toward cavitation greatly increases, because the absolute pressure existing at the vane edge in the cavitation zone is the combination of the low pressure due to vane impact and suction lift. On the other hand, an increase in pressure at the eye will improve the tendency toward cavitation by decreasing the absolute pressure at the cavitation zone.

Other conditions such as pre-rotation, direction of flow of the fluid in the impeller eye, shape of vane edge, besides the speed of the impeller will effect in same manner the cavitation characteristics of the given pump. However, the vapor pocket that bears upon the entrance vane has its inception in the zone which is in proximity to the deflecting surface of the vane edge and surface tangent to the same, wherein an abrupt drop in pressure occurs.

From the foregoing description it will be readily seen that there has been produced such a structure as substantially fulfills the object of the invention, in that a fluid is introduced at the zone where the cavitation originates and dissipates the water vapor.

While these specifications set forth in detail present a preferred construction of the structure, still, in practice, such deviations from such detail may be resorted to as do not form a departure from the spirit of the invention, as defined by the appended claims.

Having thus described the invention, the following is claimed as new and useful, and upon which Letters Patent are desired:

1. In a centrifugal pump subject to high suction lifts, the combination of a casing having a front and back wall, an axial intake port and a substantially radial discharge port; an impeller rotatably mounted within said casing and in spaced relationship to the walls of said casing, said impeller including a front shroud, a back shroud, and radially extending vanes between said shrouds, each vane having a substantially arcuate leading edge, whereby normal pressure of incoming liquid against such edge diminishes from a maximum value through zero to negative value on both sides of vane; said front shroud having a jet duct for each vane through said shroud substantially parallel to the axis of the leading edge of each vane and terminating in a vacuum region adjacent to each leading edge; and means for conducting fluid to each of said jet ducts.

2. In a centrifugal pump subject to high suction lifts, the combination of a casing having a front and back wall, an axial intake port and a substantially radial discharge port; an impeller rotatably mounted within said casing and in spaced relationship to the walls of said casing, said impeller including a front shroud, a back shroud, and radially extending vanes between said shrouds, each vane having a substantially arcuate leading edge, whereby normal pressure of incoming liquid against such edge diminishes on both sides of vane from a maximum value through zero to a negative value, said front shroud having for each vane a pair of jet ducts through said shroud substantially parallel to the axis of leading edge of each vane, with each of said ducts terminating in a vacuum region adjacent to each leading edge; and means for conducting fluid to each of said jet ducts, said means including a pair of sealing rings between said casing front wall and said impeller front shroud with one of said rings to one side of the jet ducts in said front shroud and the other of said rings to the other side of said jet

ducts to form an annular reservoir having flow connections with the jet ducts in said front shroud, and said casing front wall having a flow passage therethrough to said annular reservoir.

3. In a centrifugal pump subjected to high suction lifts, the combination of a casing having a front and back wall, an axial intake port and a substantially radial discharge port; an impeller rotatably mounted within said casing and in special relationship to the walls of said casing, said impeller including a front shroud, a back shroud, and radially extending vanes between said shrouds, each vane having a substantially arcuate leading edge, whereby normal pressure of incoming liquid against each edge diminishes on both sides of the vane from a maximum value through zero to a negative value, said front shroud having for each vane a pair of jet ducts through the shroud substantially parallel to the axis of the leading edge of each vane, with each of said ducts terminating in a vacuum region adjacent to each leading edge, said back shroud similarly having a pair of jet ducts through the shroud for each vane and means for conducting fluid to each of said jet ducts.

4. In a centrifugal pump subjected to high suction lifts, the combination of a casing having a front and back wall, an axial intake port and a substantially radial discharge port; an impeller rotatably mounted within said casing and in spaced relationship to the walls of said casing, said impeller including a front shroud, a back shroud, and radially extending curved vanes between said shrouds, each vane having a substantially arcuate leading edge, whereby normal pressure of incoming liquid against such edge diminishes on both sides of vane from a maximum value through zero to a negative value; said front shroud having for each vane a pair of jet ducts through the shroud substantially parallel to the leading edge of each vane, with each of said ducts terminating in a vacuum region adjacent to each leading edge, said back shroud similarly having a pair of jet ducts through the shroud for each vane; and means for conducting fluid to each of said jet ducts, said means including a pair of sealing rings between said casing front wall and said impeller front shroud, with one of said rings to one side of the jet ducts in said front shroud and the other of said rings to the other side of said jet ducts to form an annular reservoir having flow connection with the jet ducts in said front shroud, and said casing front wall having a flow passage therethrough to said annular reservoir, a like pair of sealing rings between said casing back wall and said impeller back shroud to form an annular reservoir having flow connection with the jet ducts in said back shroud, and said casing back wall having a flow passage therethrough to said latter annular reservoir.

5. An impeller for a centrifugal pump comprising a front shroud, a back shroud, and radially extending vanes between said shrouds, each vane having a substantially arcuate leading edge, whereby normal pressure of incoming liquid against such edge when operating in a pump, will diminish from a maximum value through zero to a negative value on both sides of vane, said front shroud having for each vane, a jet duct through the shroud substantially parallel to the leading edge of each vane, with each of said ducts terminating in a vacuum region adjacent to each leading edge.

6. An impeller for a centrifugal pump comprising a front shroud, a back shroud, and radially extending vanes between said shrouds, each vane having a substantially arcuate leading edge, whereby normal pressure of incoming liquid against such edge when operating in a pump, will diminish from a maximum value through zero to a negative value on each face of vane; said front shroud having for each vane a jet duct through the shroud substantially parallel to the leading edge of said vane, with each of said ducts terminating in a vacuum region adjacent to each leading edge, and

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said back shroud similarly having a jet through the shroud for each vane.

7. An impeller for a centrifugal pump comprising a front shroud, a back shroud, and radially extending curved vanes between said shrouds, each vane having a substantially arcuate leading edge, whereby normal pressure of incoming liquid against such edge when operating in a pump, will diminish on both sides of the vane from a maximum value through zero to a negative value, said front shroud having for each vane, a pair of jet ducts through the shroud substantially parallel to the leading edge of each vane, with each of said ducts terminating in a vacuum region adjacent to each leading edge, and said back shroud similarly having a pair of jet ducts through the shroud for each vane.

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