

[54] **PIVOTAL VANE CENTRIFUGAL PUMP**
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Primary Examiner—Henry F. Raduazo

[52] **U.S. Cl.** 415/141; 415/219 A; 415/DIG. 4;
416/186 A; 415/170 A
[51] **Int. Cl.**..... **F01d 5/12**
[58] **Field of Search** 416/186 A; 415/129, 130,
415/140, 141

[56] **References Cited**

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[57] **ABSTRACT**

A centrifugal pump having a radial flow impeller characterized by pivotally mounted vanes. The vanes are shaped and positioned with respect to one another whereby the dimensions of the flow channels defined by adjacent vanes may be varied to meet the required pressure conditions.

2 Claims, 3 Drawing Figures

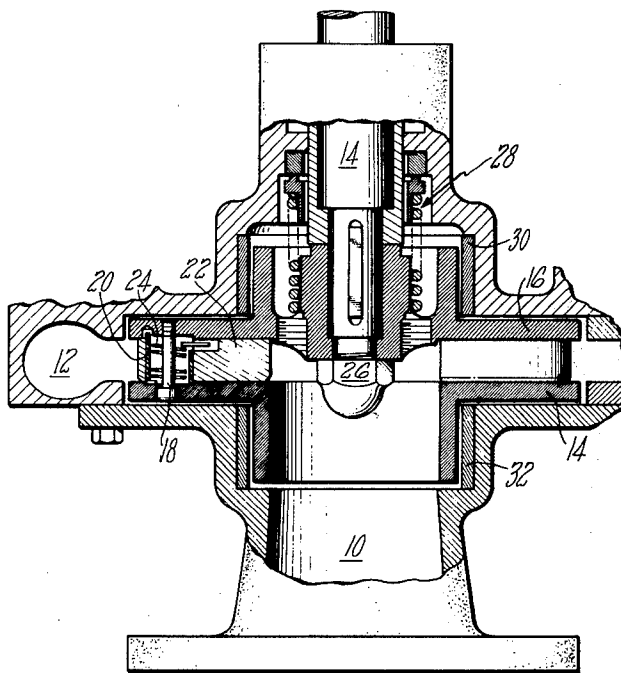


FIG. 1

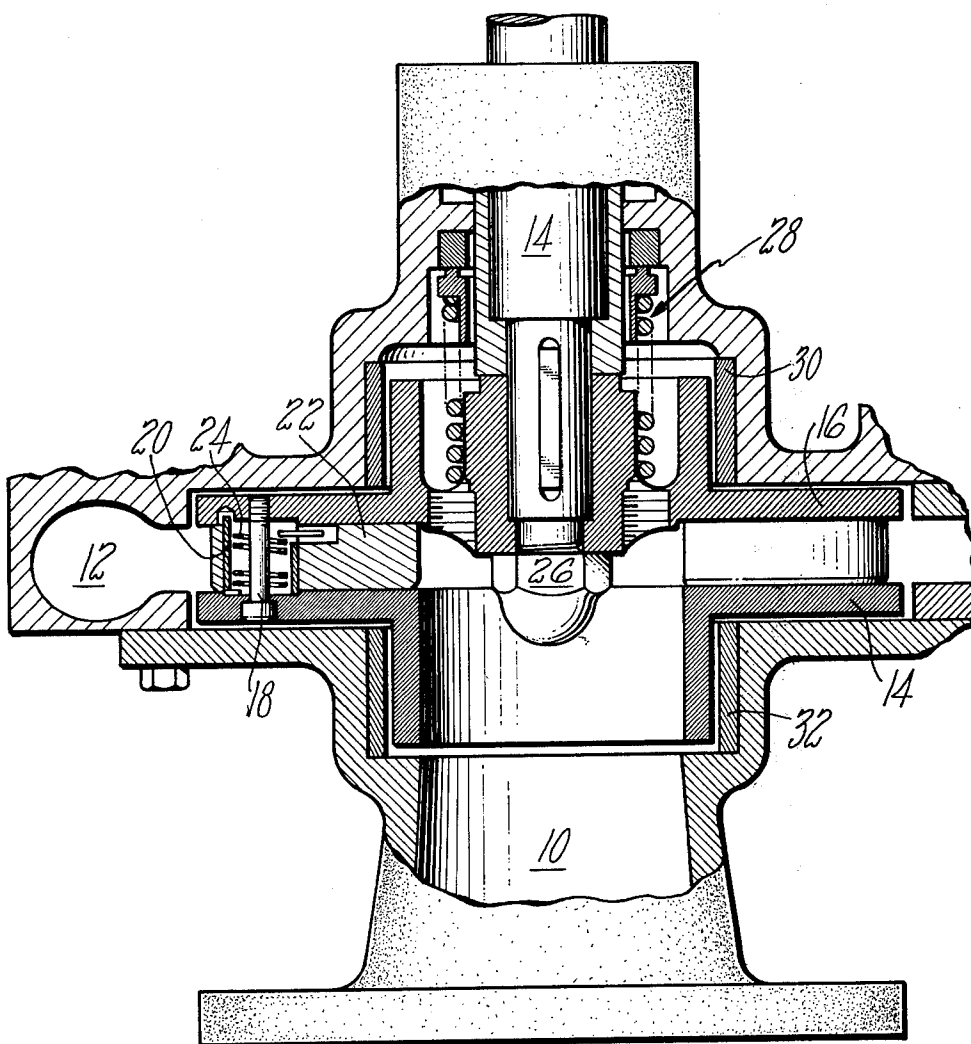


FIG. 2

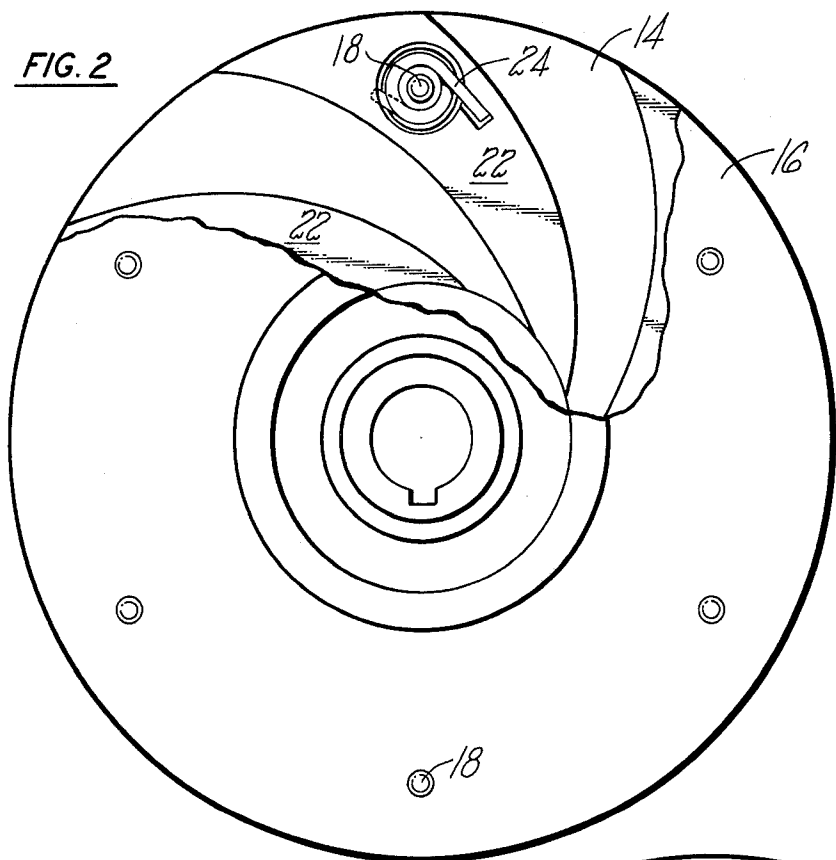
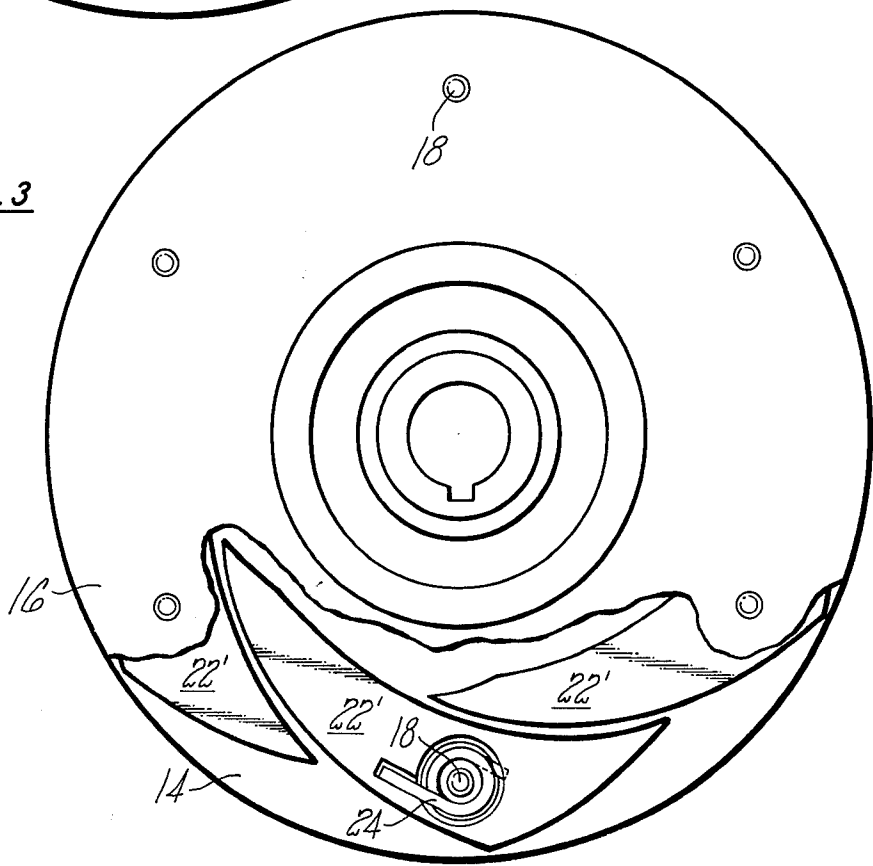


FIG. 3



PIVOTAL VANECENTRIFUGAL PUMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to improving the operating characteristics of pumps and particularly centrifugal pumps which are required to operate at low flow rates over a wide range of back pressures with a high maximum output pressure. More specifically, this invention is directed to low specific speed pumps with radial stage impellers. Accordingly, the general objects of the present invention are to provide novel and improved methods and apparatus of such character.

2. Description of the Prior Art

The present invention has been found to be particularly well suited for use with centrifugal pumps having a radial flow impeller; such pumps having an axial inlet and radial discharge for fluid delivered thereto. The achievement of constant flow, particularly with varying back pressure, has proven to be an elusive objective for designers of centrifugal pumps. Restated, a long felt need in the pump arts is to provide a centrifugal pump which would have the linear pressure-flow characteristics of a positive displacement pump, such as a gear or piston pump, but which would not subject the fluid being pumped to the coarse handling characteristics of a positive displacement pump. Thus, by way of example, there has not previously been available a high pressure, low flow centrifugal pump which would provide an output characterized by minimum hydraulic noise regardless of variations in back pressure. Such a pump would, for example, be desirable for use in any control system sensitive to flow pulsations or in cases where the process fluid could not stand harsh treatment conditions. The processing of food or blood plasma is an example where the process fluid must not be subjected to the coarse handling which is characteristic of positive displacement pumps. Numerous control systems, such as those on submarines, present environments where the hydraulic noise associated with output pressure pulsations is undesirable or unacceptable.

As discussed above, it has long been desired to provide a centrifugal pump which would duplicate the constant flow with varying pressure characteristics of a positive displacement pump. In addition to the above briefly described examples of where such a pump could be employed, it is also to be noted that positive displacement pumps are characteristically sensitive to and thus can not be employed in the handling of contaminated fluids; i.e., fluids with entrained particulate matter. Conversely, centrifugal pumps are very insensitive to entrained particulate matter and their ability to handle contaminated fluids is well known. The applications for pumps providing a constant flow at varying back pressures while moving contaminated fluids are numerous.

While the above discussion has emphasized a constant flow rate, it is to be observed that a concomitant long standing desire has been the provision of a centrifugal pump which can affectively and quietly vary its flow and pressure to match system demands. Previous attempts to produce such a pump have resorted to varying pump speed, throttling techniques or variable pump geometry. As is well known, pressure rise and flow may be varied by changing pump speed. However, since the rate of pressure rise does not vary linearly with the flow capacity of a fixed geometry centrifugal

pump with increases in speed, variations in pump speed offer a limited solution; i.e., system demands can be matched only over a limited range of pressures and flows. Throttling, and its counterpart bypassing, inherently results in inefficient operation with attendant noise and process fluid temperature increases. Conventional throttling or bypassing techniques are, accordingly, not suitable for environments where either noise or the preservation of the characteristics of the process fluid are considerations. For an example of a centrifugal pump which employs throttling at the inlet, reference may be had to Mottram et al. U.S. Pat. No. 3,442,220. Throttling at the pump input, as is well known in the art, results in cavitation and thus hydraulic noise. There are other centrifugal pumps known in the art which resort to throttling at the pump outlet. U.S. Pat. No. 3,168,870 to Hornschoch is representative of the prior art technique of internal bypassing in the interest of varying centrifugal pump capacity.

Centrifugal pumps with variable impeller geometry are also known. For an example of a centrifugal pump with a variable geometry impeller which is adapted to high specific speed applications, reference may be had to copending application Ser. No. 277,593 now U.S. Pat. No. 3,806,278 entitled "Centrifugal Pump With Variable Flow Area" which is assigned to the assignee of the present invention. A further approach to variable geometry impellers are those proposed pumps which have blade configurations of conventional cross-section and a single flow channel without pulse generation compensation. For examples of such further proposed variable geometry pumps reference may be had to U.S. Pat. No. 2,927,536 to Rhoades and U.S. Pat. No. 3,482,523 to Morando.

It is to be noted that there have, in the prior art, been hydraulic pump/turbines and variable pitch aircraft propellers which employed pivoting vanes or blades. These prior art devices have, however, been predominantly axial flow machines whereas a centrifugal pump is a radial flow machine. Prior art fluid handling devices with pivotal blades have also been characterized by rather complex external actuators which controlled the pivoting of the vanes or blades about a radial to the main axis of rotation of the devices.

SUMMARY OF THE INVENTION

The present invention overcomes the above discussed and other problems of the prior art by providing a novel and improved radial flow centrifugal pump which is characterized by a variable flow area. In accordance with the invention the vanes of a radial flow impeller are pivotally mounted, adjacent their outer periphery, and are shaped and positioned with respect to one another so as to permit adjustment of the dimensions of the flow channels between the pump axial inlet and discharge to meet the required pressure conditions.

In a preferred embodiment the invention employs curved impeller blades designed with an artificial blockage which gives the pump an improved hydraulic radius when compared to the prior art.

Although a conventional volute or diffuser can be employed as the collector, in a preferred embodiment of the invention the pump may be characterized by an axial inlet and toroidal collector. The toroidal collector possesses the desirable features of no cut-water or tongue for generating pressure pulses.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be better understood and its numerous objects and advantages will become apparent to those skilled in the art by reference to the accompanying drawing wherein like reference numerals refer to like elements in the several figures and in which:

FIG. 1 is a cross-sectional, top view of a preferred embodiment of a self-compensating centrifugal pump with a variable geometry impeller in accordance with the invention;

FIG. 2 is a front elevation view, partially broken away, of the impeller assembly of the pump of FIG. 1 in the high flow, high pressure condition; and

FIG. 3 is a front view, partially broken away, of the impeller assembly of the pump of FIG. 1 in the low flow, low pressure condition.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring simultaneously to FIGS. 1-3, a pump in accordance with the preferred embodiment of the present invention includes a housing which defines an axial inlet 10 and a toroidal collector 12. As discussed above, the pump includes a pivoting vane impeller assembly. This impeller assembly is defined by a plurality of pivotally mounted blades disposed between vaneless front and back shrouds. The front shroud, or driven vane retainer, is indicated at 14. The back shroud, or driver vane retainer, is indicated at 16. The driver and driven retainer are held together by a plurality of through bolts and associated spacers. One of several through bolts is shown at 18 in FIG. 1. A sleeve or spacer 20 is disposed about each of the through bolts 18; the sleeves being located by means of engagement with shoulders formed on the facing surfaces of the driver and driven vane retainers. The sleeves 20 provide the pivot points for the vanes, such as vane 22, and also as the anchors for preload torsion springs, such as spring 24.

The impeller assembly is keyed to the pump drive shaft 34 and is held in position on the drive shaft by means of a lock nut 26. A conventional face seal assembly, indicated generally at 28, engages the rearwardly facing side of the driver retainer 16 as shown. Wear rings 30 and 32 are respectively provided, for thrust balancing purposes, between flanges on the driver and driven vane retainers and the pump housing. The wear rings 30 and 32 are located to balance axial thrust loads, as is common with prior art open face impellers, and these wear rings seal the impeller discharge respectively to the impeller assembly back face and inlet. Conventional labyrinth seals may be employed in place of wear rings 30 and 32.

FIG. 2 shows the vanes of the pump of FIG. 1 in the high pressure-high volume flow position. FIG. 3 shows the vanes in the low pressure-low volume position. Through joint consideration of FIGS. 2 and 3 it may be seen that the area of the flow channels defined by the spaces between the pivoting vanes is variable. The vanes 22 are conventionally curved backwardly. The vanes 22 are, however, of unusual width when com-

pared to the prior art. The increased width, at the downstream or discharge ends of the vanes, is achieved by shaping the vanes whereby they impart an artificial blockage to fluid flow thereby improving the hydraulic radius of the impeller. In terms of fluid mechanics the impeller of the present invention thus approaches the optimum hydraulic radius; i.e., the minimum friction loss; for a given flow area.

Pumps in accordance with the present invention are self-compensating and operation of the pivoting vane impeller is effected by the action of the back pressure against the vane surfaces producing a moment around the pivot point. The net effect of this moment, the inertial and centripetal loads plus the pivot friction is resisted by the coil springs 24 around each pivot; the coil springs having a tang which engages the walls of a recess formed in each blade as shown in FIG. 1. Increasing back pressure thus increases the blade-to-blade channel width, the effective outside diameter of the impeller and the blade angle. All of these factors improve the impeller's ability to sustain the requisite flow against the higher back pressure.

While a preferred embodiment has been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustration and not limitation.

What is claimed is:

1. In a radial flow centrifugal pump, said pump having a drive shaft and a housing which defines an axial inlet and a collector for receiving fluid being pumped, means for varying the pump flow area comprising:

impeller means, said impeller means including a plurality of pivotally mounted vanes, said vanes being pivotal about axes oriented parallelly to and disposed circumferentially about the axis of rotation of the impeller means, said vanes being mounted for pivoting adjacent their discharge ends and being characterized by increasing width from their inlet to discharge ends, said vanes cooperating to define flow channels of variable width therebetween, the shape and mounting of each of said vanes resulting in the generation of a pivotal moment in the direction of maximum flow channel width in response to the summation of the pressure and mechanical forces applied to the vanes;

means for mounting said impeller means on the pump drive shaft; and

spring means for loading said pivotal vanes toward the channel width position commensurate with minimum flow, said spring means generating forces substantially equal and opposite to the pressure and mechanical forces imposed on the vanes under minimum flow conditions, on the operation of said pump the pressure forces on the vanes and thus the pump blade-to-blade channel width increasing in response to increases in pump back pressure.

2. The apparatus of claim 1 wherein said spring means each comprises:

a torsion spring.

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