Feb. 14, 1967 W. DOBLE 3,303,791

FLEXIBLE-VANED CENTRIFUGAL PUMP

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FIG. 1.

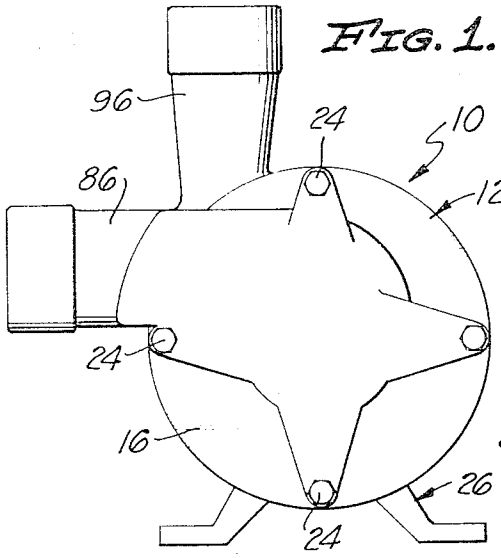


FIG. 2.

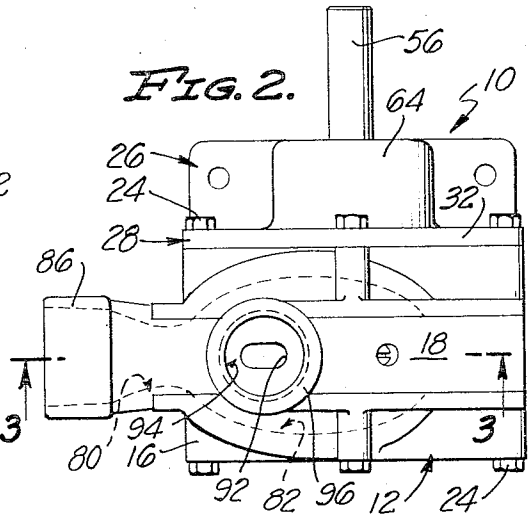


FIG. 4. FIG. 4a. FIG. 4b.

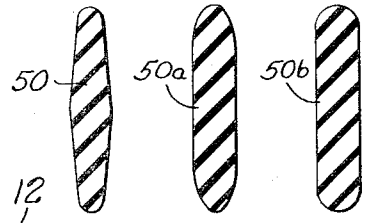


FIG. 3.

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FIG. 5.

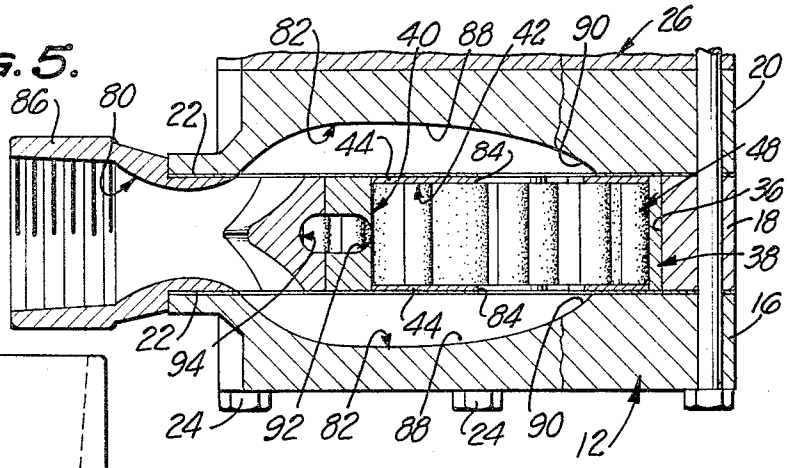
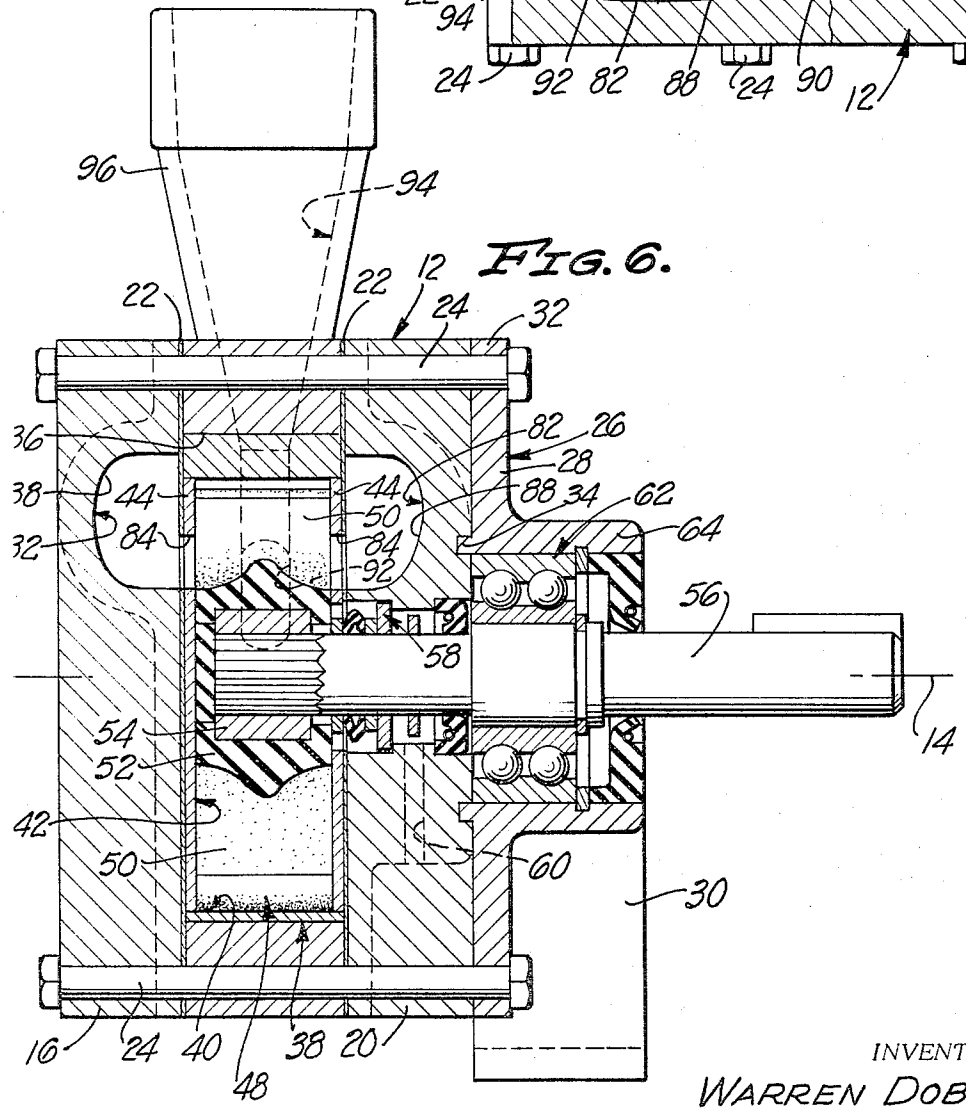


FIG. 6.



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FLEXIBLE-VANED CENTRIFUGAL PUMP

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2 Claims. (Cl. 103—117)

The present invention relates in general to pumps and, more particularly, to a pump of the flexible-vane type which discharges fluid with a centrilugal action, as well as with the usual displacement action, typical of such pumps, resulting from the intervane volume reductions produced by bending of the vanes as they encounter an outlet cam surface forming part of the peripheral wall of the chamber in which the flexible-vaned impeller is disposed.

As more specific background, the invention contemplates a flexible-vaned centrifugal pump which includes: a housing provided therein with an impeller chamber having an axis and having axially spaced end walls and a peripheral wall; an impeller in the chamber and mounted for rotation therein about the aforementioned axis in a predetermined direction, and provided with circumferentially spaced flexible blades or vanes each having axially spaced edges respectively engaging the end walls of the impeller chamber and an outer end engaging the peripheral wall thereof; the peripheral wall of the impeller chamber including an inlet cam surface of increasing radius relative to the axis of the impeller chamber in the direction of rotation of the impeller, and including an outlet cam surface of decreasing radius relative to such axis in the direction of impeller rotation; the housing being provided therein with an inlet passage terminating in an inlet port in one of the end walls of the impeller chamber radially inwardly of and in circumferential register with the inlet cam surface; and the housing being provided therein with an outlet passage communicating with the impeller chamber adjacent and in circumferential register with the outlet cam surface. Preferably, the outlet passage communicates at its inner end with an outlet port in the outlet cam surface.

A primary object of the invention is to provide a flexible-vaned pump of the foregoing nature wherein both the inlet and outlet passages for oriented generally tangentially of the impeller chamber, and wherein the inlet port in which the inlet passage terminates extends circumferentially of the impeller chamber through a substantial angle. With this construction, tangential motion is imparted to the fluid being admitted to the impeller chamber so that it enters the increasing-volume intervane spaces of the impeller at a speed at least approaching the circumferential speed of those portions of the vanes which are axially opposite the circumferentially extending inlet port. This insures smooth flow into the increasing-volume intervane spaces with a minimum of shock so as to minimize energy loss. Another object in this connection is to so shape the inlet passage, the inlet port, and the vanes themselves, as to insure complete filling of the increasing-volume intervane spaces.

The generally tangential orientation of the outlet passage takes advantage of the dynamic of kinetic energy present in the rotating fluid in the impeller chamber, so that the discharge of fluid from the impeller chamber occurs with a centrifugal action, as well as the usual displacement action. An object of the invention in this connection is to make the outlet passage divergent in the outward direction so that the outlet passage acts as a diffuser to convert the dynamic or kinetic energy of the discharge fluid to fluid pressure.

An important object of the invention is to bifurcate the generally tangential inlet passage into two branches respectively terminating in circumferentially extending inlet

ports in the end walls of the impeller chamber, thereby delivering fluid to the inner portions of the increasing-volume intervane spaces from both ends. This further insures complete filling of the increasing-volume intervane spaces with liquid moving at a speed at least approaching the circumferential speed of the corresponding portions of the vanes.

To further promote efficient filling of the increasing-volume intervane spaces, an important object is to utilize vanes which converge axially toward their respective edges, thereby minimizing restriction to incoming fluid flow.

Another object of the invention is to locate the outlet passage between the two branches of the bifurcated inlet passage, and to make the inlet and outlet passages generally perpendicular to each other. This generally perpendicular arrangment of the inlet and outlet passages makes for easy installation, which is an advantage of the invention.

Another object of the invention is to provide a pump having mounting means at one end of the housing for mounting the pump on a supporting structure, and having means connecting the housing to the mounting means in any one of a plurality of positions angularly spaced apart about the axis of impeller rotation, so as to vary the angular orientations of the inlet and outlet passages relative to the supporting structure on which the pump is mounted. With this construction, the pump may be mounted with any angular orientation to readily adapt it to various environments.

The foregoing objects, advantages, features and results of the present invention, together with various other objects, advantages, features and results thereof which will be evident to those skilled in the flexible-vaned centrifugal pump art in the light of this disclosure, may be achieved with the exemplary embodiment of the invention described in detail hereinafter and illustrated in the accompanying drawings, in which:

FIG. 1 is an end elevational view of a flexible-vaned centrifugal pump which embodies the invention;

FIG. 2 is a plan view of the pump, taken from above as the pump is viewed in FIG. 1;

FIG. 3 is an enlarged transverse sectional view taken as indicated by the arrowed line 3—3 of FIG. 2;

FIG. 4 is an enlarged sectional view taken as indicated by the arrowed line 4—4 of FIG. 3;

FIGS. 4*a* and 4*b* are views similar to FIG. 4 but showing alternatives;

FIG. 5 is a sectional view taken along the irregular arrowed line 5—5 of FIG. 3; and

FIG. 6 is a longitudinal sectional view taken as indicated by the arrowed line 6—6 of FIG. 3.

In the drawings, the flexible-vaned centrifugal pump of the invention is designated generally by the numeral 10 and includes a housing designated generally by the numeral 12. For convenience in manufacture, the housing 12 is laminated perpendicularly to the axis 14 of the pump and is shown as including an end section 16, a center section 18 and an end section 20. Suitable gaskets 22 are interposed between the center section 18 and the respective end sections 16 and 20. The sections 16, 18 and 20 of the housing 12 are secured together by uniformly circumferentially spaced bolts 24, shown as four in number.

The pump 10 includes a mounting means 26 for the housing 12. Such mounting means is shown as including a mounting member 28 provided with a pedestal 30 securable to a suitable supporting structure, not shown, it being understood that other types of mounting members may be used instead. The mounting member 28 includes an annular flange 32 through which the bolts 24 extend to secure the housing 12 to the mounting member. In order

to insure that the axis of the housing **12** will coincide with the axis **14**, the mounting member **28** is provided with an annular rib **34** receivable in a complementary annular groove in the adjacent face of the end section **20** of the housing **12**.

As previously indicated, the four bolts **24** are uniformly spaced circumferentially of the housing **12**. Also, they are equidistant from the axis **14**. Consequently, with this particular construction, the housing **12** may be secured to the mounting member **28** in any one of four angularly spaced positions. This permits four different angular orientations of inlet and outlet passages which will be described hereinafter, thereby permitting the pump **10** to be used in a wide variety of environments, which is an important feature.

The center section **18** of the housing **12** is provided with a cylindrical bore **36** the axis of which coincides with the axis **14**. Within the bore **36** is an annular liner or cam **38** the inner surface of which defines the peripheral wall **40** of an impeller chamber **42**. This impeller chamber has axially spaced end walls defined by end, wear plates **44** shown as inserted into the annular cam **38**.

Rotatable in the impeller chamber **42**, in the direction of the arrow **46** of FIG. 3, is an elastomeric impeller **48** provided with circumferentially spaced flexible, i.e., bendable, vanes or blades **50** having axially spaced edges respectively engaging the end plates **44** and having outer ends engaging the peripheral wall **40**. The impeller **48** includes a hub **52** having molded therein and bonded thereto an internally splined insert **54** telescoped over an externally splined end portion of a shaft **56** the axis of which coincides with the axis **14**. The shaft **56** projects axially through the end section **20** of the housing **12** and through the mounting member **28**, being connectible to any suitable driving means, not shown. A suitable shaft seal assembly, designated generally by the numeral **58**, is interposed between the shaft **56** and the housing section **20**, the latter being provided with a drain port **60** to dispose of leakage. The shaft is supported by a suitably sealed bearing assembly, designated generally by the numeral **62**, interposed between the shaft and a central hub **64** of the mounting member **28**.

As best shown in FIG. 3 of the drawings, the annular cam **38**, which is shown as held against rotation with the impeller **48** by a screw **66**, includes an inlet cam surface or ramp **68** of increasing radius relative to the axis **14** in the direction of rotation **46**, and includes an outlet cam surface or ramp **70** of decreasing radius relative to the axis in the direction of rotation. Between the inlet cam surface **68** and the outlet cam surface **70**, in the direction of rotation **46**, is a surface **72** of maximum radius relative to the axis **14**. Between the outlet cam surface **70** and the inlet cam surface **68**, in the direction of rotation **46**, is a surface **74** of minimum radius relative to the axis **14**. Collectively, the inlet cam surface **68**, the maximum radius surface **72**, the outlet cam surface **70** and the minimum radius surface **74** constitute the peripheral wall **40** of the impeller chamber **42**. As is conventional in pumps of the type under consideration, the vanes **50** are bent by the outlet cam surface **70** as the outer ends of the vanes traverse this cam surface, thereby decreasing the volumes of the corresponding intervane spaces to discharge fluid therefrom by way of outlet porting to be described. Similarly, as the outer ends of the vanes **50** sweep the inlet cam surface **68**, the volumes of the corresponding intervane spaces increase to receive additional fluid through inlet porting to be described.

Turning now to a consideration of the porting of the pump **10**, the housing **12** is provided therein with a bifurcated inlet passage **80** oriented generally tangentially of the impeller chamber **42** and having two branches **82** respectively terminating in circumferentially extending inlet ports **84** formed in the end plates **44** radially inwardly of and in circumferential register with the inlet cam surface **68**. More particularly, the circumferentially

extending inlet ports **84** are located, radially, just outwardly of the end faces of the impeller hub **52**, and are substantially coextensive, circumferentially, with the inlet cam surface **68**. Thus, as the outer ends of the vanes **50** traverse the inlet cam surface **68**, the corresponding intervane spaces have their volumes increased to take in fluid from both ends through the inlet ports **84**. To minimize the restriction to flow of fluid entering the increasing-volume intervane spaces, the vanes, in cross section, converge axially toward their respective edges, as shown in FIGS. 4, 4*a* and 4*b* of the drawings. In FIG. 4, the vane **50** is shown as converging axially all the way from its axial midpoint to its edges. FIG. 4*a* shows a vane **50***a* which has parallel sides in its axially central region, and which converges axially from such central region to its edges. FIG. 4*b* shows a vane **50***b* having parallel sides and rounded edges to provide axially outward convergence adjacent such edges only.

Considering the inlet passage **80** more specifically now, its outer end is formed in a horn-like tubular projection **86** which extends tangentially outwardly, with reference to the impeller chamber **42**, from the center section **18** of the housing **12**. In the construction illustrated, the outer end of the tubular projection **86** is shown as internally threaded to receive an externally threaded pipe, nipple, or the like. However, other types of connections may be used. The two branches **82** of the inlet passage **80** are formed partially within the center section **18** of the housing **12** and partially within the respective end sections **16** and **20** thereof. The axially outer walls **88** of the inlet-passage branches **82** extend generally tangentially of the impeller chamber **42**. As shown in FIG. 5 of the drawings, the axially outer walls of the branches **82** have terminal portions **90** curving axially inwardly toward the respective ends of the impeller chamber **42** to impart axially-inward components of motion to the water flowing through the branches **82**. This assists in insuring filling of the increasing-volume intervane spaces, such filling being further facilitated by the axially-outward convergence of the vanes **50** shown in FIG. 4. As shown in FIG. 3, the inlet-passage branches **82**, when viewed from the ends of the pump **10**, extend circumferentially of the impeller chamber, in the vicinities of the circumferentially extending inlet ports **84**, from their points of tangency with the corresponding portions of the impeller chamber. Expressed differently, the terminal portions of the inlet-passage branches **82** are, in effect, wrapped around the adjacent ends of the impeller hub **52** and register in such regions with the circumferentially extending inlet ports. This imparts a circumferential component of motion to the fluid entering the increasing-volume intervane spaces. It will be further noted, particularly from FIGS. 5 and 6 of the drawings, that the inlet-passage branches **82** have substantial volumes to minimize restriction to flow.

With the foregoing construction for the inlet passage **80**, its branches **82**, and the inlet ports **84**, the fluid entering the ends of the increasing-volume spaces between the vanes **50** has axially inward components of motion to insure complete filling, and has circumferential components of motion at least approaching the circumferential speed of the corresponding portions of the intervane spaces. The latter insures smooth flow with a minimum of shock. The over-all effect is complete filling of the increasing-volume intervane spaces with fluid moving at, or nearly at, impeller speed, thereby providing efficient and smooth operation, which are important features.

Located axially centrally of the outlet cam surface **70** is a circumferentially extending outlet port **92** which is substantially coextensive, circumferentially, with the outlet cam surface, and which extends tangentially outwardly through the annular cam **38** from the corresponding portion of the impeller chamber **42**. The center section **18** of the housing **12** is provided therein with an outlet passage **94** which is also oriented generally tangentially of the radially outer portion of the impeller chamber **42** and which registers at its inner end with the outlet port

92. The outlet passage 94 diverges outwardly to act as a diffuser for converting dynamic fluid energy to fluid pressure, the outer end of the outlet passage being shown as internally threaded to receive an externally threaded pipe, nipple, or the like. However, it will be understood that an external connection may be made in other ways. As in the case of the inlet passage 80, the outlet passage 94 is formed in a horn-like tubular projection 96 extending tangentially outwardly from the center housing section 18.

It will be noted from FIG. 3 of the drawings that the fluid is discharged from the decreasing-volume intervane spaces into the outlet port 92 and outlet passage 94 tangentially with a centrifugal action. As will be clear from FIG. 3 of the drawings, the action of the outlet cam surface 70 in bending the vanes 50 occurs at such a point as to cause the combined centrifugal and displacement actions to discharge the fluid into the outlet port and passage 92 and 94 as nearly tangentially as possible. Consequently, a smooth discharge with a minimum of shock is achieved, thereby maintaining maximum energy in the discharged fluid.

An important feature of the invention is that the outlet passage 94 is located between the branches 82 of the inlet passage 80 and is oriented generally perpendicularly of the inlet passage. This provides a compact porting arrangement and one which is convenient in making external connections to the pump 10 since the points at which such exteral connections must be made are located closely adjacent each other.

It might be well to point out that the centrifugal action with which the flexible-vaned pump of the invention operates results in a substantial increase in efficiency over a flexible-vaned pump operating without a centrifugal action, which is another important feature.

It is thought that the over-all operation of the pump 10 of the invention will be clear from the foregoing description so that a separate discussion of the operation is not necessary.

Although an exemplary embodiment of the invention has been disclosed herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in such embodiment without departing from the spirit of the invention as defined by the claims which follow:

I claim:

1. A flexible-vaned, combination positive-displacement and centrifugal pump including:

(a) a housing provided therein with an impeller chamber having an axis and having axially spaced end walls and a peripheral wall;

(b) an impeller in said chamber and rotatable therein about said axis in a predetermined direction and provided with circumferentially spaced, flexible, elastomeric vanes each having axially spaced edges respectively engaging said end walls and an outer end engaging said peripheral wall, the spaces between said vanes being unobstructed;

(c) said peripheral wall including an inlet cam surface of increasing radius relative to said axis in said direction of rotation, and including an outlet cam surface of decreasing radius relative to said axis in said direction of rotation;

(d) said housing being provided with a bifurcated inlet passage oriented generally tangentially of said chamber and having branches respectively terminating in circumferentially extending inlet ports in said end walls just radially outwardly from the inner ends of said vanes and spaced from the outer ends of said vanes, said ports being substantially coextensive, circumferentially, with said inlet cam surface, said branches having axially outer walls with terminal portions curving axially inwardly toward said impeller to smoothly impart axially inward components of motion to fluid passing therethrough to insure complete filling of the spaces between said vanes, said branches and said ports having substantial volume to minimize resistance to flow so that fluid enters said spaces with a circumferential component of motion approaching the speed of said impeller thereby insuring smooth, efficient flow;

(e) said outlet cam surface being provided therein with an outlet port; and

(f) said housing being provided therein with an outlet passage oriented generally tangentially of said chamber and communicating with said outlet port, thereby insuring a smooth discharge and maintaining maximum energy in the discharged fluid.

2. The invention of claim 1 wherein said vanes converge axially toward their respective edges to minimize restriction to flow of fluid entering the spaces between said vanes.

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