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P. COOPER

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CENTRIFUGAL IMPELLER AND METHOD OF MAKING SAME

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2 Sheets-Sheet 2

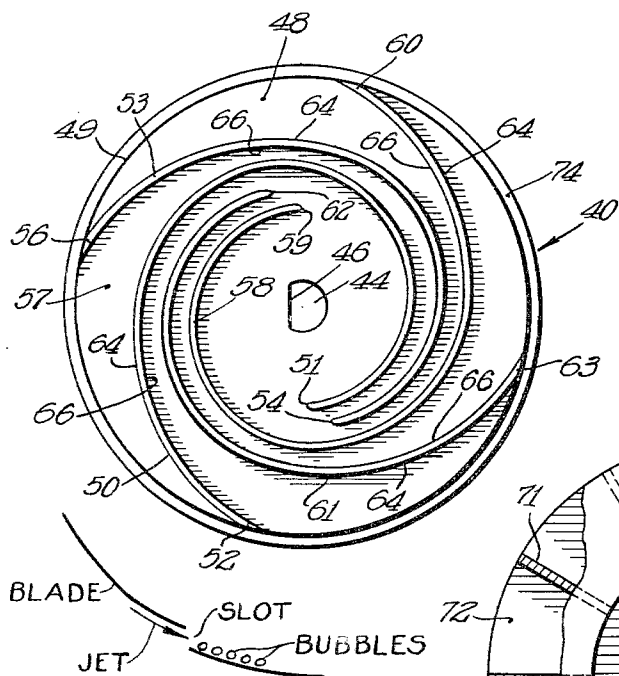


Fig. 2

Fig. 5

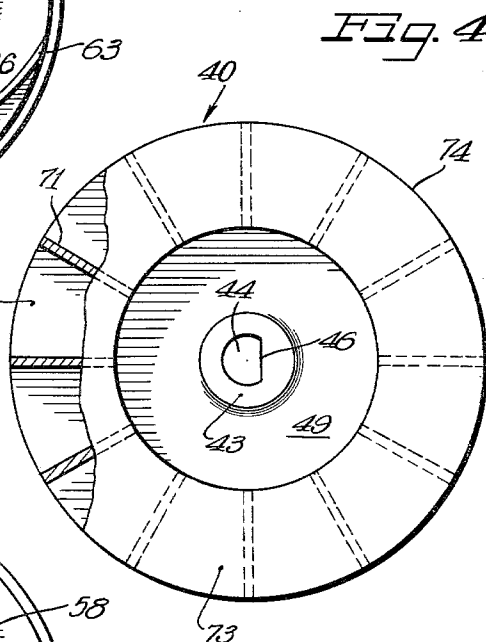


Fig. 4

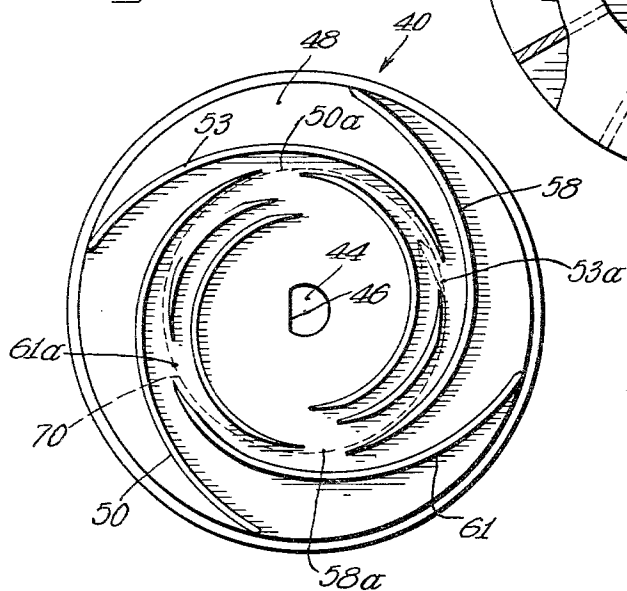


Fig. 3

INVENTOR.

Paul Cooper

BY

Hill, Sherman, Meoni, Shaw & Singer
ATTORNEYS

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CENTRIFUGAL IMPELLER AND METHOD OF MAKING SAME

Paul Cooper, Cleveland Heights, Ohio, assignor to TRW Inc., a corporation of Ohio
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This invention relates generally to turbo machines and more particularly relates to a centrifugal impeller which is characterized by a spiral vane system wherein the vanes are interrupted by slotted passageways through which jets of liquid from the high pressure side of the vanes is directed to the low pressure sides of the adjacent passages to accelerate and mix gas and liquid so the mixture can be effectively pumped.

In a pump that receives mixtures of gas and liquid at its inlet, adequate dispersion of bubbles throughout the liquid in the flow passages is required for stable operation of the machine. Furthermore, in pumps which must operate at or near the vapor pressure of the liquid, proper distributions of fluid pressure are necessary, particularly with respect to the inlet regions of the pump where the general pressure level is low and where it is important to provide improved suction performance by minimizing the adverse effects of cavitation and insure the motion of both vapor and liquid phases.

In accordance with the principles of the present invention, a centrifugal impeller is provided which is characterized by low blade angles providing long narrow passages so that any vapor cavities will become quickly indistinct due to turbulent mixing. Moreover, it is specifically contemplated by the present invention that a special vane arrangement be provided wherein the vanes embody considerable wrap to minimize the pressure difference across the vanes and thereby prevent phase separation. Moreover, the vanes are interrupted by slotted passageways which admit jets of pressurized liquid from the high pressure sides of the passages so that the liquid passes to the low pressure sides of the adjacent passages to accelerate the gas and to keep it well mixed with the liquid. The gas, therefore, flows actively along with the liquid and discharges steadily from the pump.

It is an object of the present invention, therefore, to provide a centrifugal pump impeller having improved suction performance.

Another object of the present invention is to provide a centrifugal impeller affording improved operation in liquids at or near vapor pressure.

Yet another object of the present invention is to provide a centrifugal impeller which is characterized by specific means to accelerate and mix gas and liquid so that such a mixture can be effectively pumped.

Another object of the present invention is to provide a method of making a centrifugal impeller wherein a series of concentrically disposed passageways are formed in a spiral vane system to accelerate and mix gas and liquid pumped by the impeller.

A still further object of the present invention is to provide a centrifugal impeller and method of making the same wherein each of a plurality of spirally wrapped vanes are slotted along a path concentric to the impeller axis to form passageways through which liquid passes to accelerate and mix gas and liquid so that the mixture can be steadily pumped.

Yet another object of the present invention is to provide a centrifugal impeller having a vane system on a front face and having a back face characterized by pumping vanes adapted to keep the back face at reduced pressure.

Many other features, advantages and additional objects of the present invention will become manifest from the

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detailed description which follows wherein an exemplary structural embodiment of a centrifugal impeller incorporating the principles of the present invention is shown by way of illustration, not only of the structural characteristics of the present invention but also the method steps by means of which the impeller of the present invention may be formed.

On the drawings:

FIGURE 1 is a cross-sectional view of a pump combining a positive displacement stage and a centrifugal stage and wherein the centrifugal stage incorporates the improved centrifugal impeller made in accordance with the methods contemplated by the present invention;

FIGURE 2 is a front elevational view showing the front face of a centrifugal impeller provided in accordance with the principles of the present invention before slotting;

FIGURE 3 is a view similar to FIGURE 2 but showing the impeller front face after slotting the vanes in accordance with the principles of the present invention;

FIGURE 4 is a back elevational view showing the back face of the impeller of FIGURE 3; and

FIGURE 5 is a fragmentary view illustrating the functional operation of the slots formed in the vanes in accordance with the principles of the present invention.

As shown on the drawings:

An exemplary pump is illustrated in FIGURE 1 which comprises a combination positive displacement pump and centrifugal inducer, however, it should be understood that the principles of the present invention are applicable to any centrifugal pump impeller whether embodied in a combination pump or in a single stage pump.

The pump of the illustrative embodiment is shown generally at 10 and comprises a casing 11 having two sections including a first section 12 and a second section 13 bolted together by a plurality of fasteners 14 along a mating wall 16.

A driving shaft 28 has an outwardly projecting portion 29 adapted to be connected to a driving source. A gear member 34 is journaled in a bearing 35 carried in a supporting structure 37 connected to the casing section 12. The gear member 34 has a gear portion 38 which meshes with other gear members of a gear train, thereby driving a gear member 39 at an increased rotational speed so that the gear member 39 may be used to drive the centrifugal impeller of the present invention shown generally at 40 at speeds which are in a predetermined higher proportion than the rotational speeds of the positive displacement pump housed in the casing section 12.

The casing section 13 has formed therein a pump inlet 41 providing a center inlet for the impeller 40 and there is also formed in the casing section 13 a discharge scroll shown at 42 which is connected by appropriate cored passages extending through the casing sections 12 and 13 to the inlet portion of the positive displacement pump.

Referring now to FIGURES 2-4 in connection with FIGURE 1, the specific construction of the centrifugal impeller may be explained. First of all, there is provided a hub portion 43 which establishes the rotational axis of the centrifugal impeller, having formed therein a shaft opening 44. The shaft opening 44 has a flat 46 and the opening 44 receives in driving relationship therewith a driving stub 47 projecting from the end of the gear member 39, thereby to rotatably drive the centrifugal impeller.

Extending radially outwardly from the hub 43 is a generally disk-shaped body portion 47 having parallel faces including a front face 48 and a back face 49.

The front face 48 is characterized by a vane system including plural concentrically disposed spirally wrapped vanes.

Referring, first of all, to FIGURE 2, it will be noted that the front face 48 has an outer peripheral edge or margin 49. There is provided a first blade 50 which has an inner end 51 disposed at a point nearest the rotational axis of the impeller 40. The vane 50 extends radially outwardly through a spiral wrap of substantially 360° terminating at the outer margin 49 of the front face 48 as indicated at 52.

Next, there is provided a blade 53 having a radial inner portion 54 spaced concentrically outwardly of the inner portion 51 of the blade 50. The blade 53 extends radially outwardly through a spiral wrap of more than 180° but less than 360°, terminating at the outer margin 49 as indicated at 56. There is thus formed between the blades 50 and 53 a pumping passageway 57.

A blade 58 has an inner portion 59 located diametrically opposite the inner portion 51 of the blade 50 and at the same radial spacing dimension. The blade 58 extends radially outwardly through a spiral wrap of substantially 360° terminating at 60 at the outer margin 49. There is thus formed another pumping passage 57 between the blade 53 and the blade 58. Lastly, there is a blade shown at 61 which starts radially inwardly as at 62 at the same radial spacing dimension as the inner portion 54 of the blade 53 but spaced diametrically opposite therefrom. The blade 61 extends radially outwardly through a spiral wrap of more than 180° but less than 360°, terminating at an outer portion 63 at the outer margin 49. Thus, additional pumping passages 57 are formed between the blades 58 and 61 and between the blades 61 and 50. The low blade angles provide long, narrow passages 57.

It is contemplated by the present invention that the impeller 40 would receive a gas-liquid mixture from an inlet passage similar to the inlet passage 41 in the pump 10 of FIGURE 1. Thus, the mixture would flow radially outwardly in the vane system, the purpose of the vane system being to compress the mixture and deliver it steadily to the discharge scroll 42 in liquid (by sight) form.

It will be appreciated that each of the vanes 50, 53, 58 and 61 have high pressure outer surfaces 64 and low pressure inner surfaces 66 which generally tend to cause the gas to migrate toward the low pressure inner surfaces 66 and the liquid towards the high pressure outer surfaces 64.

In accordance with the present invention, such phase separation is minimized by arranging the vanes in a special manner, thereby preventing the impeller from becoming vapor bound.

The vanes 50, 53, 58 and 61 embody considerable wrap to minimize the pressure difference across the vanes and thereby prevent phase separation. Further, in accordance with the present invention, each of the vanes is interrupted by a slotted passageway which can be conveniently formed by a slotting operation such as cutting the vanes with a milling cutter and as illustrated in FIGURE 5.

The slotting location is indicated in dashed lines at 70 and it will be noted the line 70 is essentially circular and is spaced concentrically with respect to the axis of the impeller radially outwardly of the inner ends of the vanes but radially inwardly of the outer ends of the vanes. Thus, the blade 50 is formed with a slotted passage 50a, the blade 53 is formed with a slotted passage 53a, the blade 58 is formed with a slotted passage 58a and the blade 61 is formed with a slotted passage 61a. All of the passageways 50a, 53a, 58a and 61a are disposed on the same concentric circular path.

The functional action of the slots is indicated in the diagrammatic illustration of FIGURE 5. Thus, the slotted passageways admit jets of pressurized liquid from the high pressure sides of the passages 57 so that the liquid passes to the low pressure sides of the adjacent

passages to accelerate the gas and to keep it well mixed with the liquid. Accordingly, the gas flows actively along with the liquid and discharges steadily from the pump. The vane arrangement thus provided accelerates and mixes the gas and liquid so that the resulting mixture can be effectively pumped.

The impeller of the present invention is further characterized by having formed on the back face 49 additional pumping means having the effect of moving fluid radially outwardly, thereby keeping the back face 49 at low pressure and providing an axial balancing means.

In this particular embodiment, a plurality of circumferentially spaced radially outwardly extending ribs 71 are provided, thereby forming between the ribs 71 radial pumping passages 72. A wall 73 taking the form of an annular disk-shaped portion overlies the ribs 71 in spaced relation to the back face 49 and has an outer peripheral lip 74 which projects radially outwardly of the outer edge or margin 49 of the front face 48. Thus, when the impeller 40 is rotated, fluid will be pumped radially outwardly through the pumping passages 72 and the back face 49 will be maintained at reduced pressure.

Although minor modifications might be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. A centrifugal impeller having a hub establishing an axis of rotation and a radial front face, a vane system on said front face comprising plural circumferentially spaced spirally wrapped vanes, alternate first vanes starting radially inwardly and extending radially outwardly through a spiral wrap of substantially 360°, alternate second vanes starting radially inwardly and extending radially outwardly through a spiral wrap of more than 180° but less than 360°, thereby to form long, narrow passages.
2. A centrifugal impeller as defined in claim 1 and further characterized by each of said vanes being intermediately slotted to form at least one passageway to accelerate and mix gas and liquid so that the mixture can be pumped.
3. A centrifugal impeller as defined in claim 2 and further characterized by all of said passageways being disposed on common concentric circular paths.
4. A centrifugal impeller as defined in claim 3 and further characterized by said impeller having a back face having vanes formed thereon to pump liquid radially outwardly in keeping the back face at a reduced pressure.
5. A centrifugal impeller comprising a vane system having plural vanes, each vane having an inner end, and an outer end spaced radially outwardly of said inner end, and an intermediate portion extending through a helical path between said ends, said vanes having high pressure outer surfaces and low pressure inner surfaces, said vanes including alternate long vanes having a wrap of at least 360° and shorter intermediate vanes so that the vanes together with one another form long narrow pumping passages having low blade angles, whereby gas tends to migrate towards said inner surfaces and liquids towards said outer surfaces, and a groove disposed on a circular path concentric to the impeller axis interrupting said intermediate portions of said vanes to form plural passages which direct accelerating streams of liquid from said high pressure outer surfaces to the low pressure side of the adjacent passages to accelerate and mix liquid and gas and pump the mixture steadily.

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6. A centrifugal pump impeller having a hub disposed on an axis of rotation, a radial face on said hub, short vane means on said face disposed to wrap around said axis in a spiral path and extending through at least 180°, and long vane means on said face alternating with said short vane means and extending through a wrap of at least 360°, said alternating short and long vane means forming low blade angles and long narrow passages, thereby providing stable cavitating operation over a wide range of flow rates, each vane of said vane means having outer high pressure surfaces and inner low pressure surfaces which tend to cause gas to migrate towards the low pressure surfaces and liquid towards the high pressure surfaces, and means to minimize phase separation comprising a slotted groove interrupting said vane means and disposed on a circular path concentrically disposed with respect to said axis to form plural passages through which jets of pressurized liquid are admitted from the high pressure side of said passages into the low the pressure side of the adjoining passages, thereby accelerating and mixing liquid and gas so that the gas flows actively along with the liquid.

7. A centrifugal impeller comprising a hub disposed on the impeller axis, a disc shaped body having flat parallel front and back faces extending radially outwardly of said hub, a vane system on the front face to compress a gas-liquid mixture and having plural vanes, each vane having an inner end, and an outer end spaced radially outwardly of said inner end, and an intermediate portion extending through a helical path between said ends, said vanes including alternating long vanes and short vanes, the long vanes extending through a wrap of at

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least 360° and the shorter vanes alternating therewith and forming together with the long vanes long narrow pumping passages having low blade angles, and means forming straight radial vanes on the back face to keep said back face at a reduced pressure, said means comprising plural circumferentially spaced ribs extending radially and a wall overlying said ribs and spaced from said back face, thereby forming pumping passages between the ribs to move fluid radially outwardly and provide an axial balancing means on said back face of said impeller.

8. A centrifugal impeller as defined in claim 1 and further characterized by a single circular slot intersecting each said vane intermediate its ends to form at least one passageway interrupting each vane to direct jets of liquid from the high pressure side of the vanes to the low pressure sides of the adjacent passage, thereby to accelerate and mix gas and liquid so that the mixture can be pumped.

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DONLEY J. STOCKING, *Primary Examiner.*

HENRY F. RADUAZO, KARL J. ALBRECHT,

Examiners.