

April 14, 1970

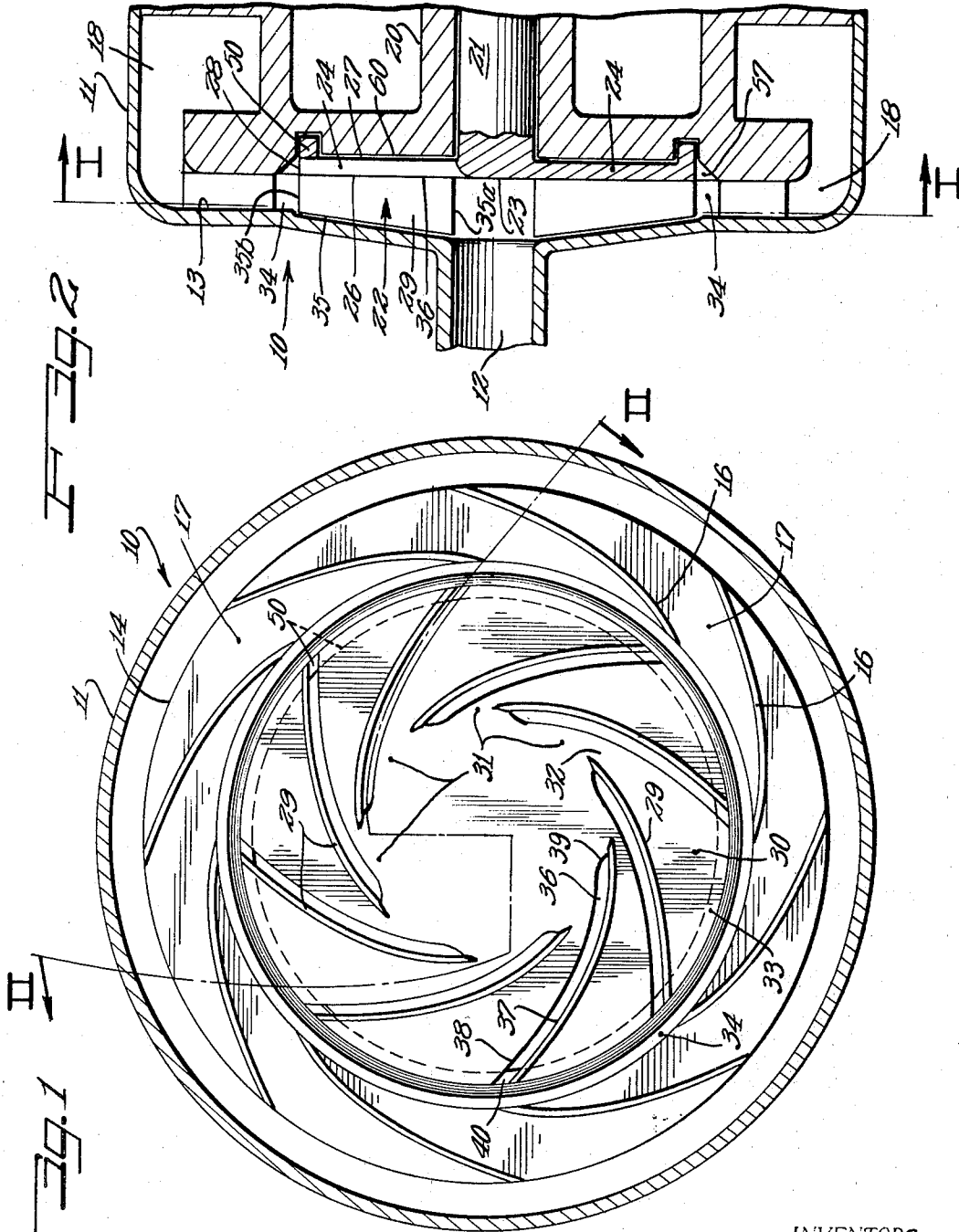
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HYDRODYNAMICALLY BALANCED CENTRIFUGAL IMPELLER

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2 Sheets-Sheet 1



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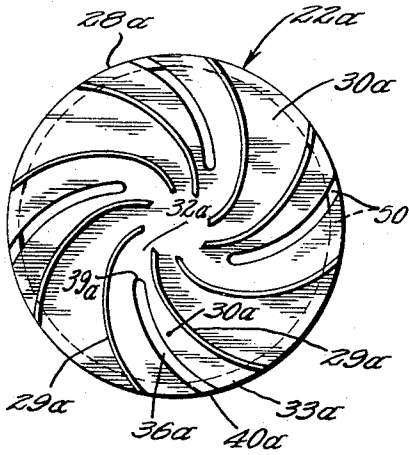
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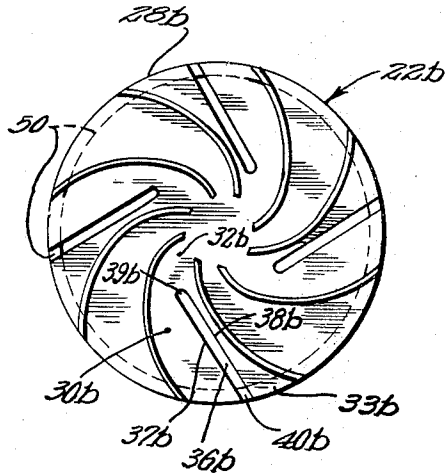
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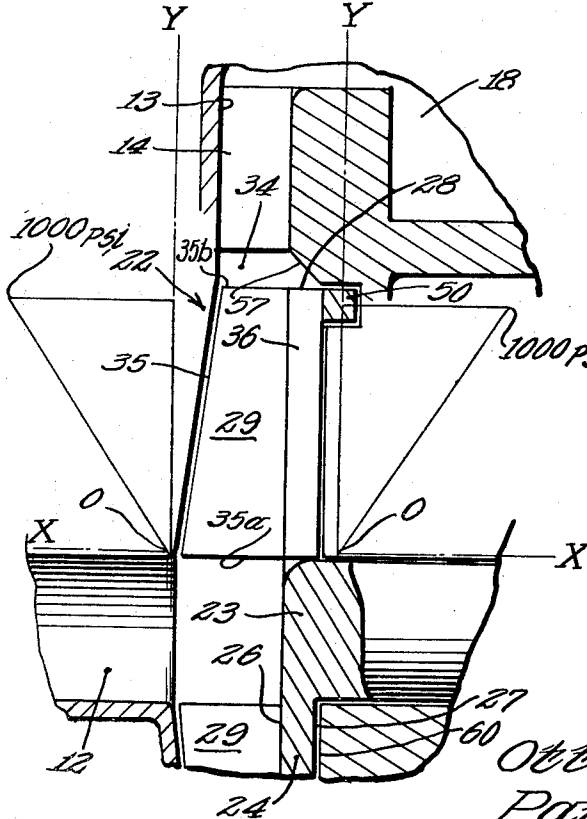
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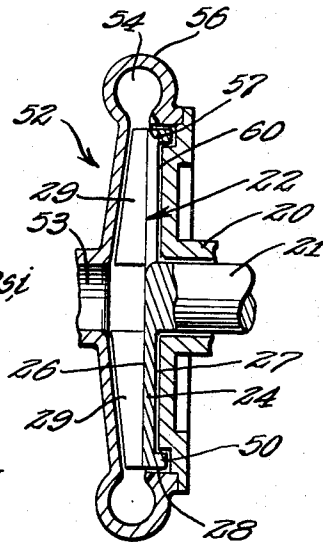
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F 39.6



F 39.5



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3,506,373  
**HYDRODYNAMICALLY BALANCED  
 CENTRIFUGAL IMPELLER**

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9 Claims

**ABSTRACT OF THE DISCLOSURE**

A rotatable centrifugal impeller having hydrodynamic balancing means in the form of slots formed in the impeller disc and opening out of the outer peripheral wall of the disc to act as a portion of the radial impeller pumping channels.

**BACKGROUND OF THE INVENTION**

Field of the invention

This invention relates generally to centrifugal pumps and centrifugal impeller configurations.

Description of the prior art

U.S. Patent No. 1,844,213 discloses a fan for a vacuum cleaner wherein grooves are located on a rear face of the impeller. Holes in the grooves extend to the front face of the impeller. Such structure promotes a recirculation rather than a pumping action.

**SUMMARY OF THE INVENTION**

The present invention utilizes a slot cut in the impeller disc between the blades and functioning as a pumping slot because it opens outwardly through the outermost peripheral wall of the disc extending between the front and rear faces of the disc.

Thus, pressure distribution is uniform since fluid from the center inlet goes to both sides of the disc. The slots do not operate as independent pumps. Rather, each slot operates in conjunction with the corresponding impeller pumping channel formed on one face of the impeller between a corresponding pair of blades. By means of such provision, a hydrodynamic pressure balance is achieved on opposite sides of the impeller.

A tie ring on the rear face of the disc reduces bending stress and keeps the pumping blades from tearing off near the inner area adjacent the hub.

**DESCRIPTION OF THE DRAWINGS**

FIGURE 1 is a cross-sectional view taken on line I—I of FIGURE 2;

FIGURE 2 is a cross-sectional view taken on line II—II of FIGURE 1;

FIGURES 3 and 4 are views of the front impeller face similar to FIGURE 1, but showing alternative slotting arrangements in accordance with this invention;

FIGURE 5 is a view similar to FIGURE 2, but showing the invention in a pump without a diffuser ring and wherein the pumping channels discharge into a volute; and

FIGURE 6 is a somewhat schematic view showing a pressure chart superimposed on the structure to demonstrate the pressure balance achieved by the present invention.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

The impeller of the present invention is shown located in a pump indicated generally at 10 and having a casing

11 formed with a center inlet 12. Radially outwardly of the impeller, the casing is provided with an annular passage 13 in which is located a diffuser ring 14 having a circumferential row of diffuser vanes 16 spaced with respect to one another to form a plurality of diffuser channels 17. Thus, the diffuser ring 14 directs fluid radially outwardly into a collection chamber 18 from which the fluid may be directed to a point of utilization or to further pumping stages as may be required.

The casing 11 has an internal boss structure 20 providing bearing means for rotatably supporting a shaft 21. In accordance with the principles of the present invention, there is situated on the end of the shaft 21 in corotatable connection therewith an impeller shown generally at 22 and comprising a center hub portion 23. The impeller further comprises a generally flat disc 24 having a front face 26 and a rear face 27. The faces 26 and 27 are generally parallel to one another and extend radially outwardly from the hub portion 23 terminating in an outer peripheral wall shown at 28.

In order to form pumping channels, the front face 26 is particularly characterized by the provision of a plurality of curved pumping blades projecting axially from the front face 26 and shown generally at 29. Thus, between each adjoining pair of pumping blades 29, there is formed a pumping channel 30. All of the respective inlet areas for the circumferential row of pumping channels 30 are disposed in a circular disposition as indicated at 31 and which location is generally axially adjacent the center inlet opening 12. Each pumping passage has a narrow throat 32 and the confines of the pumping passage prescribed by the adjoining pumping blades 29, 29 then diverges outwardly to a discharge area 33 adjacent the outer peripheral wall 28 of the impeller disc 24.

An annular space 34 is situated between the outer portion of the pumping blades 29 and the diffuser ring 14.

As will be noted on FIGURE 2, the pumping blades 29 have a tapered edge 35 so that each respective blade has its greatest axial dimension as at 35a adjacent the inlet area and its smallest dimension at 35b adjacent the discharge area 33.

In accordance with the principles of the present invention, it is contemplated that there be provided balancing means between the blades comprising slots formed in the impeller disc 24 and extending radially and axially to open through both the front face 26 of the disc 24 and the rear face 27 of the disc 24 as well as through the peripheral wall 28 of the disc 24. Such slots act as portions of the impeller flow channels to hydrodynamically balance the impeller.

In the form of the invention illustrated in FIGURES 1 and 2, the slots are formed directly adjacent each corresponding pumping blade 29 and the slots are conformably shaped with respect thereto to follow the contour of the blade. Thus, it will be noted there is a slot 36 having one wall 37 which, in effect, constitutes an extension of a corresponding side wall of the pumping blade 29. A second wall of the slot 36 is shown at 38. It will be noted that the slot 36 corresponds generally in overall length and conformation to the adjacent blade 29, the innermost end of each slot 36 being shown at 39 adjacent the innermost end of the corresponding blade 29. The outermost end of each slot 36 has a discharge opening 40 extending through the peripheral wall 28 of the impeller disc 24.

In the form of the invention shown in FIGURE 3, the balancing means takes the form of a slot 36a disposed between the pumping blades 29a but not contiguously adjacent either of each corresponding set of blades 29a, 29a. Thus, it will be noted that each slot 36a, while being curved and in general conformable configuration relative

to the corresponding blades 29a is spaced intermediate both blades of a pair of blades 29a, 29a.

The innermost end of the slot 36a is shown at 39a and is spaced outwardly of the narrow throat portion 32a of the pumping channel. The outermost portion forming the outlet 40a of the slot 36a is disposed at an intermediate part of the outlet portion 33a of the pumping channel shown at 30a.

In the form of the invention shown in FIGURE 4, the balancing means takes the form of a slot disposed between the blades but rather than being conformably shaped to the configuration of the blades, the slot has straight side walls. Thus, in FIGURE 4, the balancing means consists of a slot shown at 36b having straight side walls 37b and 38b. Again, the innermost end of the slot shown at 39b is spaced radially outwardly of the narrow throat portion 32b of the pumping channel designated in FIGURE 4 at 30b. The outlet portion of the slot shown at 40b is disposed intermediate the outlet portion 33b of the pumping channel.

With the slotted construction provided by the utilization of balancing means, it is contemplated further by the present invention to reduce bending stress by locating a tie ring which extends circumferentially continuously around the outermost edges of the impeller disc 24. Such tie ring can be advantageously provided by an integral ring portion 50 which projects axially from the rear face 27 of the disc 24 and adjacent the outermost peripheral portion of the disc 24. The tie ring 50 keeps the pumping blades 29 from tearing off near the inner areas adjacent the hub 23.

It will be readily apparent that the present invention can also be used in pump constructions other than the arrangement shown in FIGURE 2 wherein the diffuser ring 14 is provided in the outlet. To demonstrate such applicability, FIGURE 5 shows the impeller of the present invention located in a pump 52 having a center inlet 53 and having a volute chamber 54 formed by a volute casing 56 outwardly adjacent the outermost portions of the pumping channels in the impeller shown generally at 22.

As is clearly shown in both forms of the invention in FIGURE 2 and in FIGURE 5, because the slots 36 open outwardly through the peripheral wall 28, the casing is recessed peripherally adjacent thereto as at 57. It should also be noted that close running clearances are maintained between the rear wall 27 of the impeller disc and a radial wall 60 formed on the casing 11 of the respective pump structures 10 and 52. Thus, the fluid from the center inlet 12 or 53 goes to both the front and rear sides of the impeller disc 24 and effective hydrodynamic balance is achieved on both sides of the impeller because the slot 39 does not operate as an independent pump, but acts as a portion of the impeller flow channels or pumping channels 30.

The close running clearance allows the impeller internal pressure distribution to impose itself asymmetrically on the exterior of the disc, thus insuring an axial balance of the impeller, except for the lightly loaded area taken up by the shaft cross-section. The advantages of pressure distribution are illustrated graphically in FIGURE 6 where there is imposed a graph showing the pressure distribution in the application of the pump of the present invention to a typical fuel pump, for example, the afterburner pump of a jet aircraft wherein 1000 p.s.i. must be developed. As shown in FIGURE 6, there is an X coordinate and a Y coordinate illustrated on respectively opposite sides of the impeller 22 and the pressure distribution on the opposite sides of the impeller increases in a straight line relationship from zero value at or near the center inlet to a value of 1000 p.s.i. near the outer peripheral wall 28 of the impeller.

There is thus provided an improved means for hydrodynamically balancing a centrifugal impeller.

Although minor modifications might be suggested by those versed in the art, it should be understood that we

wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. In a pump, a rotatable centrifugal impeller comprising:

a hub and a generally disc shaped portion having a front face and a rear face disposed on spaced parallel radial planes,

an annular peripheral wall extending between said two faces at the outermost extremities of said disc portion, a plurality of curved pumping blades projecting axially from said front face and disposed to extend from an inwardly located inlet zone radially outwardly to open outwardly adjacent said peripheral wall,

thereby to form impeller flow channels for pumping fluid from said inlet zone to an outlet zone outwardly of said impeller,

and balancing means between said blades comprising: slots formed in said disc shaped portion and having spaced substantially parallel walls extending radially and axially to open through both of said front and rear faces and having a discharge opening extending through said peripheral wall,

a casing for said pump having a pumping chamber in which said impeller rotates, said casing having a wall with a recess peripherally overlying said discharge openings of said slots to receive the fluid discharged thereby,

whereby said slots act as portions of the impeller flow channels to hydrodynamically balance the impeller.

2. In a pump as defined in claim 1 wherein said balancing means comprises:

each said slot formed directly adjacent each corresponding pumping blade and being conformably shaped with respect thereto to follow the contour of the blade.

3. In a pump as defined in claim 1 wherein said balancing means comprises:

each said slot formed in each corresponding pair of adjoining pumping blades and having the walls of said slot spaced circumferentially from each corresponding blade.

4. In a pump as defined in claim 3 wherein each said slot constitutes a groove having straight radially outwardly extending walls opening out of said peripheral wall between a corresponding pair of blades.

5. In a pump as defined in claim 3 wherein each said slot constitutes a groove spaced circumferentially from each corresponding adjoining pumping blade but being conformably curved in the same configuration shape as said blades to follow the contour of the blades.

6. In a pump as defined in claim 1 and being further characterized by said disc portion having a tie ring extending circumferentially continuously around the outermost edges thereof to reduce bending stress and projecting from said rear wall of said disc portion.

7. In a pump as defined in claim 6 wherein each said slot has walls spaced apart from one another by a spacing dimension less than the axial extent of the curved pumping blades.

8. A pump comprising:

a casing having a center inlet,

a ring of diffuser vanes in said casing outwardly of said center inlet,

means forming a collection chamber and a passage from said collection chamber comprising an annular recess surrounding said diffuser ring,

and a rotatable centrifugal impeller inwardly of said diffuser ring for impelling fluid from said center inlet and comprising,

an impeller disc having a bladed front face confronting said center inlet and forming a plurality of impeller pumping channels for pumping fluid from said center inlet to said ring of diffuser vanes,

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and balancing means comprising slots formed in said disc between the said front face and the rear face of said disc,

each said slot opening through the outermost peripheral wall of said disc adjacent said ring of diffuser vanes,

thereby to act as a portion of a corresponding impeller pumping channel and operating to hydrodynamically balance the impeller.

9. A pump as defined in claim 8 and further characterized by said disc portion having a tie ring extending circumferentially continuously around the outermost edges thereof to reduce bending stress.

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