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(54) **Reversible centrifugal pump with identical hydraulic performance either way.**

(57) A reversible enclosed cast centrifugal impeller containing radial impeller vanes shaped with a gradual change in the vane angle on both identical working sides for identical hydraulic performance in either direction is provided in a centrifugal pump. Fluid flow enters into the impeller eye and careful rounding of the inlet edges to an airfoil shape, combined with a small vane thickness reduces cavitation. A fully concentric case gives symmetrical uniform flow areas between the vanes and an exit flow splitter directing the flow through the impeller into the concentric case, thereby eliminating flow separation at the impeller exit and controlling required exit area. Axial thrust balancing holes are used to reduce the pressure area behind the back shroud. The splitter angle is the same as the absolute exit angle of the fluid leaving the impeller to avoid shock losses.

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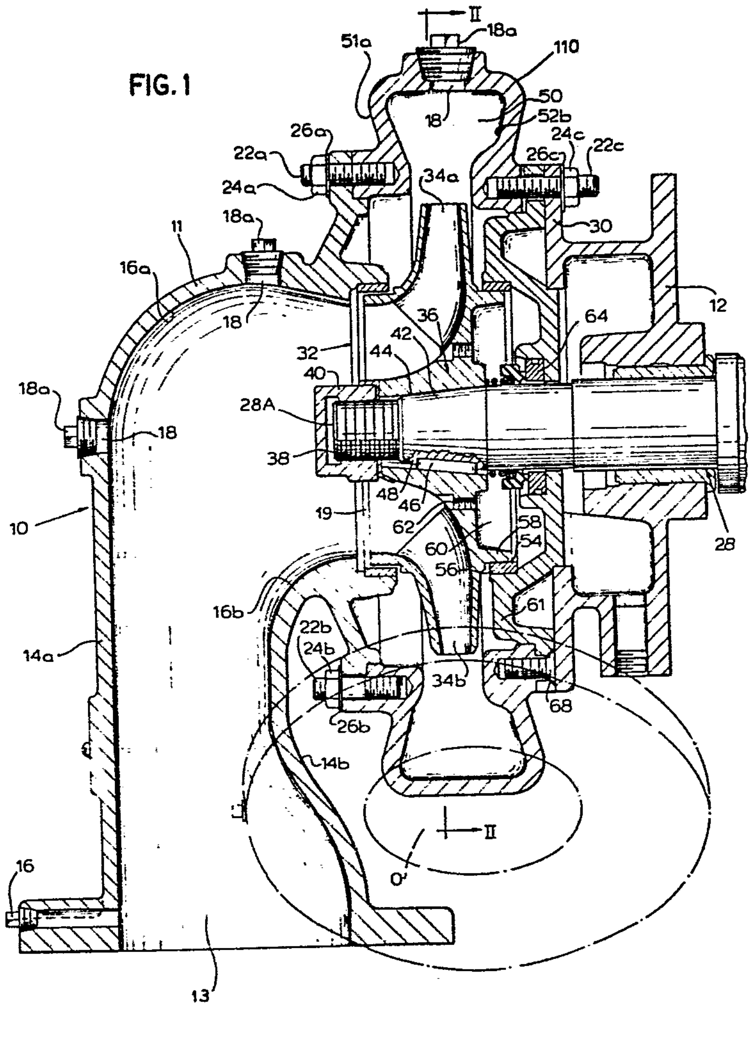
FIG. 1



II
18a
51a
110
18
50
52b
26a
24c
22a
26c
22c
34a
24a
30
18a
11
16a
12
18
36
42
64
32
44
40
28A
18a
18
38
48
46
19
62
58
10
60
54
28
56
16b
61
22b
24b
14a
34b
68
26b
14b
II
0'
16
13

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DESCRIPTION

"REVERSIBLE CENTRIFUGAL PUMP WITH IDENTICAL HYDRAULIC PERFORMANCE EITHER WAY"

The invention relates to a reversible centrifugal pump and more particularly to an improved reversible centrifugal pump wherein the centrifugal impeller contains radially shaped impeller vanes with gradually changing vane angles on both identical working sides so as to provide identical hydraulic performance in either rotational direction.

Heretofore, reversible centrifugal pumps have been incapable of providing identical hydraulic performance and efficiency in either rotational direction. Varible shaped impeller vanes have resulted in uneven flow characteristics through the pump as well as markedly different pressure.

In addition, severe cavitation problems occur within the pump itself when sudden changes and directional flow occur. Such cavitation, which results in a vacuum being formed around the impeller blades, compounds the problems of decreasing hydraulic performance and efficiency.

In accordance with the principles of the present invention, a centrifugal pump is provided which is particularly characterized by a fully concentric case designed to afford uniform flow areas between the vanes and an exit flow splitter directing the flow through the impeller into the concentric case, thereby to eliminate flow separation at the impeller exit and controlling required exit area.

The pump is also characterized by a reversible enclosed cast centrifugal impeller containing radial impeller vanes shaped with a gradual change in the vane angle on both identical working sides for identical hydraulic performance in either rotational direction.

Fluid flow enters into the impeller eye and careful rounding of the inlet edges to an airfoil shape, combined with a small vane thickness reduces cavitation.

A shroud is located in the casing behind the impeller on the side opposite the inlet of the impeller. Axial thrust balancing passages extending through the impeller are used to reduce the pressure area behind the back shroud.

The splitter angle is made the same as the absolute exit angle of the fluid leaving the impeller, thereby to avoid shock losses.

ON THE DRAWINGS

Fig. 1 is a cross-sectional view of the pump assembly incorporating the principles of the present invention;

Fig. 2 is a cross-sectional view taken along lines II-II of Fig. 1;

Fig. 3 is a fragmentary cross-sectional view taken along lines III-III of Fig. 2; and

Fig. 4 is an enlarged fragmentary sectional view illustrating additional details of the exit path provided in the pump of Fig. 1.

Fig. 1 shows a sectional view of a pump generally at 10 having a casing construction which includes a suction piece 11, a pumping chamber piece 110, and a rotating shaft mounting piece 12. The suction piece 11 is shown in the form of an elbow and contains an inlet passage 13 which is formed by walls 14a, 14b having curved portions 16a, 16b which act to gradually change the direction of inlet flow and thereby reduce the cavitation effect, and which is in communication with a supply of fluid. If desired, the pump 10 may be provided with a plurality of openings 18 for measuring pressure and fluid flow and for removing entrapped air pockets and which are closed by plugs 18a. It will be understood that the suction piece 11 may take the form of a straight tubular configuration extending axially relative to the pumping chamber piece 110.

The pumping chamber piece 110, in which is formed a volute pumping chamber communicates with the inlet passage 13, via an inlet eye 19 and is secured to walls 14a, 14b by means of a plurality of fastening studs as exemplified in fastening studs 22a, 22b. A corresponding plurality of nuts 24a, 24b secure washers 26a, 26b to side walls 14a, 14b so as to provide a tight sealing arrangement.

The rotating shaft mounting piece 12 has a mounting flange 30 which is secured to the pumping chamber piece 110 by means of a plurality of studs as exemplified by fastening stud 22c. A nut 24c for each stud 22c affixes a washer 26c in a tight sealing arrangement to the mounting flange 30.

A reversible impeller 32, having a plurality of impeller vanes or pumping vanes 34a, 34b which are spaced circumferentially and extend radially, and a hub

36, are fastened to a threaded end portion 38 of a drive shaft 28 by means of a securing nut 40. In order to provide one means of contact between the drive shaft 28 and the impeller 32, a tapered median section 42 of the drive shaft 28, adjacent a threaded end portion 38, is inserted into a correspondingly tapered receiving opening 44 on hub 36 in a tight fitting relationship. A plurality of key elements 46, protruding from the hub 36, are inserted into a corresponding plurality of receiving slots 48 located on the drive shaft 28 so as to provide the primary means for contact between the drive shaft 28, which is capable of rotating in a clockwise or counterclockwise motion, and the impeller 32. The drive shaft 28 is engaged by means of a power source, and the contact between the drive shaft 28 and the impeller assembly 32 is provided by a plurality of key elements 46 as well as the tapered end section 42 which enable the impeller assembly 32 to be rotated simultaneously with the drive shaft 28.

The rotational motion of the impeller 32 acts to draw water through the inlet passage 13 into a receiving chamber 50 of the casing portion 11. The receiving chamber 50 has symmetrical walls 52a, 52b which act to provide an evenly distributed radial load regardless of the rotational direction of the impeller assembly 32. A very small clearance area 54 is provided for between a case ring 56 and an impeller flange 58 so as to enable the impeller assembly 32 to rotate freely while preventing large amounts of water from entering a cavity or a pocket portion 60.

The rotational motion of the impeller 32 creates a substantial pressure differential between the relatively high pressure maintained in the receiving chamber 50 as compared to the relatively low pressure maintained in the inlet passage 13. The pressure differential caused by the rotational motion of the impeller 32 tends to load the drive shaft 28 along its axis toward the inlet passage 13 resulting in increased force being applied against the drive shaft 28 by a back shroud 61. In order to reduce this effect caused by the pressure differential, a plurality of threaded axial thrust balancing passageways exemplified by threaded passageway 62 extend completely through the impeller 32 from the inlet side of the back side. The threaded passageway 62 also serves to prevent the build up of fluid within the pocket portion 60 by providing means for passing fluid under high pressure in pocket portion 60 into the inlet passage 13. When the pump is started, the operator may bleed off entrapped air pockets by selectively opening one or more of the plugs 18a.

A seal assembly 64 is positioned around the circumference of the drive shaft 28 so as to prevent the loss of any fluid along the outer surface of the drive shaft 28. The seal assembly 64 is affixed to the back shroud 61 which in turn is mounted to the pumping chamber piece 110 by means of a plurality of securing means such as a flat head screw 68. The insertion of the tapered end section 42 of drive shaft 28 into the corresponding receiving opening 44 of impeller hub 36 insures a snug fit of the parts.

In order to facilitate the selective separation of the pump assembly parts, the suction piece 11 is first removed, thereby exposing the impeller nut 40. When the impeller nut 40 is removed an impeller pulling means (not shown) may be employed which engages against an end face 28A on the end of the shaft 28. The impeller pulling means may be of the type wherein threaded rods are adapted to engage the threaded passageways 62.

As shown in Fig. 2, the casing portion 11 is fully symmetrical about a horizontal axis or plane 69a and a vertical axis or plane 69b, both of which axes or planes are shown in Fig. 2 in dashed lines and designated by the corresponding reference numerals 69a and 69b. The reversible impeller 32 consists of a plurality of circumferentially spread radially extending pumping vanes 34 mounted to the hub 36. Each of the impellers is formed with a carefully rounded inlet edge 70 so as to describe an air foil shape. The thickness of each vane 34 is relatively narrow so that the dimensional extent is shown at 70a. It will be noted that the rounded inlet edges 70 provide a gradual change in the vane angle and each side of each vane, shown as 70b and 70c, respectively, form identical working sides. The air foil shape terminates in a trailing edge 70d at the outer periphery of the impeller. By virtue of the rounded inlet edges 70, the air foil shape and the relatively small vane thickness 70a, it will be apparent that cavitation will be substantially reduced. There should be a sufficient number of vanes 34 so as to provide good guidance to the fluid passing through the impeller and to keep the fluid pressure on each individual vane 34 relatively low.

Symmetrically positioned between the vanes 34 are a corresponding plurality of exit flow splitters 71. Uniform flow areas 72, formed by vanes 34 and exit flow splitters 71, direct the flow of fluid through the impeller 32 into the concentric casing portion 11. By virtue of such arrangement, flow separation at the impeller exit is eliminated and the required exit area is controlled.

A pumping chamber 74, formed within the pumping chamber piece 110 and centrally disposed on the axes or planes 69a, 69b, is bounded in part by a wall surface 76 formed by one side of a dual flow splitter shown generally at 78 and which dual flow splitter 78 is triangular in cross-sectional configuration.

The dual flow splitter 78 has side wall surfaces 80 and 82 which intersect the wall surface 76 and extend downwardly, using the orientation of Fig. 2, to a common apex 84 located on the vertical plane 69b. The positioning of the dual flow splitter 78 directs the flow into the throats 90 and 92 regardless of the rotational direction of the impeller 32.

The surface 80 of the dual flow splitter 78 is spaced from an adjoining wall of the casing portion 11, as shown at 86, and the surface 82 of the dual flow splitter 78 is likewise spaced from an adjoining wall of the casing 11, as shown at 88, thereby to form a pair of throats 90 and 92 symmetrically disposed on opposite sides of the vertical plane 69b.

The throats 90 and 92 merge into a common discharge opening 94 extending through a discharge flange 96. In order to avoid shock losses resulting from the impact of fluid exiting the impeller 32 and striking the wall 52 of the casing portion 11, the angle formed by the dual flow splitter 78 is generally the same as the absolute exit angle of the fluid leaving the impeller 32. The ratio of the relative flow area between the impeller vanes 34 and the throat portions 90 and 92 control the head, quantity and power characteristics of a particular pump.

As shown in Fig. 3, a pair of recessed portions 98a, 98b, located in the dual flow splitter 78 are separated by means of a divider section 100.

Fig. 4 illustrates the means used to reduce the shock losses resulting from the force of the fluid exiting the impeller 32 and striking wall 86. The symmetrically shaped dual flow divider 78 is positioned in such a manner so as to form an angle with throat area 90 which is the same as the absolute exit angle of the fluid leaving the impeller 32.

Although various modifications might be suggested by those skilled 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 my contribution to the art.

CLAIMS:

1. In a centrifugal pump, a reversible impeller having radial vanes with inlet edges rounded to an airfoil shape and having an identical symmetrically disposed gradually changing vane angle on both sides for identical hydraulic performance when rotated in either direction.

2. A centrifugal pump comprising; a casing having a fully concentric configuration, a reversible impeller in said casing having radial vanes with inlet edges rounded to an airfoil shape, said impeller having identical symmetrically disposed gradually changing vane angles on both sides for identical hydraulic performance when rotated in said casing in either direction, an exit flow splitter directing the flow through the impeller into the concentric casing, said splitter and said impeller together forming uniform flow areas between the vanes and the splitter to eliminate flow separation at the impeller exit.

3. A centrifugal pump as defined in claim 2 and further characterized by said splitter being generally triangular in cross-section and forming a splitter angle which is the same as to absolute exit angle of the fluid leaving the impeller, thereby to avoid shock losses.

4. A centrifugal pump comprising a casing having a fully concentric configuration, a reversible impeller in said casing having inlet edges rounded to an airfoil shape and with an identical symmetrically disposed gradually changing vane angle on both sides, an exit flow splitter directing the flow through the impeller

into the concentric casing, a back shroud in said casing adjacent said impeller on the side opposite said inlet, and means forming axial thrust balancing passages extending through said impeller to reduce the pressure area behind the back shroud, said impeller being selectively rotatable in either direction for identical hydraulic performance in either direction.

5. A reversible enclosed centrifugal pump assembly comprising: a pump housing; an inlet passage formed within said pump housing and in communication with some source of fluid; a casing portion within said pump housing and in communication with said inlet passage; an impeller assembly comprising a plurality of impeller vanes, a corresponding plurality of exit flow splitters, and an impeller hub, affixed to said casing portion and positioned so as to displace fluid at increased pressure in a generally even distribution throughout said casing portion; a rotating shaft mounting assembly comprising a drive shaft assembly connected to a power source and affixed to said impeller hub in such a manner so that a rotational motion induced in said drive shaft by said power source will produce a simultaneous synchronized rotational motion in said impeller assembly; a dual flow splitter formed as part of the internal structure of said pump housing and positioned so as to direct the flow into the throats along the walls of said casing portion resulting from the fluid exiting the impeller assembly; and an outlet passage for conducting the fluid to a point of utilization.

6. A reversible enclosed centrifugal pump assembly comprising: a pump housing; an inlet passage formed within said pump housing and in communication with some source of fluid and having walls with curved portions so as to reduce the cavitational effect; a casing portion within said pump housing in communication with said inlet passage and having a generally symmetrically shaped configuration so as to provide even fluid flow characteristics; an impeller assembly comprising a plurality of impeller vanes having a generally symmetrical air foil configuration, a corresponding plurality of alternating individual exit flow splitters adjacent each of said impeller vanes and forming uniform impeller exit flow areas, and an impeller hub, and positioned so as to displace fluid drawn through said inlet passage under increased pressure in a generally even distribution throughout said casing portion; a rotating shaft mounting assembly comprising a drive shaft assembly connected to a power source and affixed to said impeller hub in such a manner so that a rotational motion induced in said drive shaft by said power source will produce a simultaneous synchronized rotational motion in said impeller assembly; a dual flow splitter of generally symmetrical design formed as part of the internal structure of said pump housing and positioned so as to direct the flow into the throats along the walls of said case portion resulting from the fluid exiting the impeller assembly; a plurality of passageways formed in said impeller hub and providing communication between pocket portions formed by the rotational motion of said

impeller assembly and said inlet passage so as to relieve pressure build up occurring within said pocket portions as well as providing a means whereby fluid collected under higher pressure within said pocket portions during the rotational motion of said impeller assembly may be returned to said inlet passageway; and an outlet passage for conducting the fluid to a point of utilization.

7. The reversible enclosed centrifugal pump assembly of claim 6 in which said casing portion is affixed to said walls of said inlet passage by means of a plurality of studs.

8. The reversible enclosed centrifugal pump assembly of claim 6 in which said drive shaft assembly is affixed to said casing portion by means of a plurality of studs.

9. The reversible enclosed centrifugal pump assembly of claim 6 in which the angle formed by said dual flow divider and said walls of said inlet passage is generally the same as the exit angle of the fluid leaving said impeller assembly.

10. The reversible enclosed centrifugal pump assembly of claim 6 in which the rotational motion of said drive assembly produces a corresponding simultaneous rotational motion in said impeller assembly by means of a plurality of key inserts.

11. The reversible enclosed centrifugal pump assembly of claim 6 in which impeller pulling means may be inserted into said passageways so as to assist in the disassembly and removal of said drive shaft.

12. The reversible enclosed centrifugal pump assembly of claim 6 in which said passageways are threaded.

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FIG. 1

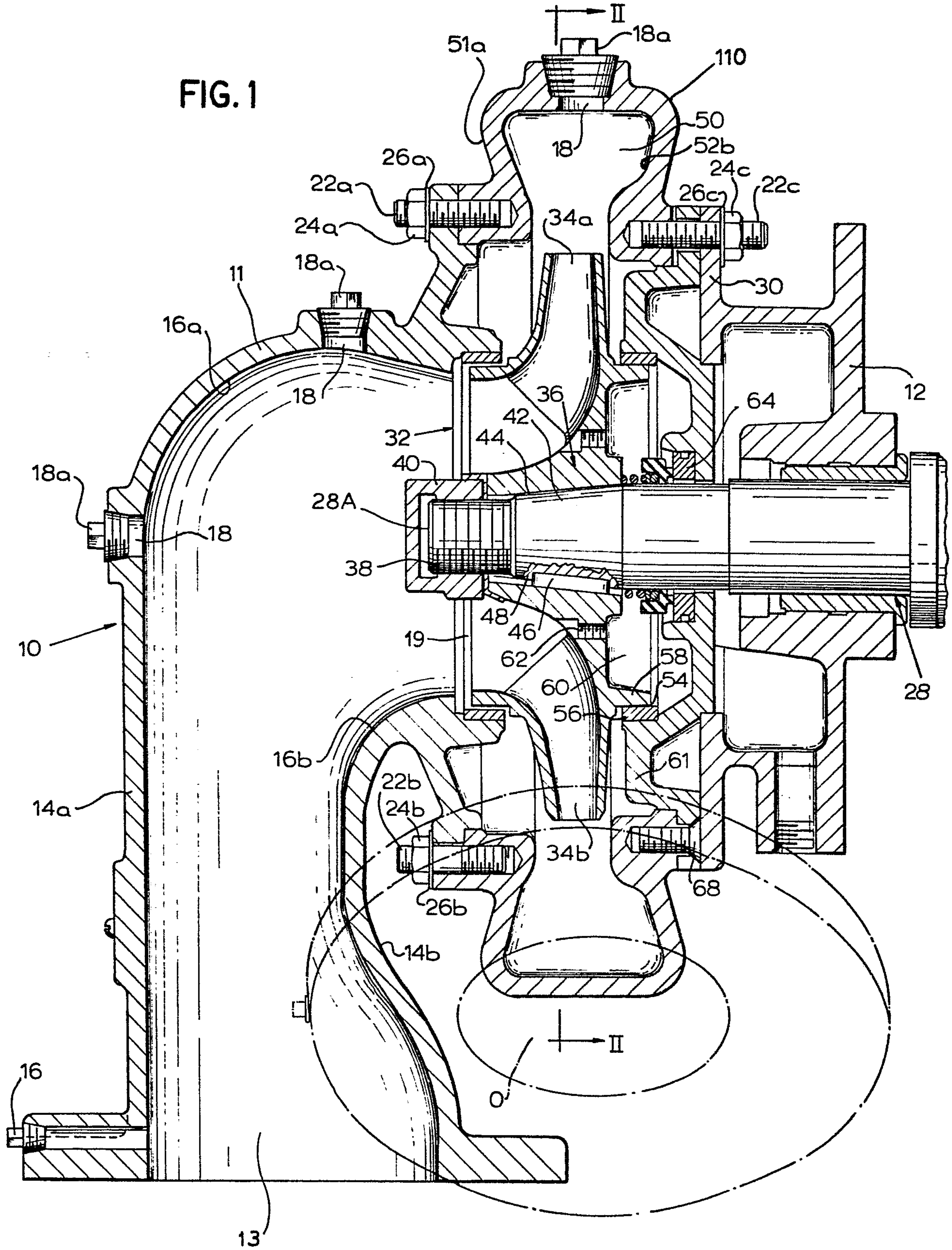

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FIG. 2

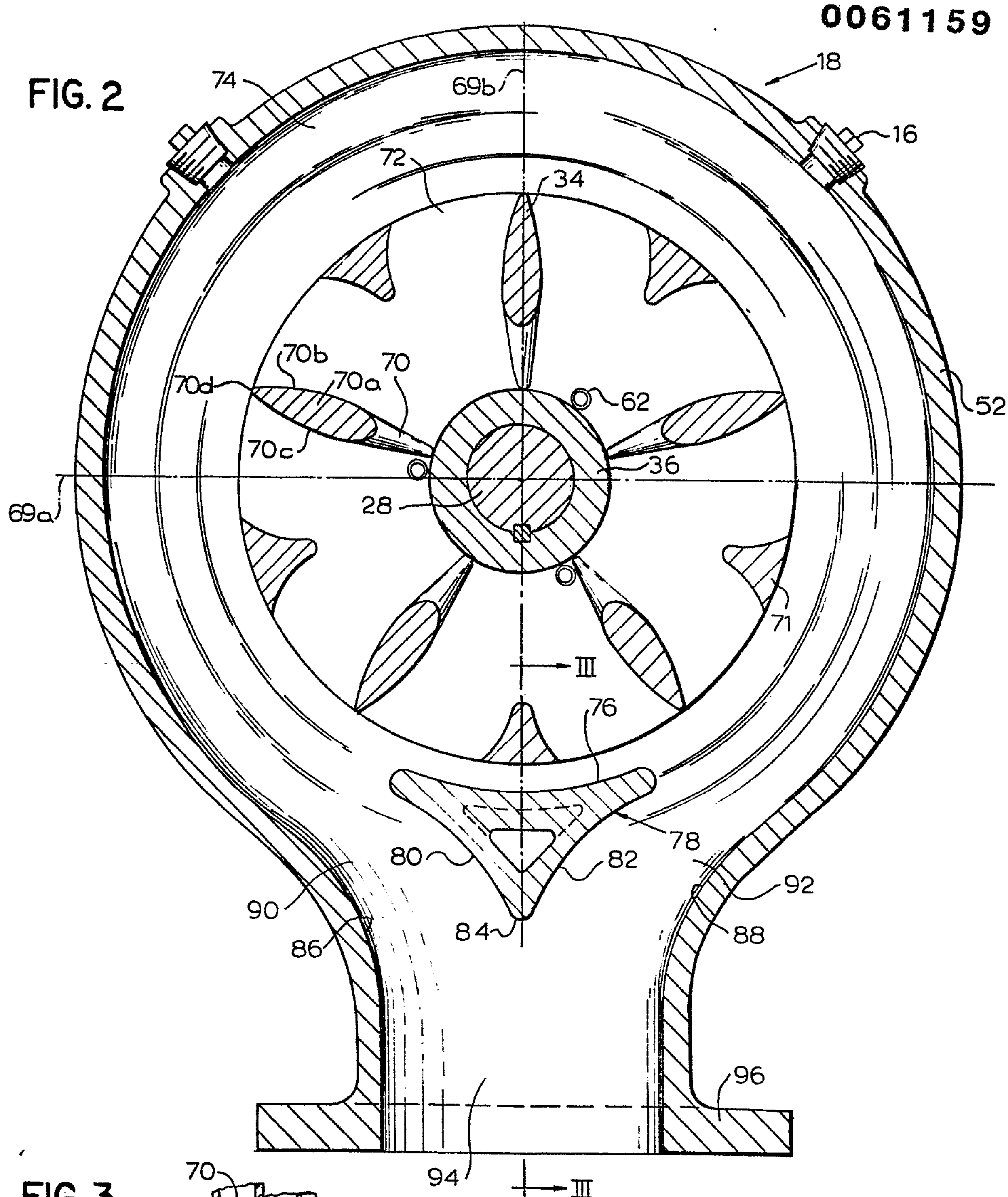

FIG. 3

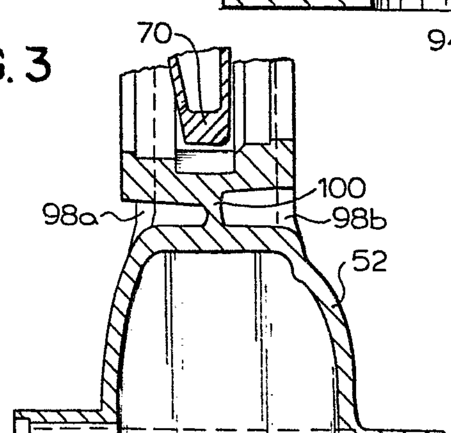

FIG. 4