

Sept. 23, 1958

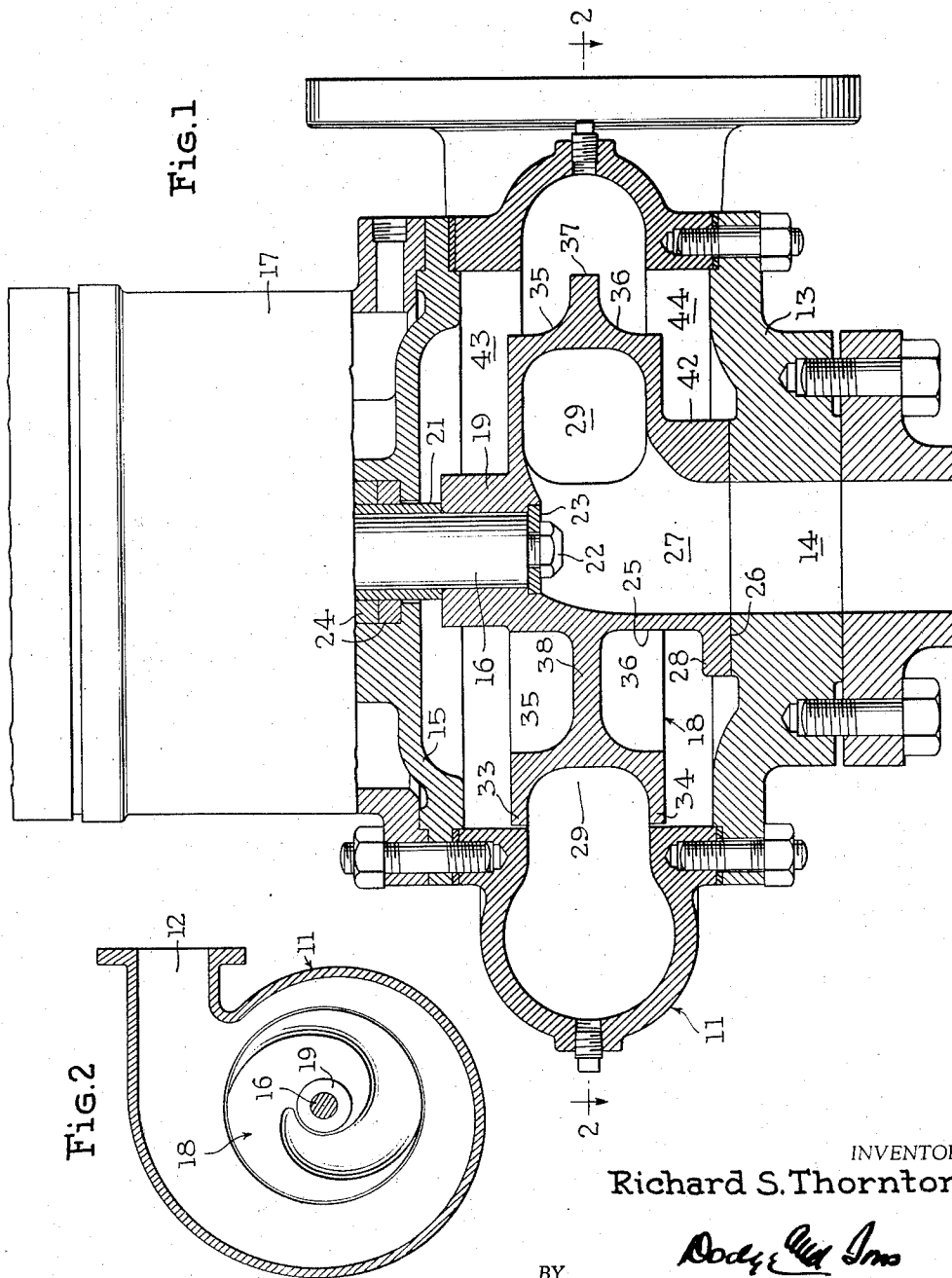
R. S. THORNTON

2,853,019

BALANCED SINGLE PASSAGE IMPELLER PUMP

Filed Sept. 1, 1954

5 Sheets-Sheet 1



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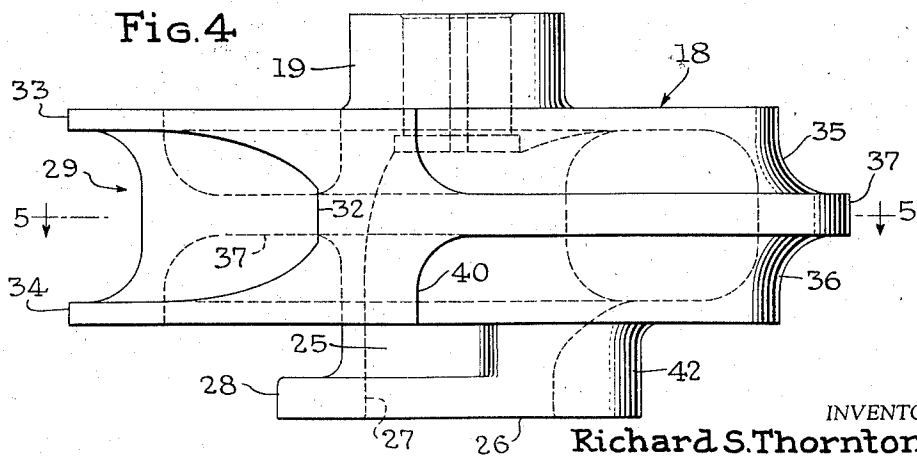
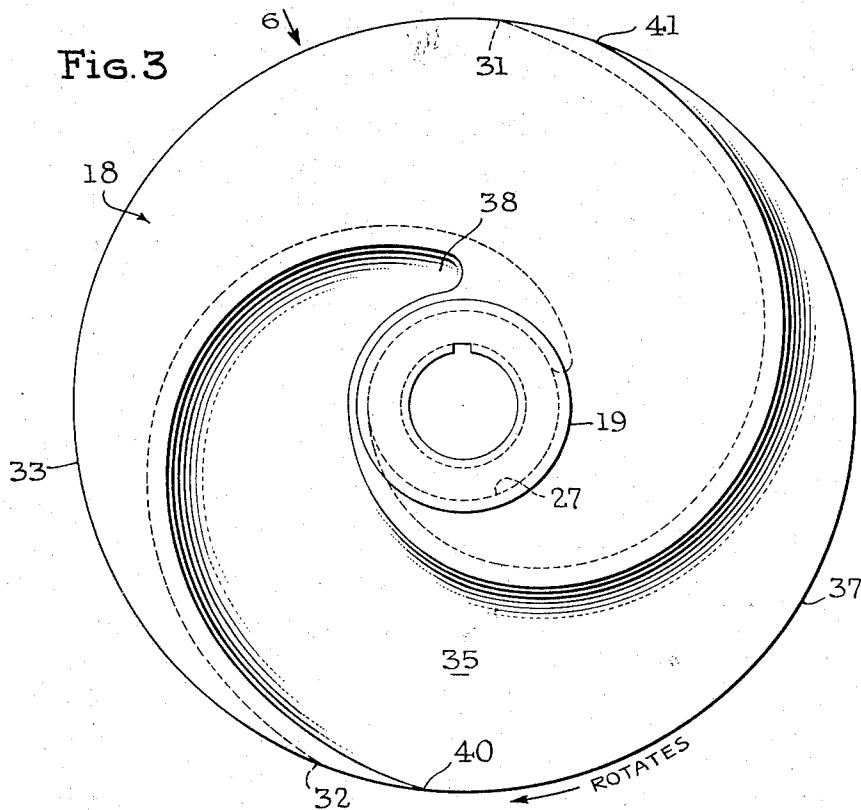
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5 Sheets-Sheet 2



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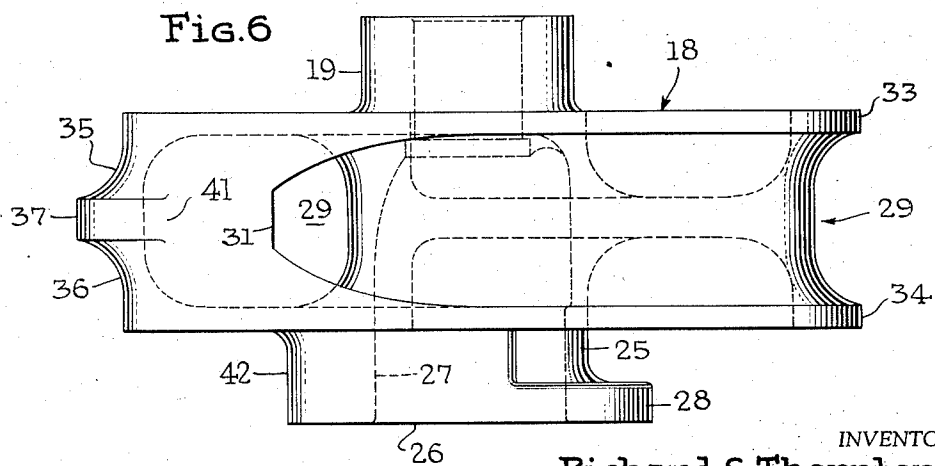
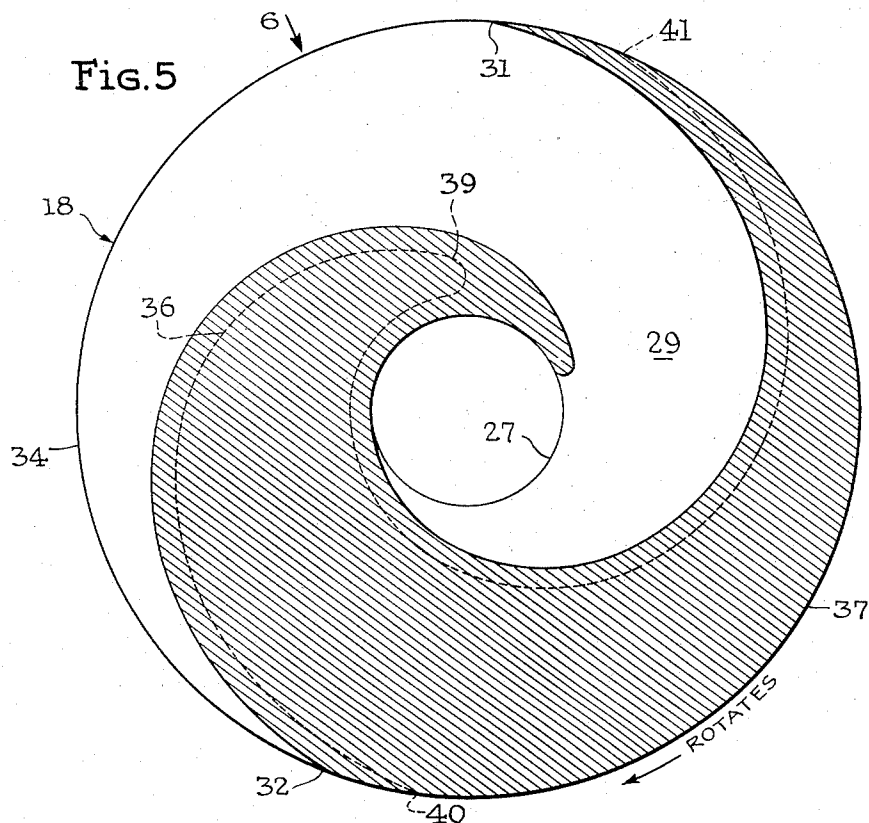
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BALANCED SINGLE PASSAGE IMPELLER PUMP

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5 Sheets-Sheet 3



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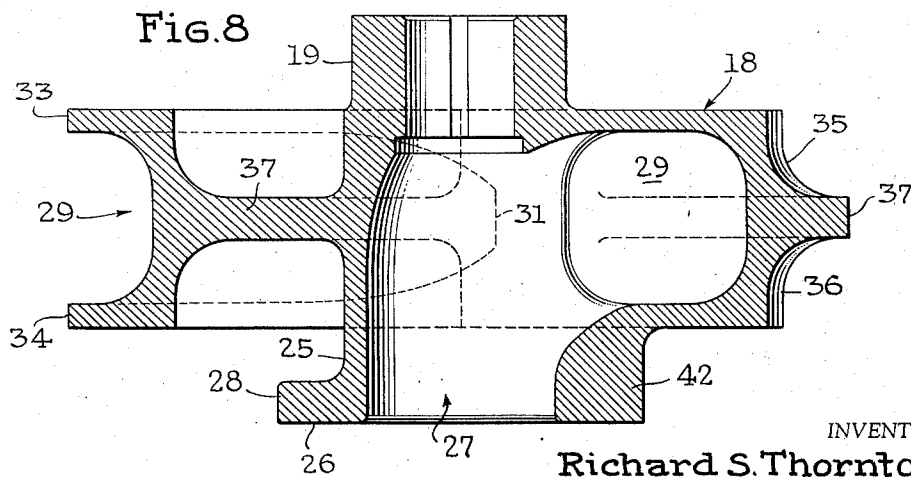
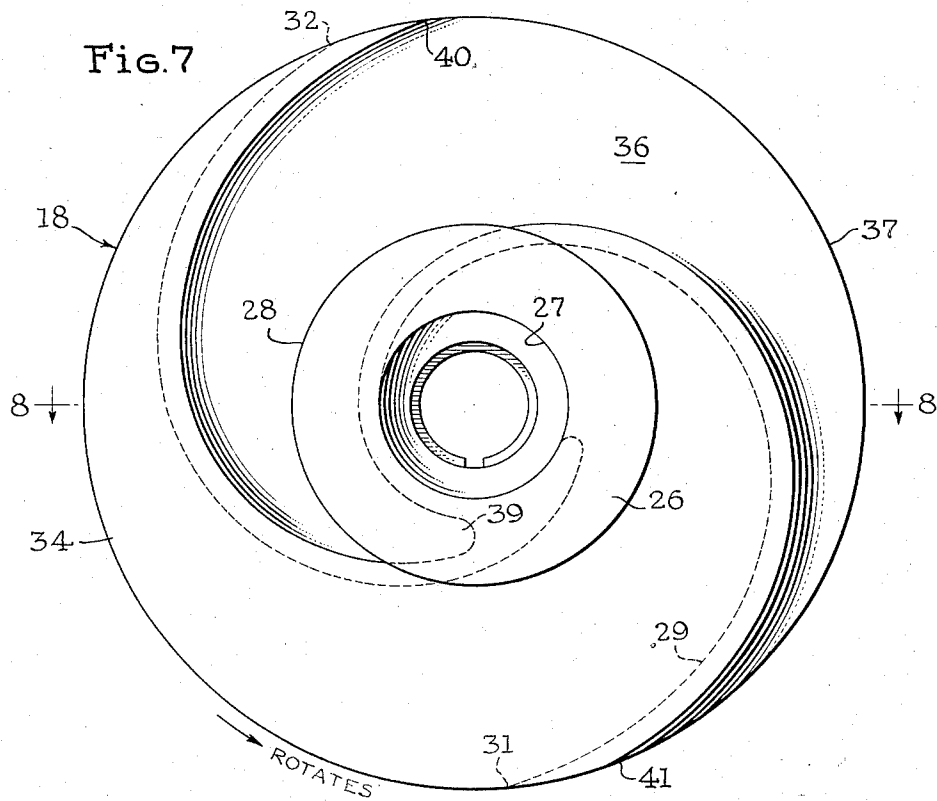
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BALANCED SINGLE PASSAGE IMPELLER PUMP

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5 Sheets-Sheet 4



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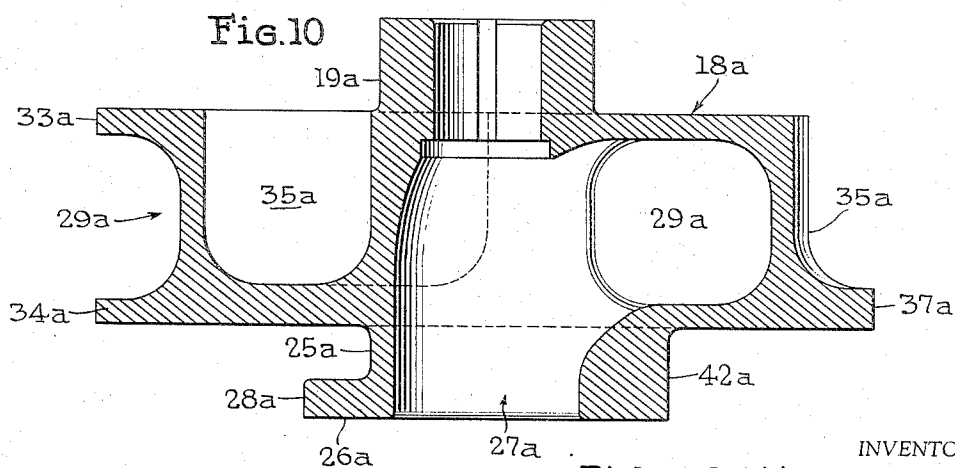
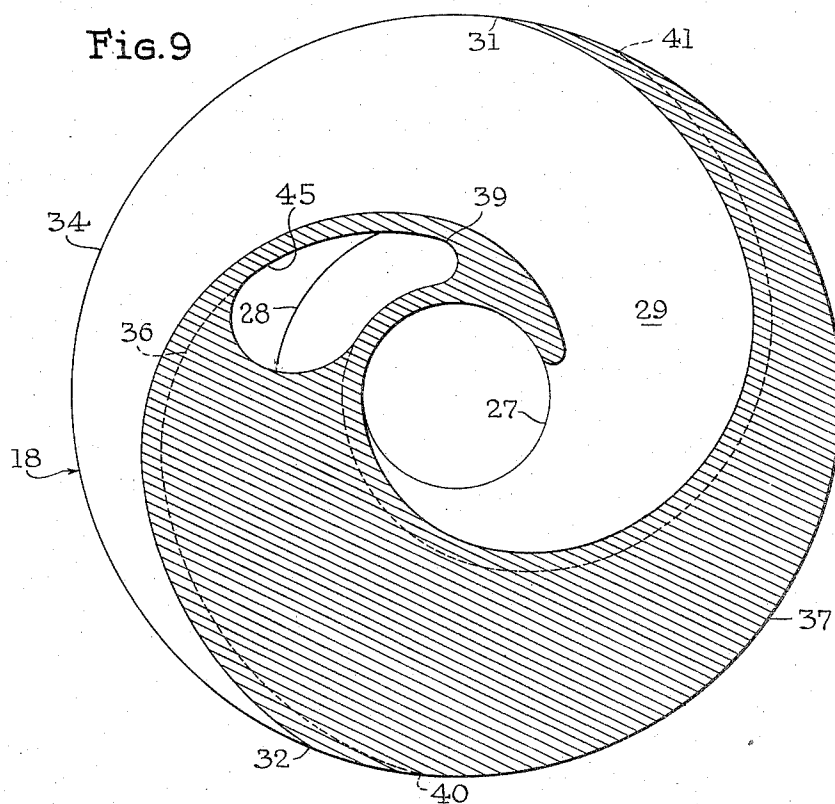
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BALANCED SINGLE PASSAGE IMPELLER PUMP

Filed Sept. 1, 1954

5 Sheets-Sheet 5



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2,853,019

BALANCED SINGLE PASSAGE IMPELLER PUMP**Richard S. Thornton, Aurora, Ill., assignor to The New York Air Brake Company, a corporation of New Jersey****Application September 1, 1954, Serial No. 453,479****7 Claims. (Cl. 103—103)**

This invention relates to non-clogging centrifugal pumps.

The commercial art became active about forty years ago, with the work of Albert B. Wood, Patent 1,182,439, and continued for many years on the basis of twin passage impellers in a snail-shell housing. These have the advantage of inherent balance but do clog on stringy material. The art apparently overlooked the single passage impeller of the Seitz Patent 495,760, perhaps because 1893 too long preceded the demand for sewage pumps. Another possibility is that the Seitz design was tried and found unsatisfactory. A single passage impeller is not inherently balanced. It develops hydraulic forces that vary with operating conditions and tend to defeat balance. Seitz discloses nothing as to balance except possibly static balance which is a small factor in the problem.

As a practical matter non-clog single-eye impellers must be mounted on the end of a rotary shaft in overhung relation to the shaft bearings. In such case radial forces which cause faulty running-balance lead quickly to shaft breakage.

Attempts to balance single passage impellers have been made with palliative effects, but past methods depended on the use of unchanging balancing masses. Hence prior art "balanced" impellers cannot meet the changing conditions inherent in the service. They are successful only in limited ranges.

Static balance is never the sole determining factor. Running-balance is affected by changing factors. The mass of the impeller rotor is a fixed quantity, but the mass of the flowing stream varies with the nature of the liquid being pumped. Worse still, are those varying unbalancing force reactions developed by the flowing liquid between the rotating impeller and the enclosing housing. These forces are large and they vary with, speed of rotation, discharge head and the specific weight of the liquid being pumped.

The invention provides a rotary impeller in which the impeller carries unpumped free liquid whose mass and motion closely approximate the mass and motion of the pumped liquid, but whose balance destroying tendency is 180° out of phase with that of the pumped liquid. To produce this effect the impeller carries peripherally exposed sockets similar in form to the single pumping passage, arranged to fill with liquid passing through the pump, and diametrically opposed on the impeller to the pumping passage.

Then, if the impeller is designed to be in running balance in air, it will run in balance when pumping, or nearly so. Obviously rotary flowing liquid passing through the pumping volute, and liquid short-circuited in the balancing passages and reflux chambers, develop somewhat different forces so that true perfection is not attainable, but it is approached to an extent hitherto not considered possible. The results are commercially satisfactory and better than can be had with any fixed-mass balancing scheme. Obviously axial forces should be

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balanced, but the invention imposes no penalty in this respect.

The drawings show the invention incorporated in a centrifugal pump having a vertical shaft axis. It is adaptable to pumps having horizontal axes. In fact the position of the shaft axis is a matter of choice.

Fig. 1 is a fragmentary view showing the impeller and the enclosing housing chiefly in axial section and on a reduced scale.

Fig. 2 is a simplified horizontal section on the line 2—2 of Fig. 1 intended to show the snail-shell contour of the housing.

Figs. 3 to 8 are views of the impeller drawn to a somewhat larger scale than Fig. 1.

Fig. 3 is a plan view.

Fig. 4 is a front elevation of the impeller positioned as in Fig. 3.

Fig. 5 is a section on the line 5—5 of Fig. 4.

Fig. 6 is an elevation looking in the direction of the arrow 6 in Figs. 3 and 5.

Fig. 7 is a bottom view, i. e. a view looking into the eye of the impeller.

Fig. 8 is a section on the line 8—8 of Fig. 7.

Fig. 9 is a view similar to Fig. 5 showing a modification.

Fig. 10 is a view similar to Fig. 8 showing another modification.

Statements of direction refer to parts positioned as in Fig. 1.

The housing of the pump comprises a volute or snail-shell member 11 of known form with discharge passage 12. See Figs. 1 and 2. The member 11 is annular in form but closed at the bottom by plate 13 with central inlet passage 14 and at the top by plate 15 with a central opening for the impeller shaft 16. The cylindrical flanged member 17 encloses and supports some driving unit for shaft 16, customarily an electric motor (not shown).

As clearly shown in the drawing the parts 11 and 13 are connected by studs. So also are the parts 11, 15 and the flange on member 17. Gaskets, also shown in the drawing, seal the members 13 and 15 to member 11.

The impeller, indicated generally by the numeral 18 is cylindrical in external outline and includes an external hub 19 keyed to shaft 16 and clamped against a journal sleeve 21 on shaft 16 by the machine screw 22 and washer 23. The sleeve 21 turns in a packing or sealing unit conventionally represented at 24.

The hub 19 projects from the upper side of the impeller 18, and from the lower side projects a neck 25 which has a terminal plane surface 26 (normal to the axis of shaft 16). Surface 26 makes a free running fit with the plane upper face of member 14 around the eye 27 of the impeller. Eye 27 registers with passage 14, said eye and passage being coaxial with shaft 16. The neck 25 is not symmetrical with respect to the impeller axis, a portion of it being reduced in thickness behind a flange 28, for reasons which will be discussed hereinafter.

Reference should now be made to Figs. 3—8 which show the impeller on a larger scale and in greater detail. The section in Fig. 8 corresponds to that in Fig. 1.

As best shown in Figs. 5 and 8 the eye 27 communicates with a volute passage 29. This can be dimensioned to pass any solid which will enter through the eye, according to principles known in the art. For example it can be, as shown, approximately uniform in cross section until it starts to emerge at the line 31 on the periphery. From the point of emergence, it continues as a channel to the line 32. Between 31 and 32, an arc of something less than 180°, it necessarily diminishes in depth (i. e. the dimension radial to the impeller 18) but throughout this arc it is open to the volute housing 11. The channel

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lies between flanges 33, 34 which continue the circular contour of the impeller.

The passage 29 is a void within the impeller, and to balance this, use is made of two voids of approximately equal aggregate volume and substantially identical volute contour, both displaced from passage 29 by an arc of 180° measured about the periphery of the impeller. These voids are identified by the numerals 35 and 36 (see particularly Figs. 3 and 7) and are separated by a web 37 (see Figs. 4, 6 and 8) whose periphery continues the circular contour of the impeller. While, as above stated the design of volute passage 29 can be varied according to principles known in the art, it is important that the voids 35, 36 be similar in volute contour to passage 29 and of basically equal aggregate cross section therewith.

Channel 35 starts at 38 adjacent hub 19 (see Fig. 3) and 36 starts at the similar point 39 behind the flange 28. Indeed the flange is used to permit the necessary undercut. The channels start to emerge on the periphery of the runner at 40 diametrically opposite 31 and terminate at 41 diametrically opposite 32. The web 37 is of such thickness and so filleted as to match the mass of the shrouding flanges 33 and 34, which, be it noted are similarly filleted. The thickness of web 37 is desirably held to a minimum where the web commences at 38, 39, i. e. opposite the opening from eye 27 into passage 29. This favors balance. The extra metal shown at 42 has a similar balancing function.

The spaces 43 and 44 which are clearly shown in Fig. 1, are important factors as to balance of the impeller. When the pump is running these spaces are liquid-filled and the liquid is that which is being pumped. In its dry condition, the impeller is in static balance and approximately running balance so its effect on balance is negligible. When the pump is in operation liquid flows continuously through passage 29. There is also recirculatory flow from each of the spaces 43 and 44 outward through the corresponding passages 35 and 36 and back to the spaces 43 or 44 as the case may be. While the hydraulic reactions do not precisely match, they are basically similar and the effect is a close approximation to hydraulic balance.

Impellers designed to handle solids of very large size present increased difficulty as to static and dynamic balance because the arc subtended by the junction of eye 27 and passage 29 is large. In such case recourse may be had to the modified construction of Fig. 9. In this figure parts identical with those in Fig. 5 are identically numbered. The modification is the presence of an opening 45 through the web 37 in the sector opposite the junction of eye 27 and passage 29. In effect the web in this area is made so thin that it actually or substantially disappears. The static and dynamic balancing effects differ only in degree from those secured with the construction of Figs. 1-8, for the location of the area 45 conforms substantially to the area in which the web is made as thin as practicable in the embodiment of Figs. 1 to 8.

An opening through the web is not considered desirable because it might lead to clogging. It could be used in the case of rotors which for some reason present an extreme balancing problem.

The impellers shown in Figs. 1-8 and 9 have the web 37 centered in the periphery of the impeller. In the absence of special considerations, this is deemed to be the best arrangement, but it is not the only practicable arrangement within the broad scope of the invention. Fig. 10 shows a limiting case in which the web 37a is along one edge of the periphery of the impeller. Parts in this view corresponding to parts shown in Fig. 8 are numbered as in Fig. 8 with the distinguishing letter a.

The arrangement shown in Fig. 10 avails of only one of the reflux chambers 43 or 44, and hydraulic forces developed in the direction of the axis of rotation do not neutralize each other to the extent that they do in the

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structures of Figs. 1-8 and 9. However, the arrangement is workable and may even be desirable in cases where it can be used to balance out axial thrusts exerted on the shaft by the weight of the parts or other factors.

Prototypes have been built and tested in practical service, and have demonstrated good pumping performance, ability to pass stringy material without clogging, and remarkable freedom from vibration, not merely at one speed, but over as wide a range as is likely to be encountered in commercial use.

The invention provides a single passage impeller which has not only good running balance as to its own mass, but also good running balance as to liquid which fills it, and above all good running balance as to the hydraulic forces which its operation necessarily develops between the impeller and the housing. Attainment of the third effect affords ability to operate successfully over a wide performance range.

I claim:

1. In a centrifugal pump, the combination of an enclosing housing having an annular channel and a discharge passage leading therefrom; a generally cylindrical impeller encircled by said channel and spaced from said housing to afford a reflux space comprising at least one annular reflux chamber, said impeller having a single eye coaxial with the impeller, and at least two volute passages of substantially identical volute profiles displaced from each other by 180° of arc measured on the circumference of the impeller, one of which volute passages communicates at its inner end with said eye and at its outer end with said annular channel and another of which volute passages is closed from said eye at its inner end and is in communication with said reflux space; means defining an inlet passage leading to said eye; and means for rotating said impeller about its geometric axis.

2. In a centrifugal pump, the combination of an enclosing housing having an annular channel and a discharge passage leading therefrom; a generally cylindrical impeller encircled by said channel and spaced from said housing to afford two reflux chambers, said impeller having a single eye coaxial with the impeller, and volute passages of substantially identical profile, the first of which communicates with the eye, and the two others of which are closed from the eye, are of aggregate cross sectional area equal to the cross sectional area of the first passage and displaced 180° of arc from the first passage as measured around the impeller, said first passage merging into the periphery of the impeller between shrouding flanges, and the other two being separated by a web whose cross section matches the aggregate cross section of said flanges; means defining an inlet passage leading to said eye and means for rotating said impeller about its geometrical axis.

3. The combination defined in claim 2 in which said web substantially bisects the periphery of the impeller so that the passages separated thereby are equal in cross section throughout their lengths.

4. The combination defined in claim 2 in which the passage which communicates with the eye is substantially uniform in cross section from the eye to its point of merging with the periphery of the runner.

5. The combination defined in claim 2 in which, within a sector opposite the junction of the eye with said volute passage, said web diminishes in thickness substantially to zero in an area outside, but closely adjacent, said eye.

6. The combination defined in claim 2 in which said web substantially bisects the periphery of the impeller so that the passages separated thereby are equal in cross section throughout their lengths, and within a sector opposite the junction of the eye with said volute passage, said web diminishes in thickness substantially to zero in an area outside, but closely adjacent, said eye.

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7. In a centrifugal pump, the combination of an enclosing housing having an annular channel and a discharge passage leading therefrom; a generally cylindrical impeller encircled by said channel and spaced from said housing to afford a single reflux chamber, said impeller 5 having a single eye coaxial with the impeller and two volute passages of substantially identical volute profiles displaced from each other by 180° of arc measured on the circumference of the impeller, one of which volute passages communicates at its inner end with said eye 10 and at its outer end with said annular channel, and the other of which volute passages is closed from said eye at its inner end and is in communication with said reflux space throughout a major portion of its length; means 15 defining an inlet passage leading to said eye; and means for rotating said impeller about its geometrical axis.

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