Sept. 9, 1947. V. SCHLEYER 2,427,307

CENTRIFUGAL PUMP

Filed Oct. 31, 1945 3 Sheets-Sheet 1

Fig. 1.

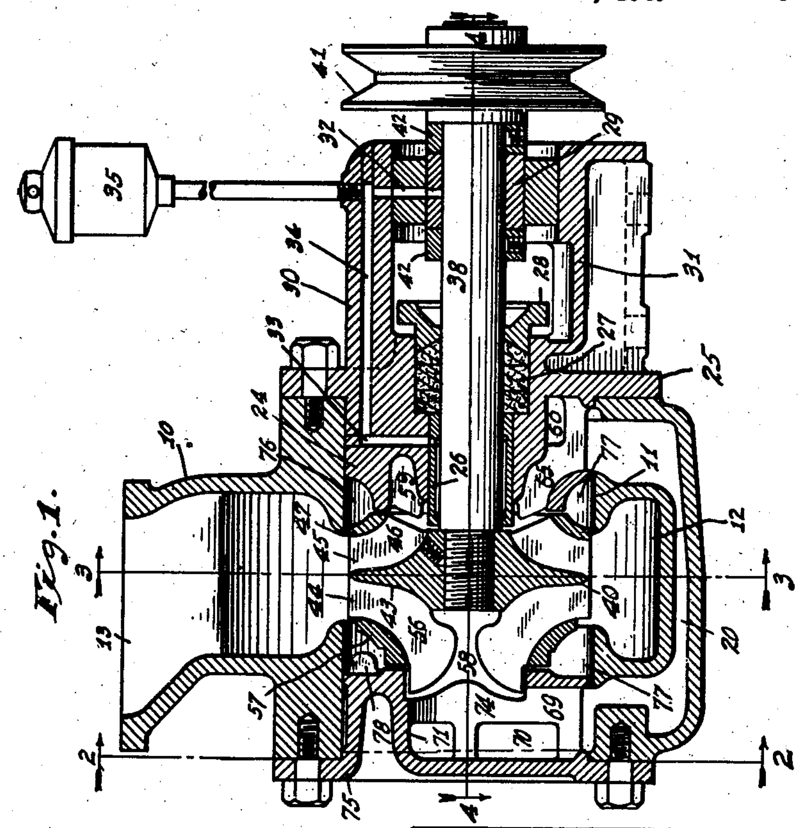

Fig. 2.

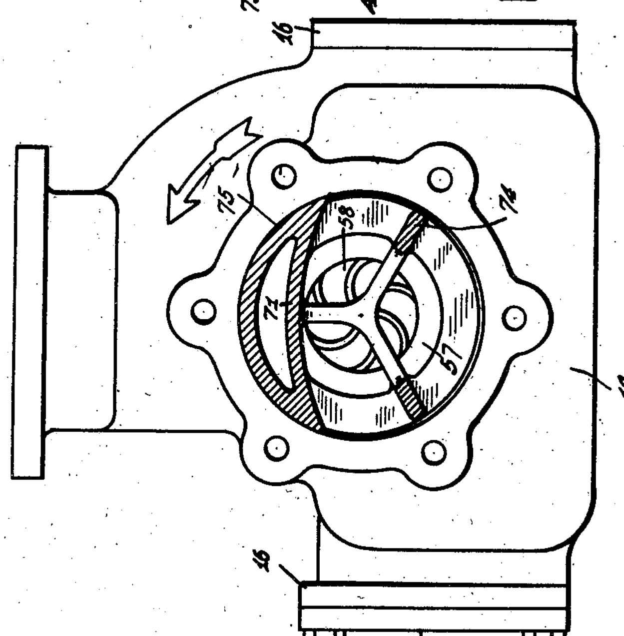

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Fig. 3.

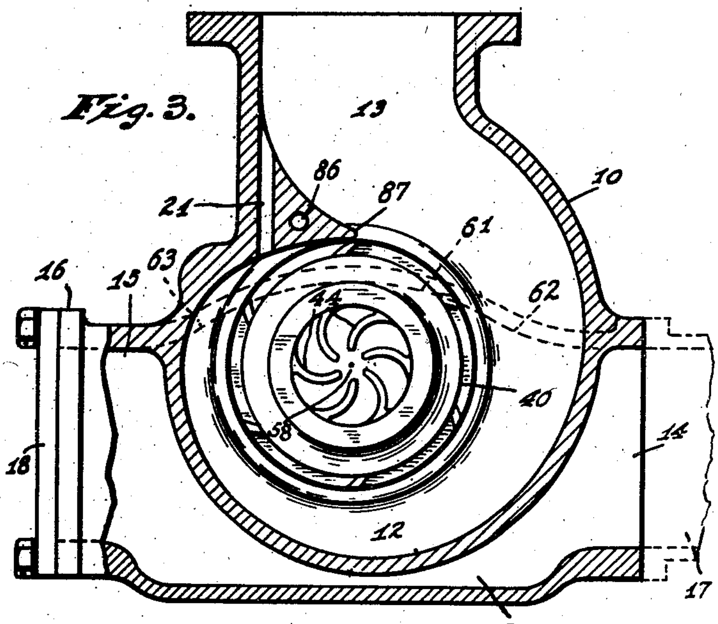

Fig. 6.

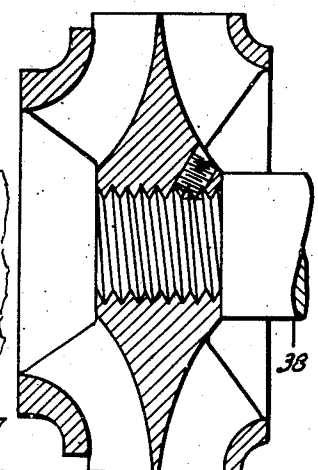

Fig. 4.

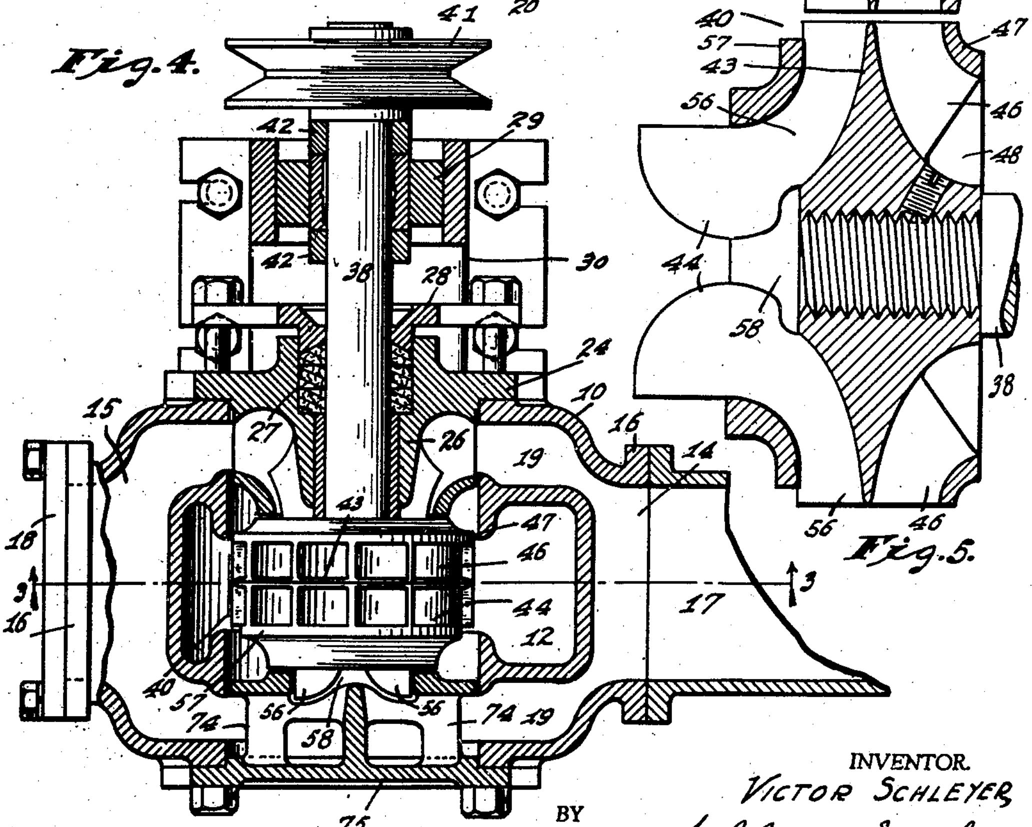

Fig. 5.

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Fig. 7.

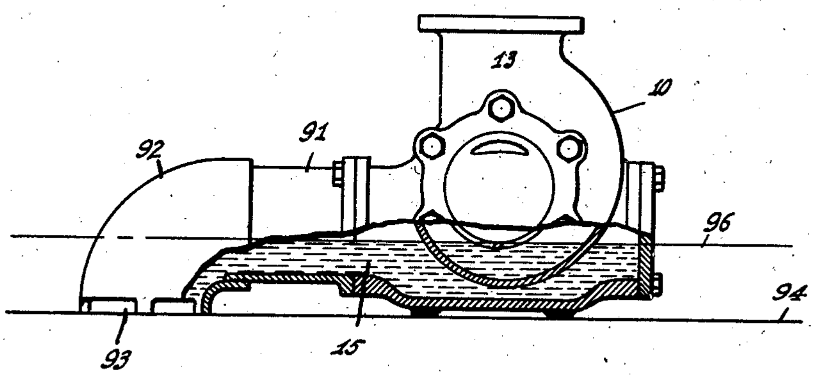


Fig. 9.

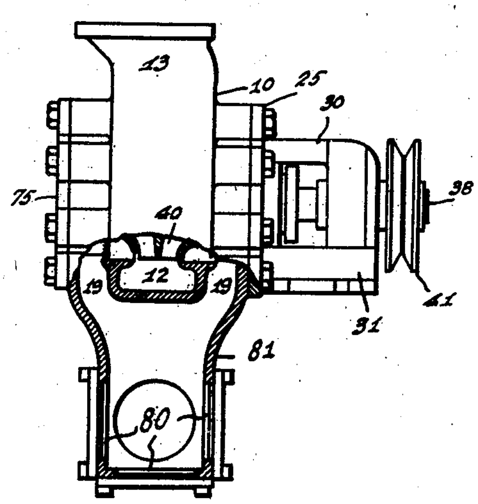
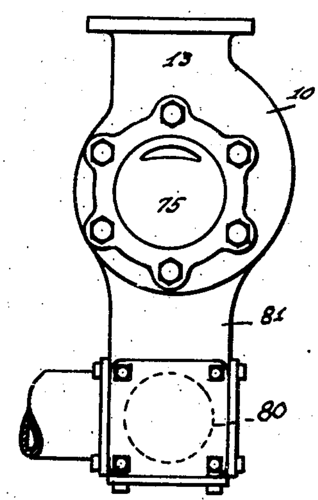


Fig. 8.



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CENTRIFUGAL PUMP

Victor Schleyer, Anderson, Ind.

Application October 31, 1945, Serial No. 625,780

15 Claims. (Cl. 103—113)

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This invention relates to a centrifugal pump which requires no priming.

My pump, like prior centrifugal pumps, has a double-suction impeller comprised of a rotor which forms a pair of impellers, a set of impeller blades for each impeller, a shroud on each set of blades, and an intake eye for each impeller; and has inlet passages leading to said eyes, and a volute and discharge passage to receive and carry away the discharge from the impellers.

Centrifugal pumps are generally recognized as having certain limitations, which my pump does not have. Prior centrifugal pumps must be filled with liquid before they will operate. To this end they either are primed immediately prior to each use, or are installed so that they will remain submerged. The priming is done either manually, or by some associated automatic vacuum equipment and valve means in the pump to close its discharge during priming. Submerged installation is either by mounting the pump below the level of the liquid to be pumped, or by associating the pump with a series of reservoirs and valves which keep the pump flooded. The latter arrangement is used in so-called "self-priming" pumps. Whether primed or submerged, prior centrifugal pumps must be completely filled with liquid, and air completely eliminated therefrom—from all intake passages, from the rotor, and from the volute—before satisfactory operation can be had. If air elimination is not complete, either because of faulty installation or incomplete priming, prior pumps will not operate efficiently or smoothly, and will often become airbound, lose their prime, and cease pumping. Priming of such prior pumps must be while they are at rest, they cannot be primed while running. If prime is lost, the pump must be stopped, re-primed, and then re-started. Thus, prior pumps cannot handle an intermittent supply of liquid.

On the basis of accepted practice, these limitations would be expected in my pump. But the unexpected and surprising fact is that my pump substantially avoids these limitations. It requires neither priming nor submerged installation, but may be started dry and will pick up liquid and start pumping it from a level substantially below its axis. It requires no valves, or vacuum equipment, or reservoirs, although it does not preclude the use of such equipment. It readily handles an intermittent supply of liquid.

Moreover, my pump is compact and of simple and maintenance-free construction; and may have its horizontal shaft axis close to the floor on which the pump is mounted. It is especially advantageous for use as a bilge pump, particularly on amphibian vehicles; for it may be permanently connected with a propelling motor thereof, and will act automatically to keep the bilge water at a low level.

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The two impellers of the double rotor in my pump have separate sets of blades, those blades are shrouded, and the shrouds form inlet eyes for the respective impellers, opening in opposite axial directions. The rotor shaft passes through one only of said eyes so that that eye has an annular opening. The other eye is circular and is smaller in diameter than the annular eye, but desirably is of substantially the same opening area. In each impeller, the blades extend inward to within the associated eye, and outward to the periphery of the rotor. The rotor also desirably includes unshrouded blades near its periphery, which may be formed by terminating the shroud of the circular-eye impeller short of the ends of its blades, to expose their tips.

This rotor is mounted in a compact casing which forms a volute to receive liquid from the impellers, a discharge passage, desirably leading upward from the top of said volute, and intake passages to the two impeller eyes. Such intake passages desirably terminate in suction chambers respectively adjacent the two impeller eyes; and the highest points in each set of said passages and chambers is at the top of its associated inlet eye.

The pump is so arranged that as the liquid level rises therein (with the rotor assumed to be at rest so that the action of the rotor on the liquid is ignored), the liquid first reaches the peripheral unshrouded blades, then the lower portion of the annular eye and the blades therein, then the lower portion of the circular eye and the blades therein, then the rotor center line, then the top of the circular eye, and then the top of the annular eye. From a dry start, the pump will begin to pump when the liquid level reaches the bottom of the rotor.

The accompanying drawings illustrate my invention. In such drawings: Fig. 1 is a vertical section on the shaft axis of a pump embodying my invention; Fig. 2 is a vertical section normal to the section of Fig. 1, on the lines 2—2 of Fig. 1; Fig. 3 is a vertical section normal to the section of Fig. 1, on the line 3—3 of Figs. 1 and 4, but showing the rotor in end-elevation; Fig. 4 is a horizontal section on the shaft axis of said pump, on the line 4—4 of Fig. 1, but showing the rotor in plan; Fig. 5 is an axial section on an enlarged scale of the pump rotor shown in Figs. 1 to 4; Fig. 6 is an axial section of a modified form of pump rotor; Fig. 7 is an end elevation of said pump fitted with an intake pipe and positioned for use as a bilge pump; Fig. 8 is an end-elevation of a modified pump, embodying a multiple intake fitting; and Fig. 9 is a side-elevation of the pump shown in Fig. 8.

The pump shown in Figs. 1 to 4 has a main casing 10 provided with a horizontal cylindrical bore 11. Opening from this bore is a volute 12, the passage of which is of generally elliptical cross section with its major axis parallel with the bore axis and substantially uniform throughout the length of the volute, and with its minor axis radial with respect to the bore axis and progressively increasing from the cut-water end of the volute to the discharge end thereof. The volute 12 has its cut-water at the top, and there joins a discharge passage 13 leading upwardly. Behind the cut-water, a small vertical vent hole 21 leads from the volute to the discharge passage 13.

The casing 10 also forms inlet openings 14 and 15 on a common axis transverse and below the bore axis, and is conveniently provided with flanges 16 for the attachment of supply pipes 17 or of one supply pipe 17 and a cap 18. The casing 10 is cored on both sides and below the volute to provide intake passages 19 which interconnect the intake openings 14 and 15 at both sides and below the volute and which open to the bore 11 at both sides of the volute. By this interconnection, and especially by the lower interconnecting passage 20 between the bottom of the volute 12 and the flat bottom wall of the casing, liquid entering one of said ports 14 or 15 may flow freely to the space adjacent the other of said ports. Desirably, the openings of the intake passages 19 to the bore are below the top of the bore and the tops of such openings are slightly above the intake openings 14 and 15, so that the upper walls of the passages 19 will lead smoothly and with a slight rise toward high points at the tops of the impeller eyes.

One end of the bore 11 (the right end in Fig. 1) receives a cylindrical portion 24 of a yoke frame 25. The cylindrical portion 24 is formed to receive a bearing at its inner end, shown as a sleeve bearing 26, a packing 27 behind said bearing, and a packing retainer 28 which is accessible for adjustment from outside the pump assembly. On the outer end of the cylindrical portion 24, the frame 25 carries a yoke formed of upper and lower arms 30 and 31 and a cross-head, to rigidly support an outboard bearing, as shown as a sleeve 29. Conveniently, the lower arm 31 of the yoke may form a mounting plate for the pump. Vertical drilled passages 32 and 33 provided respectively in the cylindrical portion 24 and in the cross head of the yoke and connected by a horizontal drilled passage 34 in the upper arm 31, carry lubricant, as from a spring loaded lubricant cup 35, to the two bearings 26 and 29.

The main shaft 38 for the pump is mounted in the bearings 26 and 29. It carries a rotor 40 at its inner end and suitable driving means such as a pulley sheave 41 at its outer end. It may also carry thrust collars 42 on opposite sides of the bearing 29, although because the rotor 40 is balanced, these are not essential.

As may be seen in Figs. 1 and 5, the rotor 40 comprises a hub with a radially extending tapering web 43 and with impellers 44 and 45 respectively formed on opposite sides of that web. The impeller 45 includes a set (conveniently six) of impeller blades 46, which carry a shroud 47 at

their sides opposite the web 43. Such shroud 47 has a central opening, to form an inlet eye for the impeller, and extends outwardly therefrom to the periphery of the rotor 40. The blades 46 start at the hub with their inner ends substantially at the circumference of the bearing sleeve 26, and extend outwardly in a spiral to the periphery of the rotor 40, joining the shroud 47 at the edge of its central opening. Their inner edge, therefore, lies substantially on a line extending from the circumference of the eye inwardly and axially to the rotor hub. The shaft 38 and the bearing 26 pass through the opening of the impeller shroud 47, so that the eye 48, formed thereby, has an annular opening.

The impeller 44, formed on the opposite side of the web 43 from the impeller 45, is generally symmetrical therewith. It has a set (conveniently six) of impeller blades 56, and a shroud 57. The inner edge of the shroud 57 defines an inlet eye 58 for the impeller 44 and the shroud extends outwardly toward, but desirably short of, the periphery of the rotor 40. The blades 56 extend outwardly to the periphery of the rotor 40 and inwardly beyond the inner edge of the shroud 57, into the eye 58. In the preferred modification shown in Figs. 1 to 5 inclusive, those blades 56 are continued almost to the axis of the rotor 40 and protrude axially through and beyond the eye 58. In the modification of Fig. 6, the blades 56 extend inwardly to a line which extends from the inner edge of the shroud 57 inwardly and axially to the hub of the rotor 40. The shaft 38 ends within the hub of the rotor 40 and neither the hub nor the shaft extends through the eye 58, so that that eye has a full-circular opening. But the diameter of the eye 58 is smaller than the outside diameter of the eye 48, so that it may and desirably does have the same area as the eye 48.

When, as in the preferred construction, the outer diameter of the shroud 57 is less than the outer diameter of the blades 56, the outer corners or tips of those blades form blade-portions which are exposed axially, and the area of the shroud end-face is reduced.

The cylindrical portion 24 of the frame 25 is cored to provide a suction chamber 60, or a continuation of the inlet passages 19, which is open at the cylindrical surface over areas that register with the bore openings of the inlet passages 19 of the casing to receive liquid therefrom and to carry it to an outlet ring 59 whose opening registers with the eye 48 of the impeller 45. The top wall 61 of this suction chamber 60 coincides with the ring 59 at the top thereof, curves downwardly therefrom about a center located a substantial distance below the center line of the rotor 40, and below the center line of the inlet openings 14 and 15. Thus, such top wall 61 forms an arcuate chord across the upper portion of the casing bore 11, with its highest point, in the plane of Fig. 1, at the top of the inlet eye 48. As may be seen in Fig. 3, this top wall 61 forms a smooth continuation of upwardly curved walls 62 and 63 defining the top of the inlet passages 19 from the inlet ports 14 and 15, at the shaft-side of the casing 10. By this construction, the top wall of the inflow passages 14, 19, and 60 has a continuous rise terminating at the top of the eye 48, so that any air which may be in those passages may freely flow through the eye 48 and the impeller 45 to the discharge passage 13.

To prevent rotation of the liquid in the suction chamber 60, that chamber is desirably provided with radial webs 65 which may protrude into the eye 48 of the impeller 45 into close proximity to the inner edge of the impeller blades 46.

A suction chamber 70 for the impeller 44 is formed at the other end of the bore 11, by inwardly projecting portions of a cap 75. That chamber 70 has openings registering with bore openings of the intake passages 19, and a ring 69 adjacent the shroud 57 about an opening registering with the impeller eye 58, to receive liquid from that intake passage and deliver it to the eye 58. As in suction chamber 60, the top wall of the suction chamber 70 is desirably an arcuate wall 71, about a center below the center line of intake ports 14 and 15, extending chordally across the upper portion of the bore 11. At its top point it coincides with the top of the ring 69 and lies adjacent the circular eye 58 of the impeller 44. Since the eye 58 is of smaller diameter than the outside diameter of eye 48, the high point of this chordal wall 71 is at a lower level than the high point of wall 61. The top walls of the intake passages 19 leading to the chamber 70 extend from the inlet ports 14 and 15 with a slight rise to meet the ends of the wall 71 at the bore surface. The resulting passages from the ports 14 and 15 to the eye 58 have top walls which rise from said ports to the top of said eye 58, so that air therein may freely escape therefrom through the impeller and to the pump discharge 13.

The suction chamber 70 is desirably provided with radial webs 74, which have openings through them near the end wall of the cap 75, and which desirably extend close to the inner ends of the blades 56 of the impeller 44.

When the impeller blades 56 terminate within the eye 58, as shown in Fig. 6, the radial webs 74 desirably protrude into the eye 58, in the same relation as webs 65 and eye 48. When the impeller blades 56 protrude from the eye 58, as shown in Fig. 1, they are surrounded by the ring 59, and revolve within it.

The end faces of the rotor 40, formed by the faces of the shrouds 47 and 57, have radial planar surfaces surrounding the respective eyes; and the rings 49 and 59 form similar surfaces opposed to such rotor surfaces. Running clearances are provided between each set of opposed surfaces; but here, as elsewhere in my pump, operation does not depend on close clearances, save of course at the shaft bearings.

Radially outward beyond said opposed radial surfaces, the opposed faces are more widely spaced, and form annular chambers 76 and 77 adjacent the surface of the bore 11 at opposite sides of the bore opening of the volute 12. A cored passage 86 through the metal just behind the cut water of the volute interconnects the two chambers 76 and 77.

Such annular chambers are in restricted communication with the volute 12 and with the suction chambers 60 and 70, by leakage past the clearances between the rotor and the rings and the volute lips. They thus form pressure chambers in which pressure is received on the opposite end-faces of the rotor. The amount by which the shroud 57 is short of the periphery of the rotor affects the action of such pressure on the end-thrust of the rotor. Such action is further affected by the use of stationary radial blades 78 in one of such chambers, by obstructing the movement of liquid therein and converting its kinetic energy to pressure energy. By the use of such pressure chambers, the short shroud 57, and the blades 78, axial end thrust on the impeller is substantially avoided, even though the impeller is not symmetrical about its central radial plane.

A modified form of casing 10 is shown in Figs. 8 and 9. Here, intake ports 80 for the pump are formed in a box-like portion 81 of the casing, below the bottom of the volute 12. Intake passages extend upwardly from this box 81 on opposite sides of the volute 12 into communication with suction chambers similar to those described above, which have circular outlet openings registering with the eyes 48 and 58 of the two impellers 45 and 44. By using this downwardly extending portion 81, several inlet ports 80 are provided, which may be used either alternatively or simultaneously to suit the requirements of a desired installation; and at the same time dead-end passages are avoided.

In both pump modifications shown, air in the pump may freely escape to the upwardly leading discharge passage, and no pockets are formed in which air may be trapped.

To illustrate one advantageous use of my pump, Fig. 7 shows it as a bilge pump. In this installation, its compactness is of substantial advantage, and permits it to be mounted with its intake openings close to the floor line 94. Thus, a pump having a capacity of approximately 300 gallons per minute has an intake port 15 of approximately three inch inside diameter, and may be mounted with the top of said port not more than four and one-half or five inches from the floor line 94. In such pump, the rotor had an outside diameter of approximately three and one-half inches, was operated at about 3500 R. P. M. and was mounted on an axis below the tops of the intake openings 14 and 15, so that such axis was within four or five inches of the floor line 94.

In the installation of my pump as a bilge pump as illustrated in Fig. 7, the port 14 is closed by a cap 90, and the port 15 carries a short inlet pipe 91 connected to a down turned elbow 92, which leads to an inlet opening 93 close to the floor line 94. The discharge 13 of the pump, in such installation, is connected to a discharge pipe (not shown) leading upwardly to an outlet point. The pump may be permanently connected to a motor for continuous operation, or it may be connected through a clutch, and operated only when pumping is desired or necessary. An important advantage of my pump is that it may be operated continuously, regardless of whether it is dry or pumping, and that it need not be primed, or at rest when water reaches it, but will pick up and discharge water as it accumulates.

The pump installation illustrated in Fig. 7 has been found by test to operate as follows: When the bilge water level rises above the intake openings 93 to the level 96 of the bottom of the impeller 40, just above the volute opening at the bottom of the bore 11, the pump promptly begins to pump. In my tests, the discharge point, connected to the discharge passage 13 by a 3½ inch pipe or hose, was more than five feet above the pump rotor axis, and water was discharged at such point rapidly and in a solid stream. Such discharge continued until the water level fell to below the intake openings 93. Even then, pumping continued, although a substantial proportion of air was being inducted at those openings 93, to further lower the water level to a substantial distance below the tops of said openings 93.

When the water level again rose to the level 96 pumping was promptly resumed. This cycle of p'-king up, pumping, and reducing the water level to below the openings 93, was repeated, over and over again, when the water supply to the bilge space was less than the full capacity of the pump. When a greater quantity of water was available to the pump, it pumped continuously.

Thus, within its capacity of about 300 gallons per minute, continuous operation of the pump maintained the bilge water level below the level 96 of the bottom of the rotor 40—at less than two and one-half inches above the floor line 96—even though the pump ran dry for intermittent periods. No priming was necessary.

In view of the general rule that centrifugal pumps require to be filled with water while at rest prior to pumping operation, either by submergence or priming, this action of my pump is surprising and unexpected. I believe the explanation of it is as follows.

The pump has some air exhausting or suction capacity, even when dry, although this may not be great. When, however, the water level rises so that water may flow (or leak between the lip of the volute 12 and bottom of the rings 69 and 79) to fill the bottom of the volute and be engaged by the impeller blade tips, it is thrown around the volute to the discharge passage 13. Thence it drains back, as through the chambers 76 and 78 to further raise the water level in the pump and to increase the amount of water being thrown by the blade tips. The pump then handles a mixture of air and water which progressively contains a higher proportion of water. The suction of the pump, therefore, progressively increases, to progressively suck more water through the intake, to further raise the water level in the pump. When the water level reaches the bottom of the annular impeller eye 48, the impeller 45 begins to pump it; while the other impeller 44, with its smaller and higher eye, is still operating on air. Some of this water pumped by the impeller 45 acts to further raise the water level, and both impeller eyes soon receive water.

Water pick up is probably a progressive action of this sort, and air exhaustion results from the combination of its being entrained in the water and of the freedom to escape which the pump arrangement gives to it.

Although probably progressive, as above outlined, the action of the pump in picking up full pumping operation while in operation and without priming is a rapid action. The water pick up is not only prompt, but its discharge is so forceful as to be violent; and the pump strongly tends to retain prime rather than to lose it. On a boat, and especially on an amphibian vehicle, the pitching and rocking of the boat or vehicle may cause a pump intake to be alternately flooded and dry. My pump is uniquely suited to meet the requirements of service as a bilge pump under those conditions, not alone for its prompt and forceful action, but also because of its compact, balanced, and sturdy design.

These same characteristics give my pump many other advantageous uses, as for example in the chemical industry.

I claim as my invention:

1. A centrifugal pump, comprising a rotor on a horizontal axis, two shrouded impellers formed on said rotor, inlet eyes respectively opening in opposite axial directions, one of said eyes being annular and of greater diameter than the other, said two eyes being of substantially equal opening-area, and a common volute for said two impellers.

2. A centrifugal pump, comprising a rotor on a horizontal axis, two shrouded impellers formed on said rotor, inlet eyes respectively opening in opposite axial directions, one of said eyes being annular and of greater diameter than the other, said two eyes being of substantially equal opening-area, blades in each of said impellers leading from within the circumference of said inlet eyes and terminating at the periphery of said rotor, a common intake for said two impellers, intake passages from said intake to said eyes, and a common volute for said two impellers.

3. A centrifugal pump, comprising a rotor on a horizontal axis, two shrouded impellers formed on said rotor, inlet eyes respectively opening in opposite axial directions, one of said eyes being annular and of greater diameter than the other, said two eyes being of substantially equal opening-area, a common volute for said two impellers, and means to balance said rotor against end thrust.

4. A centrifugal pump, comprising a rotor on a horizontal axis, two shrouded impellers formed on said rotor, inlet eyes respectively opening in opposite axial directions, one of said eyes being annular and of greater diameter than the other, blades in each of said impellers terminating at the periphery of said rotor, a common volute for said two impellers, pressure chambers formed adjacent the end-surfaces of said shrouds, the shroud having the smaller-diameter eye being radially terminated short of the ends of its associated blades.

5. A centrifugal pump, comprising a rotor on a horizontal axis, two shrouded impellers formed on said rotor, inlet eyes respectively opening in opposite axial directions, one of said eyes being annular and of greater diameter than the other, blades in each of said impellers, the blades in said smaller-eye impeller being formed to protrude axially through said eye beyond their associated shroud, an intake leading to said eyes, and volute means for said impellers.

6. A centrifugal pump, comprising a pair of shrouded impellers rotatably mounted on a common axis with their eyes opening in opposite axial directions, means to receive the discharge from said impellers, an annular chamber adjacent the outer axial face of the shroud of each impeller, the eye of one of said impellers being of smaller diameter than the eye of said other impeller, the shroud of said smaller-eye impeller being of smaller outside diameter than the shroud of said larger-eye impeller and the tips of its associated blades being exposed to the adjacent annular chamber, intake conduits to the eyes of said impellers, the annular chamber to which said blade tips are exposed being in restricted communication at its bottom with an intake conduit, and a conduit interconnecting said two annular chambers.

7. A centrifugal pump, comprising a frame, a shaft journalled in said frame, a rotor carried by said shaft, a casing forming a volute around said rotor, two impellers formed in said rotor on opposite sides of a common web, blades in each of said impellers, a shroud on the blades of each impeller opposite said web and forming an axially open inlet eye, one of said eyes forming an annular opening around said shaft, the other eye lying beyond the end of said shaft and forming a circular opening of smaller diameter than said annular opening, the shroud forming said circular

eye being of smaller outside diameter than the outer ends of its associated blades and of smaller outside diameter than said other shroud, the inner ends of blades in said impellers being closer to said shaft axis than the circumference of their associated eye.

8. A centrifugal pump, comprising a frame, a shaft journalled in said frame, a rotor carried by said shaft, a casing forming a volute around said rotor, two impellers formed in said rotor on opposite sides of a common web, blades in each of said impellers, and a shroud on the blades of each impeller opposite said web and forming an axially open inlet eye, one of said eyes forming an annular opening around said shaft, the other eye lying beyond the end of said shaft and forming a circular opening of smaller diameter than said annular opening.

9. A centrifugal pump, comprising two impellers on a common horizontal axis, blades in said impellers, shrouds on said blades, eyes in said shrouds, the shroud of one of said impellers having a smaller eye diameter than the other shroud and extending outward a shorter radial distance than its blades, inlet passages leading from a common inlet opening to the blade portions beyond said smaller shroud and to the eyes of said impellers, whereby liquid in said pump as its level rises will successively reach said blade portions, then the larger of said eyes, and then the smaller of said eyes.

10. A centrifugal pump, comprising a rotor on a horizontal axis, two impellers in said rotor, blades in each of said impellers, a shroud on the blades of each impeller, an inlet eye formed in each of said shrouds, one of said eyes having an annular opening and the other a circular opening, said circular-opening eye being of smaller diameter than the said annular eye, a volute for said rotor, an outlet through which air may escape from said volute at the top thereof, a ring registering with each said eye, an intake opening below the top of said smaller eye, intake passages leading from said intake opening to said rings, and being formed wholly below the tops of the openings in said rings and to permit free escape of air therefrom as water rises in said passages.

11. A centrifugal pump, comprising a rotor on a horizontal axis, two impellers in said rotor, blades in each of said impellers, a shroud on the blades of each impeller, an inlet eye formed in each of said shrouds, one of said eyes having an annular opening and the other a circular opening, said circular-opening eye being of smaller diameter than the said annular eye, a volute for said rotor, an outlet through which air may escape from said volute at the top thereof, a ring registering with each said eye, a plurality of intake openings below the top of said smaller eye, intake passages leading from each of said openings to each of said rings, said passages being formed to permit free escape of air therefrom through said rings as water rises in said passages, said passages being interconnected below said rings whereby water may flow from each of said openings to the passage space adjacent to the other opening.

12. A bilge pump, comprising a rotor on a horizontal axis, two impellers in said rotor, blades in each of said impellers, a shroud on the blades of each impeller, an inlet eye formed in each of said shrouds, one of said eyes having an annular opening and the other a circular opening, said circular-opening eye being of smaller diameter than

the said annular eye, a volute for said rotor, a discharge passage leading from the top of said volute upward to a discharge point, an intake conduit having an inlet port below said eyes and leading upwardly therefrom to said eyes, said conduit being so formed that as water rises therein substantially all air therein may freely escape therefrom at said eyes.

13. A centrifugal pump, comprising a horizontal double-impeller rotor having two inlet eyes, one of said eyes being of smaller diameter than the other, a casing, an intake opening, intake passages leading upward therefrom to said eyes and so formed that as water rises therein substantially all air may escape therefrom through said eyes, a volute surrounding said rotor, an upward leading discharge passage from said volute and in communication with the top of said volute, said pump providing a restricted communication from said intake passages to said volute below the lowermost of said two eyes.

14. A centrifugal pump, comprising a casing having an axial bore, a volute formed in said casing and opening from said bore, intake passages formed in said casing and opening to said bore at areas spaced axially from said volute opening, an upward leading discharge passage in communication with the top of said volute, a frame which has a cylindrical portion received in said bore, a shaft journalled in said frame coaxial with said cylindrical portion, a double impeller rotor carried by said shaft at the inner end of said cylindrical portion in position to discharge into said volute, a set of blades in each axial half of said rotor, a shroud on each set of the blades, a suction chamber in said cylindrical portion of said frame, said suction chamber having its high point at the top of its adjacent impeller eye and communicating therebelow with said intake passages in said casing, a closure at the opposite end of said bore, a suction chamber formed by said closure and opening to said circular eye, said chamber having its high point adjacent the top of its adjacent impeller eye and communicating below said top with said intake passages.

15. A centrifugal pump, comprising a casing having an axial bore, a volute formed in said casing and opening from said bore, intake passages formed in said casing and opening to said bore at areas spaced axially from said volute opening, an upward leading discharge passage in communication with the top of said volute, a frame which has a cylindrical portion received in said bore, a shaft journalled in said frame coaxial with said cylindrical portion, a double impeller rotor carried by said shaft at the inner end of said cylindrical portion in position to discharge into said volute, an annular impeller inlet eye surrounding said shaft, a circular impeller inlet eye at the opposite side of said rotor and beyond the end of said shaft, said annular eye being of larger outside diameter than said circular eye and of substantially equal opening area, a rotor hub, a common radial web on said hub for the two impellers of said rotor, said web being of progressively smaller axial thickness from said hub to the periphery of said rotor, a set of blades in each axial half of said rotor, which blades extend inward to within the circumference of their associated eye, a shroud on the blades associated with said annular eye which extends to the outer ends of said blades, a shroud on the blades associated with said circular eye which extends toward but short of the ends of said blades to leave the tips thereof unshrouded, a suction chamber

in said cylindrical portion of said frame said suction chamber having its high point at the top of its adjacent impeller eye and communicating therebelow with said intake passages in said casing, a closure at the opposite end of said bore, a suction chamber formed by said closure and opening to said circular eye, said chamber having its high point adjacent the top of its adjacent impeller eye and communicating below said top with said intake passages.

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