May 22, 1945. G. F. WISLICENUS 2,376,528

CENTRIFUGAL PUMP

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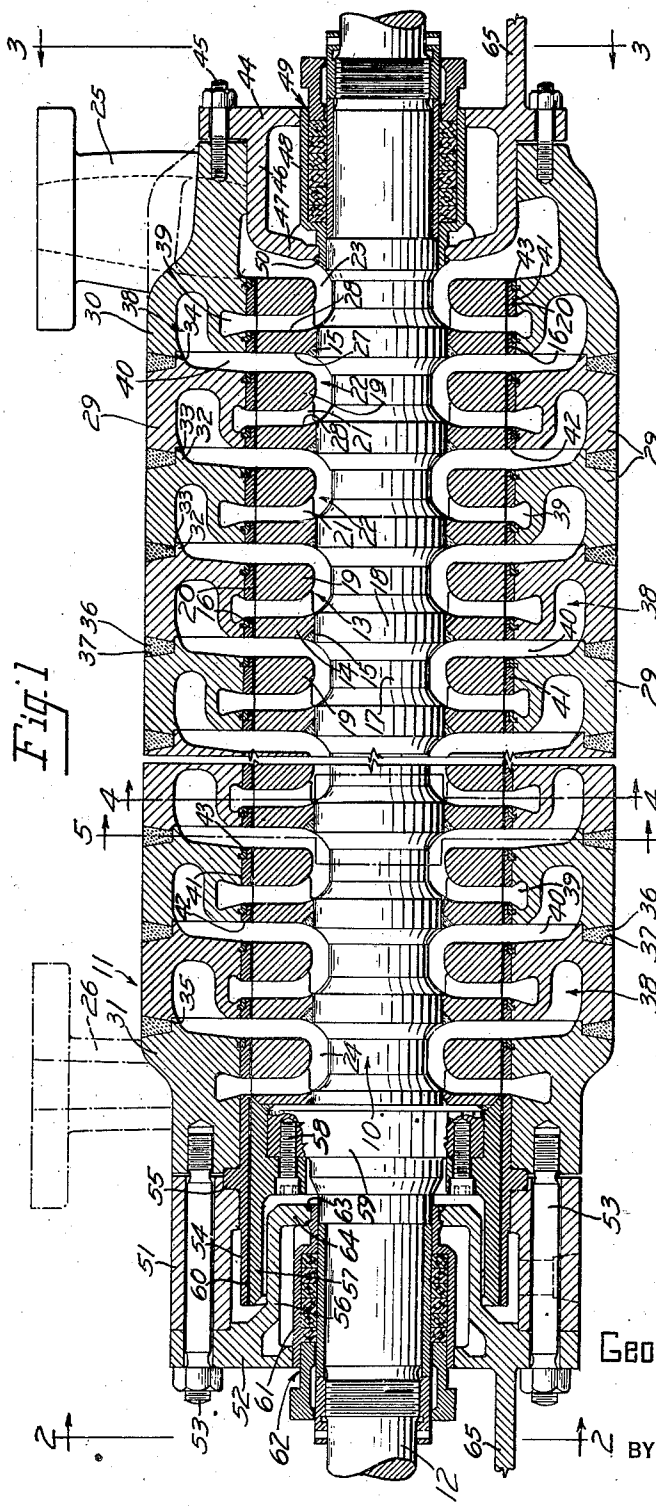


Fig. 1

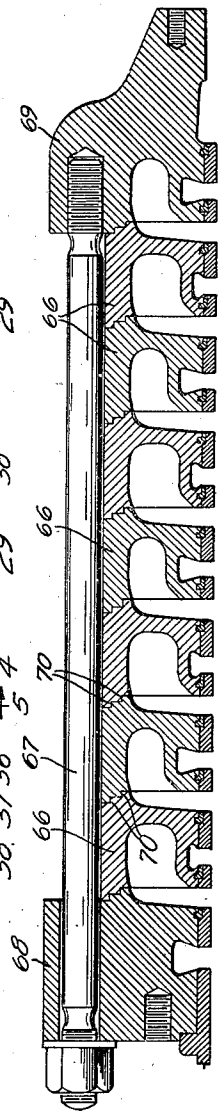


Fig. 6.

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Fig. 2.

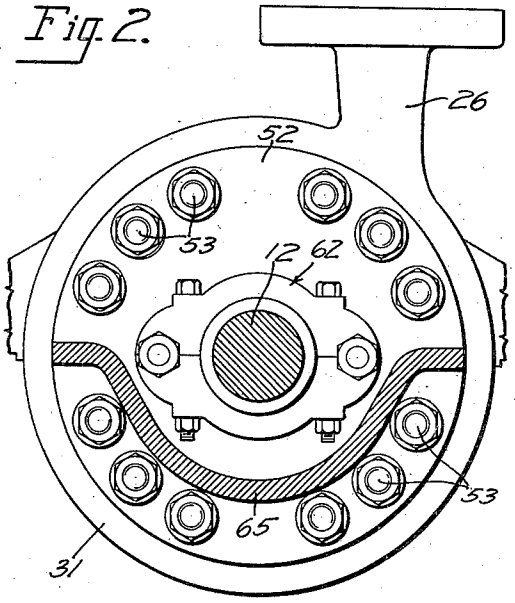


Fig. 3.

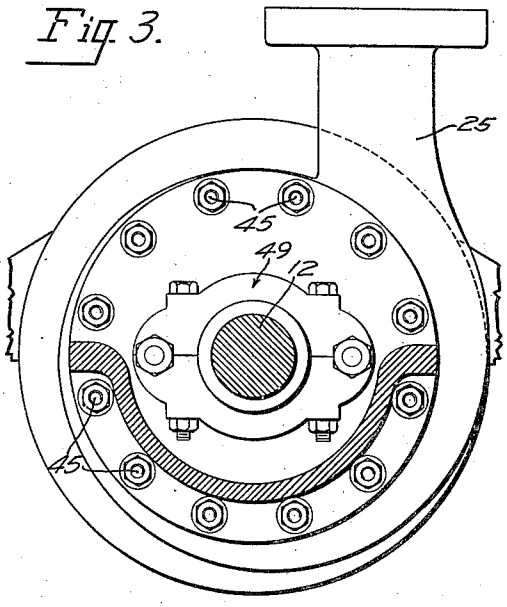


Fig. 4.

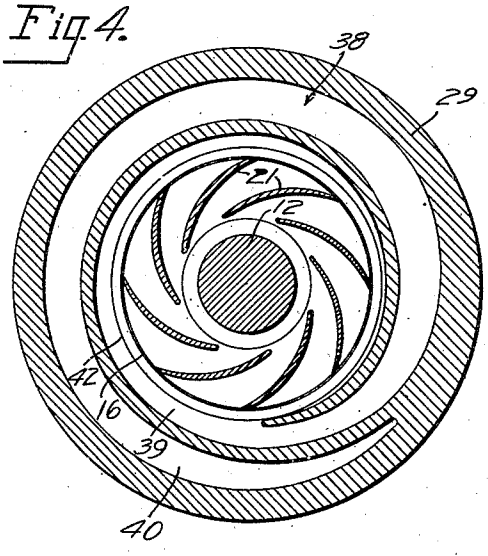
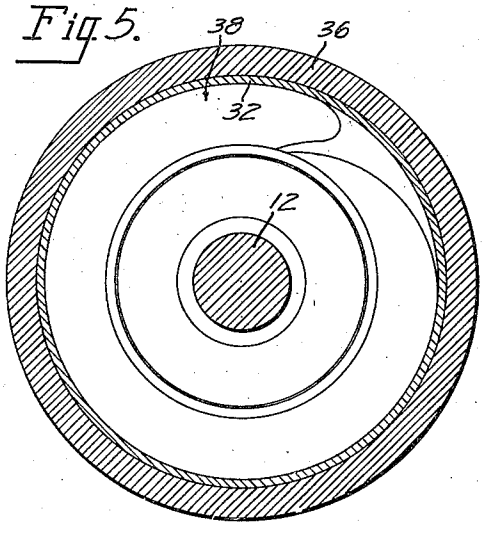


Fig. 5.



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Patented May 22, 1945 2,376,528

UNITED STATES PATENT OFFICE

2,376,528

CENTRIFUGAL PUMP

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Application March 2, 1944, Serial No. 524,711

3 Claims. (Cl. 103—108)

This invention relates to centrifugal pumps, compressors and the like, and more particularly to a rotor and casing structure for machines of the foregoing types.

Casings of the type employed in multistage pumping units and the like are divided either "horizontally" along their axes or "vertically" at right angles to the axes, between the respective stages. The horizontally split casing construction has the advantage of relative ease in dismantling the units. On the other hand, it has been found that in spite of the most extensive efforts the problem of avoiding interstage leakage in horizontally split casings affords substantially unsurmountable difficulties. The complete elimination of interstage leakage is almost a necessity in most high pressure pumps, since even a small leakage causes destruction of the surrounding material and thereby an increase of such leakage to an intolerable degree.

The leakage problem has led to the adoption of the vertical split construction for high pressure and high temperature centrifugal pumps. In this form of design, the stationary part of the pump immediately surrounding the rotor is formed out of ring shaped parts with solid diaphragms reaching inward between the impellers to the wearing diameter. Since these parts can be formed by forging or pressing a nearly one hundred percent leakage-proof construction may be obtained. In dismantling the unit, however, it is necessary to remove the impellers and the stage pieces one by one from the shaft, thus making the process of dismantling a rather lengthy and complicated matter. In order to overcome this difficulty, pumps of this type have been incorporated in a unit barrel for repair or overhauling. The whole interior pump assembly may be removed from the casing barrel as a unit and replaced by a completely assembled spare unit. In this way, the time required for dismantling the pump interior interferes little with the operating schedule of the pump. While this construction has been found very successful, its very nature makes it rather expensive to build and delicate to assemble.

The hydraulic requirement of using a large number of stages is in many cases in conflict with the requirement of mechanical reliability of the unit. While most high speed multistage pumping units are operated at speeds above the first critical speed, it is still necessary to keep the static shaft deflection within conservative limits. These deflections must be less than the radial running clearances in the interior of the unit in order to avoid metallic contact leading to a rapid destruction of the wearing surfaces. Since an increased number of stages will result in a greater shaft bearing span, the hydraulic advantages of the larger number of stages may be partially or totally offset by the necessary increase in shaft diameter resulting from the foregoing consideration of shaft stiffness.

A large diameter shaft passing through the inlet cross-section of a radial flow impeller is generally detrimental to the efficiency of the impeller, since it forces an increase in the eye diameter and thereby in the circumferential velocity at which the impeller receives the fluid. Since an increased number of stages reduces the head per stage and thereby the outside diameter of each impeller, it is obvious that the increasing shaft diameter has a rapidly growing influence on the form of the impeller and thereby on its hydraulic qualities.

In many practical cases, a point has been reached where because of the foregoing reasons an increase in the number of stages will not result in the usual increase in efficiency unless the corresponding increase in shaft diameter can somehow be avoided. So far the most effective way to accomplish this result has been through the use of internal bearings.

Elimination of any stationary diaphragms which reach between the individual impellers makes it possible to reduce the axial length required for the respective stages so that the number of stages may be somewhat increased without increasing the bearing span of the shaft.

Accordingly, an object of the present invention is to provide a machine of the type described wherein the construction is such as to avoid the objectionable leakage features characteristic of present day devices.

Another object is to provide a machine of the type described wherein the casing and the rotor are of such design as to permit axial removal of the rotor intact from the casing by merely detaching one or both end covers of the casing.

Another object is to provide a casing and a rotor of such construction that the running joints in the casing and the rotor may be machined in one setting to automatically assure alignment.

Another object is to provide a casing structure comprising an assembly of stage pieces or casing rings, in which the exact stage distances may be assured through pre-machining of the individual pieces, and in which the casing may be expeditiously built in any number of stages by merely

assembling and securing together the requisite number of stage pieces.

Another object is to provide a machine of the type described wherein the casing and the rotor are so co-actively designed that the rotor may comprise a permanently assembled unit which is easily removed from the casing without dismantling thereof, with the exception of one or both of the end covers of the casing, and in which the rotor embodies an impeller structure characterised by a relatively small eye diameter to greatly reduce the circumferential velocity at which the impellers receive the fluid.

Another object is to provide a casing and rotor structure of such design as to eliminate the necessity of stationary diaphragms which reach between the individual impellers to reduce the axial length required for each stage, and in which the necessity of spacer sleeves for mounting the individual impellers on the rotor shaft is completely eliminated, with a consequent reduction in eye diameter.

Another object is to provide a machine of the type described wherein the rotor is of such construction that the fluid enters through a cylindrical section having the same diameter as the discharge section of the rotor and proceeds to flow toward the axis of the rotor between rotating side walls, in which the casing contains all the stationary fluid passages to eliminate the necessity of horizontal or vertical separation of the casing, and in which the rotor may be axially removed as a unit from the casing.

A further object is to provide a machine of the type described wherein the construction is such as to avoid the objectionable features characteristic of horizontally split or vertically split casings of present day construction.

With these and other objects in view, as may appear from the accompanying specification, the invention consists of various features of construction and combination of parts, which will be first described in connection with the accompanying drawings, showing a centrifugal pump of a preferred form embodying the invention, and the features forming the invention will be specifically pointed out in the claims.

In the drawings:

Figure 1 is a longitudinal, sectional view of a centrifugal pump in accordance with the present invention.

Figure 2 is a partial sectional view taken along the line 2—2 of Figure 1.

Figure 3 is a partial sectional view taken along the line 3—3 of Figure 1.

Figure 4 is a sectional view taken along the line 4—4 of Figure 1.

Figure 5 is a sectional view taken along the line 5—5 of Figure 1.

Figure 6 is a sectional view of a modified form of casing structure.

Referring more particularly to the drawings, the improved pump shown in Figure 1 comprises a rotor 10 mounted in a casing 11. The rotor 10 includes a shaft 12 to which impellers 13 are fixedly and permanently attached. Each impeller comprises a side wall or disc 14 which is welded at 15 to the shaft 12, and the walls 14 have annular wearing faces 16 of a common diameter. The shaft 12 is undercut at 17, the undercuts comprising circumferential grooves, and the walls 14 are mounted on the uncut shaft portions 18.

Between the walls 14 are arranged annular rings 19 provided with wearing faces 20 of the same diameter as the walls 14. Outward flow fluid impinging vanes 21 fixedly relate the rings 19 to their respective walls 14, and the rings are of such shape and arranged in such manner as to co-act with the walls 14 and the faces of the undercuts 17 to provide fluid passages 22 generally U-shaped in cross-section. The inlet eye of the pump is indicated at 23 and the last-stage eye at 24. These eyes respectively communicate with an inlet 25 and a discharge 26.

Each fluid passage 22 extends circumferentially of the axis of the rotor 10, and the legs 27 and 28 of the fluid passages comprise fluid inlets and fluid outlets, respectively. Both the fluid inlets and fluid outlets extend 360° about the rotor and open through the annular perimeter thereof. The vanes 21 are arranged in the legs 28 of the respective fluid passages 22, and the side faces of the walls 14 flare outwardly adjacent the shaft 12 in conformity with the face contours of the undercuts 17 so that the latter comprise continuations of the respective fluid passages. The foregoing rotor structure forms the subject matter of an application for patent on Rotor filed on even date herewith.

The casing 11 comprises a series of identically contoured stage pieces or casing rings 29 and two end pieces 30 and 31, all arranged in end to end relationship and of such diameters as to provide a chamber for the rotor 10. In multistage centrifugal pumps wherein a single volute (as shown in Figure 4) is employed, the stage pieces or sections of the assembled pump are staggered with respect to the one next thereto, (that is, they are preferably displaced 180°) to balance radial forces. Annular flanges 32 are provided at one end of the respective pieces 29, which flanges are appropriately fitted against annular shoulders 33 on the other ends of the respective pieces. The end piece 30 is also provided with an annular shoulder 34 fitting over the flange 32 on the adjacent piece 29. An annular flange 35 is formed on the end piece 31 for engagement with the shoulder 33 on the adjacent piece 29. Means for fixedly connecting the pieces 29 and the end pieces 30 and 31 into a unitary structure comprise welded joints 36. All the pieces 29 and the end pieces 30 and 31 are so shaped as to provide circumferential grooves 37 for the welded joints 36.

Internally the pieces 29 and the end pieces 30 and 31 are contoured to provide fluid passages 38 having fluid inlets 39 and fluid outlets 40 opening through the inside annular perimeter of the casing 11 for communication with the fluid outlet and inlet legs 28 and 27, respectively, in the rotor 10. Thus the assembled pieces 29 and end pieces 30 and 31 provide a casing having a rotor chamber and provided with fluid passages having communication with the rotor chamber. The inlets 39 and 40 lie in the planes of the legs 27 and 28, respectively, and the fluid passages 38 are in series communication with the fluid passages 22 to provide a continuous fluid passage extending from the inlet 25 to the outlet 26.

Casing rings 41 and 42 are attached to the inner faces of the pieces 29 and the end pieces 30 and 31, as through the medium of locking rings 43. All the casing rings 41 and 42 are of identical inside diameter and lie in the planes of the wearing faces 20 and 16, respectively. It will thus be seen that the rotor 10 may be axially removed as a unit from the casing 11, since the diameter of impeller wearing faces is at least equal to or greater than the outside diameter of the impellers, the inside diameter of the casing rings

41 and 42 being the smallest diameter of the rotor chamber. In this way any stationary parts reaching between the impellers of the individual stages are completely eliminated.

To the end piece 30 is attached an end cover 44 as by bolts 45, which cover includes an inwardly extending flange 46 appropriately fitted inside the end piece 30 and provided with an inturned annular flange 47. The cylinder 48 of a stuffing box 49 is welded at 50 to the inturned flange 47.

A spacing ring 51 is interposed endwise between the end piece 31 and an end cover 52 at the other end of the casing 11. Bolts 53 pass through the end cover 52 and the spacer ring 51 and are threaded into the end piece 31 for connecting these parts into a unitary structure. A casing ring 54 of considerable length extends inside the end piece 31 and the spacer ring 51 at discharge end of the casing and is provided with a flange 55 which is securely clamped between the end piece 31 and the spacer ring 51. An inwardly extending flange 56 is formed on the end cover 52 and extends inside a sleeve 57 bolted at 58 to a flange 59 on the shaft 12. The sleeve 57 has a wearing surface 60 of considerable area which is arranged in co-active relationship with the inner or wearing face of the ring 54. The wearing face of the ring 54 is of the same diameter as the wearing faces of the casing rings 41 and 42, while the wearing face 60 is of the same diameter as the wearing faces 16 and 20. The cylinder 61 of a stuffing box 62 is welded at 63 to an inwardly extending annular flange 64 at the inner end of the flange 56.

Both end covers 44 and 52 are provided with extensions indicated fragmentarily at 65 which serve as supports for the usual line and thrust bearings (not shown).

In lieu of building the pump casing from assembled castings, the casing may be cast in one piece. The advantages of building up the casing of individual and small castings resides in the simplification of foundry problems and low pattern costs. This construction also facilitates cleaning of the fluid passages, and the exact stage distances are assured by pre-machining the individual stage pieces before welding. The individual stage pieces may be produced in large quantities and kept in stock cleaned, pre-machined, and ready for assembly. Thus casings of any number of stages may be easily built up by combining the desired number of stock parts by welding. Final machining of the casing is done after the casing has been welded together and appropriately annealed.

Figure 6 illustrates a modification wherein the casing comprises stage pieces or casing rings 66 arranged end to end in the same manner as the pieces 29. In lieu of welded connections between the pieces 66, the pieces are clamped into a unitary structure by bolts 67 which extend through an end piece 68 at one end of the casing and are threaded into an end piece 69 at the other end of the casing. In Figure 6, the pieces 66 are provided with engaging annular shoulders 70 which place and maintain the pieces in coaxial relationship, as is also true of the flanges 32 and 35 and annular shoulders 33 in the structure of Figure 1. The two end pieces 68 and 69 are also shouldered in the same manner as the pieces 66. Internally the pieces 66 and end pieces 68 and 69 may be identical with the pieces 29 and end pieces 30 and 31.

Both forms of the device avoid the weakness of either the horizontally split or vertically split casing designs. No horizontal split is necessary to remove the rotor from the casing. Furthermore, the great delicacy of accurately machining the hidden joints in horizontally split multistage casings is completely eliminated, reducing the essential machining of the casing to that of a single bore of constant diameter.

The elimination of any stationary diaphragms reaching between the individual impellers makes it possible to reduce the length required for each stage so that the number of stages may be somewhat increased without increasing the bearing span of the rotor shaft. The possibility of fastening the impellers more or less permanently on the shaft makes it very much easier to hold the impellers individually without the use of spacer sleeves. This in turn permits undercutting of the shaft in the region of the impeller inlet and thereby reducing the impeller inlet diameter without an undue reduction of the average shaft diameter.

The axially removable rotor makes it unnecessary to use the double construction of present day barrel pumps since it avoids the principal disadvantage of the less expensive vertical split construction, namely, the tedious piece by piece dismantling of the whole pump including breaking of the suction and discharge connections, which so far has been necessary for removing the rotor from this type of pump.

While the drawings show a straightaway or successive arrangement of the stages of the pump or analogous machine, it is obvious that the principles of the present invention are equally applicable to stage arrangements where the stages are arranged in back-to-back relation or in groups disposed in opposed relation, as is the practice in constructing some types of centrifugal pumps.

Obviously, the foregoing structure of both forms of the invention may be easily adapted to compressors, turbines, and the like without departing from the spirit of the invention.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

What is claimed is:

1. In a centrifugal pump of the multistage type, the combination of a casing having an inlet and a discharge, said casing being provided with a rotor chamber circular in cross-section and first fluid passages having first inlets and first outlets opening into said chamber, a rotor comprising a shaft having circumferentially extending grooves, walls fixed to said shaft between said circumferential grooves, rings lying between said walls and spaced from the faces thereof and the faces of said circumferential grooves to provide second fluid passages having second inlets and second outlets respectively communicating with said first outlets and first inlets in such manner as to connect said first and second fluid passages in series to provide a fluid passage leading from said inlet to said discharge, and vanes in said second fluid passages fixedly connecting said rings to the respective walls, said walls and said rings having wearing faces of such diameter with respect to the face of said chamber as to provide a running clearance between the rotor and the casing, said rotor having a maximum annular contour such with respect to the minimum annular contour of said chamber as to be axially removable therefrom intact.

2. The invention claimed in claim 1 wherein said second fluid passages are generally U-shaped in cross-section, and casing rings attached to said casing in the planes of the respective wearing faces.

3. In a centrifugal pump of the multistage type, the combination of a casing having an inlet and a discharge, said casing being provided with a rotor chamber circular in cross-section and first fluid passages having first inlets and first outlets opening into said chamber, a rotor comprising a shaft, annular walls fixed to said shaft in co-axial relationship therewith and spaced one from the other, rings lying between said walls and spaced from the faces thereof and the surfaces of said shaft between said walls to provide second fluid passages having second inlets and second outlets respectively communicating with said first outlets and first inlets in such manner as to connect said first and second fluid passages in series to provide a fluid passage leading from said inlet to said discharge, the surfaces of said shaft between said walls being in fluid passage defining relationship with the faces of said walls, and vanes in said second fluid passages fixedly connecting said rings to the respective walls, said walls and said rings having wearing faces of such diameter with respect to the face of said chamber as to provide a running clearance between the rotor and the casing, said rotor having a maximum annular contour such with respect to the minimum annular contour of said chamber as to be axially removable therefrom intact.

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