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MULTIPLE STAGE CENTRIFUGAL PUMP

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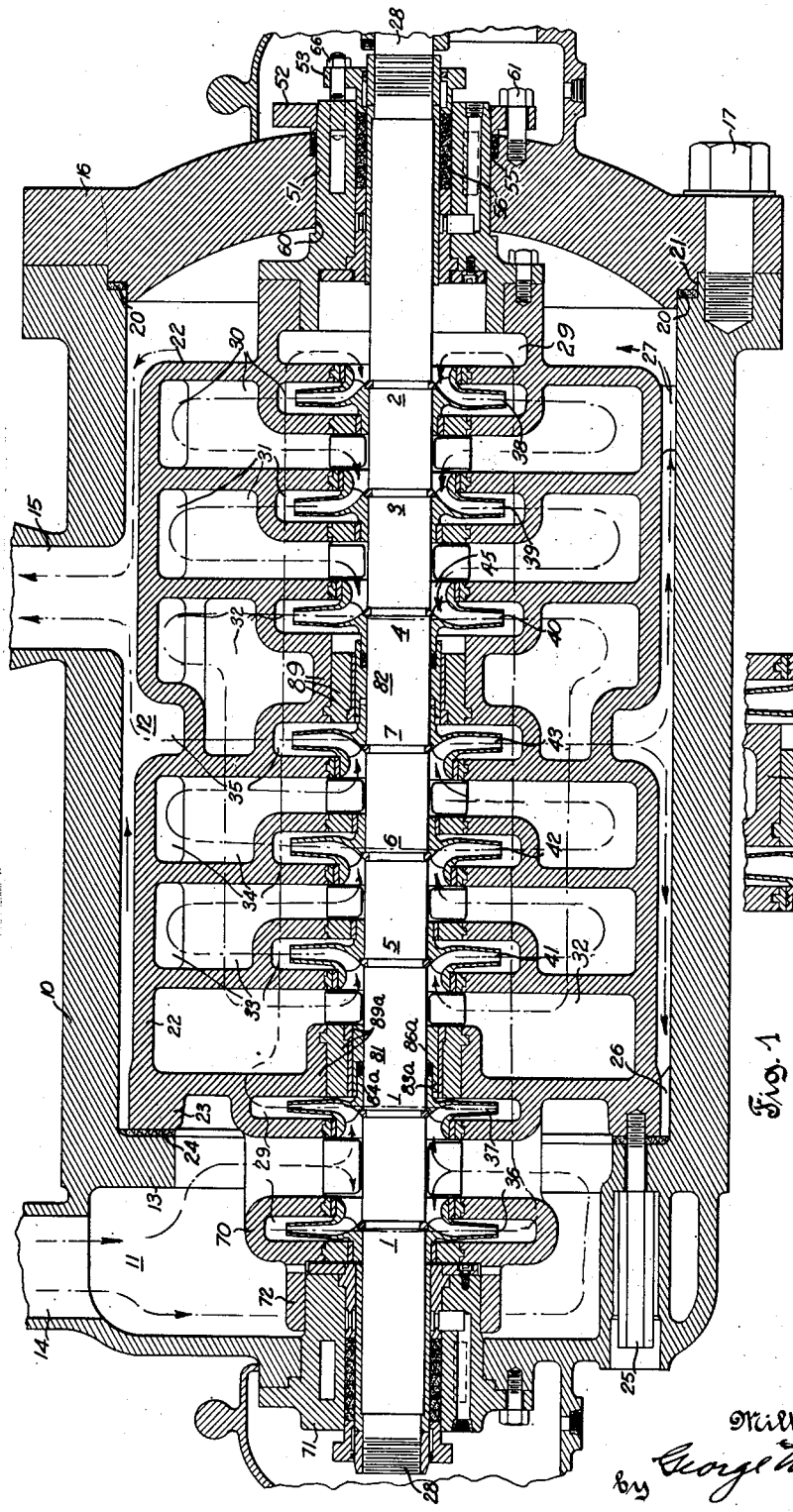


Fig. 1

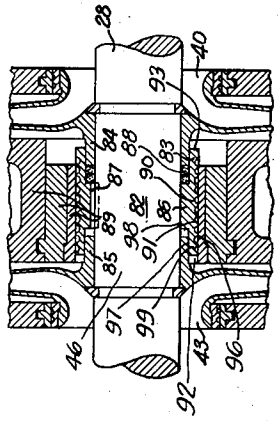


Fig. 2

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MULTIPLE STAGE CENTRIFUGAL PUMP

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4 Claims. (Cl. 103—108)

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This invention relates to multiple stage centrifugal pumps. More specifically this invention relates to improvements in sealing arrangements between the pumping stages of a multiple stage centrifugal pump. The principal object of this invention is the provision of a new and improved liquid pumping machine.

In multiple stage centrifugal pumps, one of the problems has been the sealing of the outboard ends of a pump casing to an impeller shaft passing therethrough. To simplify this problem, the pumping stages have been arranged with the first stage on one end of the shaft, the second stage on the opposite end of the shaft and all subsequent stages arranged between the first and second stage. With this arrangement of stages, the outboard shaft seals need only resist the intake pressure on one end and first stage discharge pressure on the other end of the pump casing. This arrangement of stages results in having a greater pressure differential between some of the adjacent stages than others. When this pressure differential is quite high, a substantial loss in efficiency may result from the higher pressure liquid leaking into the stage developing lower pressure. For instance, a pump developing 2,000 lbs. per square inch in eleven stages, with the seventh stage inboard of and adjacent to the first stage, may have as much as 1,000 lbs. per square inch pressure differential between these two stages. Accordingly, a primary object of this invention is to provide interstage sealing means that will effectively reduce leakage from a pumping stage developing high pressure, into an adjacent stage developing less pressure.

Another object of this invention is to provide interstage sealing means that will utilize the higher pressure within an adjacent stage, to compress packing material about the impeller shaft into sealing engagement therewith.

Still another object of this invention is to provide interstage sealing means that will protect the impeller from wear and will itself be easily and cheaply replaceable when worn.

Objects and advantages other than those above set forth will be apparent as the description of the invention proceeds.

The novel features of the invention and how the objects are attained will appear from this specification and the accompanying drawing showing two embodiments of the invention and forming a part of this application and all these novel features are intended to be pointed out in the claims.

In the drawing:

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Fig. 1 is a sectional view of a seven stage double casing centrifugal pump embodying two embodiments of the invention; and

Fig. 2 is an enlarged view of one of the embodiments of the invention.

Fig. 1 discloses a pump comprising an outer casing 10 with a divided inner casing 22 spaced within. Dividing of the inner casing 22 to facilitate assembly is well known in the prior art as shown by the patent to Hollander, U. S. 1,655,546. The inner casing 22 contains a series of pumping stages 1 to 7, in which the pressure of the liquid is progressively raised. Stuffing box members 51 and 71 support the casings 10, 22 in proper axial alignment.

The outer casing 10 is divided into an intake chamber 11 and a discharge chamber 12 separated by an annular projection 13. An inlet passage or passageway 14 transmits liquid at intake pressure to the intake chamber 11. A discharge passage or outlet passageway 15 transmits the liquid from the discharge chamber 12 at discharge pressure. The outer casing 10 is open at the discharge chamber 12 end of the casing. This open end is fitted with a casing cover 16 which is attached to the outer casing 10 by means of bolts 17, and a liquidtight seal is insured by a gasket 20 which is set in a recess 21 to avoid the possibility of blowing out. The inner casing 22 is inserted into the open end of the outer casing 10 and mounted therein. The radial shoulder 23 of the inner casing 22 is seated against the annular projection 13 within the outer casing 10. The inner casing 22 is held firmly against the projection 13 by the discharge pressure of the liquid within the discharge chamber 12. A gasket 24 is fitted between the shoulder 23 and the projection 13 to provide a liquidtight seal between the intake chamber 11 and the discharge chamber 12. Bolts 25 provide an initial seal and keep the inner casing 22 in position during periods of starting and stopping when the pressure within the discharge chamber 12 may not be enough to maintain the seal. Keys 26, 27 also aid in supporting the inner casing 22 in proper alignment, in that they keep the inner casing 22 from turning within the outer casing 10.

A shaft 28 is mounted in the inner casing 22 and extends through both ends of the outer casing 10. The pumping stages comprise a series of annular passages or compartments 29 to 35 which are formed in the inner casing 22 for directing the fluid through the inner casing 22, as shown by the dot dash flow lines in Fig. 1. The annular passages or compartments 29 to 35 are hydrauli-

cally connected in series relation by means of impellers 36 to 43 mounted on the shaft. The impellers 36 to 43 are operatively disposed to establish predetermined pressures in the respective compartments into which they impel fluid. Each of impellers 36 to 43 has an inlet similar to the inlets 45 of the impellers 40, 43.

A section 70 of the inner casing 22 extends into the intake chamber 11 of the outer casing 10. A stuffing box member 71 is fitted about the shaft 28 to the outer casing 10 and extends through the outer casing 10 into the intake chamber 11. An annular sleeve 72 extends from the section 70 and embraces the stuffing box member 71 thereby supporting the section 70 in proper axial alignment.

A special stuffing box arrangement is provided for sealing the inner casing 22 to the shaft 28 and to the end cover 16. This arrangement will allow axial expansion of the inner casing 22 relative to the outer casing 10 in response to changes in pressure and/or temperature within the inner casing 22. When a pump of this general type is used for pumping a liquid at high temperature such as boiler feed water, the axial movement of the inner casing 22 relative to the outer casing 10 may be quite substantial and frequent as changes in demand are made upon the pump. To permit this relative movement and yet maintain an effective seal, an annular member 51 is fitted to the inner casing 22 and extends through an opening 60 in the end cover 16. Glands 52, 53 and packing 55, 56 placed concentrically about and within the member 51 thereby effect a seal between member 51 and the end cover 16, and between the member 51 and the shaft 28. Bolts 61, 66 keep the glands 52, 53 drawn up tight on the packing 55, 56 to maintain the seal at all times. This stuffing box arrangement is described and claimed in the copending application of Hugh L. Ross, Serial No. 123,768, filed October 26, 1949. It will be understood that as far as the invention of the present application is concerned, means of other form may be provided for sealing the inner casing 22 to the shaft 28 and to the cover 16.

The pressure of the fluid as it passes through the inner casing 22 is raised in the pumping stages 1 through 7. The first stage comprises two impellers 36, 37 both of which take suction from the intake chamber 11 and discharge into the passages 29 which direct the liquid to the opposite end of the inner casing 22, where the liquid enters stage 2. The liquid is then directed through the remainder of the stages 2 to 7, which have a single impeller 38 to 43 in each, and the path of the liquid is shown by the passages numbered 30 to 35. The fluid passes from the final pumping stage 7 to the passage 35 which discharges into the pressure chamber 12 of the outer casing 10 and the fluid is then discharged from the pump through the discharge passage 15. The arrangement and location of the stages is further described and claimed in the copending application of Edward J. Blackwell, Serial No. 123,719, filed October 26, 1949.

The arrangement and number of stages as illustrated results in having between stage 1 and stage 5, fourth stage pressure in the fluid passage 32 adjacent the passage 29 having first stage pressure therein, and between stage 7 and stage 4, seventh stage pressure in the passage 35 adjacent the passage 32 having fourth stage pressure therein. The high differential in pressure at these two locations requires a special high pressure sealing means or liquid seal structures 81, 82 to reduce leakage of the high pressure liquid into the passage of lower pressure, resulting in a loss of pump efficiency. The sealing means 81 illustrates an embodiment to be used between the adjacent stages 1 and 5 in which the impellers 37, 41 are both facing in the same direction. The sealing means 82 illustrates an embodiment to be used between the adjacent stages 4 and 7 in which the impellers 40, 43 are mounted back to back.

The sealing means 82 shown in greater detail in Fig. 2 comprises a sleeve 83 having annular radially extending surfaces 92, 93 presented respectively to compartments 35, 32 adjacent each end of the sleeve 83. The sleeve 83 is concentrically mounted on shaft segment 46. Shaft segment 46 is defined as that part of shaft 28 extending between impellers 40, 43. The sleeve 83 telescopically surrounds at least a portion of each of the collars 84, 85 of impellers 40, 43 disposed in the adjacent compartments. The collars 84, 85, respectively, extend rearwardly of the inlet 45 of each of the impellers 40, 43. The sleeve 83 presents intermediate its ends a first external axially extending sealing surface 96 and a second internal axially extending sealing surface 97. The first external surface 96 of sleeve 83 is in slidable sealing engagement with the internal surface 91 of the casing portion 89 which may be integral with casing or in the form of a bushing inserted in the casing as shown in Figs. 1 and 2. The second internal sealing surface 97 has a first inwardly directed flange means, shown as flange 86 and an axially extending means 99. Flange 86 presents a third surface 98 which embraces the shaft segment 46 and is in slidable sealing engagement therewith. The axially extending means 99 embraces portions of collars 84, 85 and is in slidable and nonrotatable engagement with portions of collars 84, 85. Means cooperating with the shaft 28 and the sleeve 83, shown as key 87, prevents the sleeve 83 and the flange 86 from rotating about the shaft 28 but allows them to slide axially relative to the shaft 28. The sleeve 83 and the flange 86 define with the collar 84, a space about the shaft 28 for resilient means, shown as packing rings 88. The differential pressure of seventh stage over fourth stage will act upon the sleeve 83 and the flange 86 to force the packing rings tightly against the collar 84 and the shaft 28 to thereby prevent leakage along the shaft 28. The internal surface 91 of the casing bushing or portion 89 embraces the outer surface of the sleeve 83. Circumferentially disposed grooves 90 on sleeve 83 reduce leakage between the bushing 89 and the sleeve 83.

The embodiment illustrated by the sealing means 81 in Fig. 1 is exactly the same as the sealing means 82 except that the sleeve 83*a* is mounted about the collar 84*a* of a single impeller 37. The sleeve 83*a* does not extend beyond the flange 86*a* as in the sealing means 82. The cross sectional surface of the sleeve 83*a* and flange 86*a* is therefore L-shaped rather than the T-shape that is presented by the corresponding surface in the sealing device 82.

Both of these sealing means 81, 82 reduce the leakage between adjacent passages by utilizing their pressure differential to act upon packing to create an effective seal. The greater the differential in pressure, the greater will be the force on the packing to resist leakage along the shaft. The sleeve 83, 83*a* turns with the shaft 28 and protects the impeller collars 84, 84*a*, 85 from wear. The sleeve 83, 83*a* and the bushing 89, 89*a* will

in time become worn but can be replaced at relatively low cost.

In operation, as the shaft 28 is rotated, the first stage impellers 36, 37 take suction from the intake chamber 11. Impellers 36, 37 discharge the liquid into annular passages 29 including the one adjacent the sealing means 81. Passages 29 convey the liquid from the first stage to the suction portion of the impeller 38 mounted in passage 30 which forms the second stage. The liquid is pumped from the intake chamber 11 to the discharge chamber 12 through a series arrangement of seven pumping stages. Fourth stage liquid discharge and seventh stage liquid discharge appear on opposite sides of sealing means 82, and first stage liquid discharge and fourth stage liquid discharge appear on opposite sides of sealing means 81.

The higher fourth stage liquid pressure acts on sleeve 83a and causes it to compress packing rings 88 against collar 84a thereby sealing the first stage from the fourth stage.

Sealing means 82 operates in a like manner except that in this arrangement sleeve 83 telescopically surrounds portions of the two collars 84 and 85. The seventh stage liquid pressure urges sleeve 83 against the packing rings 88 which in turn are compressed against collar 84 to seal the fourth stage from the seventh.

From the foregoing it will be apparent to those skilled in the art that the illustrated embodiments of the invention provide a new and improved liquid pumping machine and accordingly accomplish the objects of the invention. On the other hand, it will also be obvious to those skilled in the art that the illustrated embodiments of the invention may be variously changed and modified, or features thereof, singly or collectively, embodied in other combinations than those illustrated, without departing from the spirit of the invention, or sacrificing all of the advantages thereof, and that accordingly the disclosure herein is illustrative only, and the invention is not limited thereto.

It is claimed and desired to secure by Letters Patent:

1. In a centrifugal pump comprising a casing defining an inlet passageway, an outlet passageway and a plurality of compartments adapted for fluid communication, a shaft supported for rotation in said casing and extending between and through said compartments, a plurality of impellers mounted on said shaft and hydraulically connecting said compartments in series relation between said inlet and outlet passageways for the flow of liquid therethrough, each of said impellers having a collar extending rearwardly of the inlet of each of said impellers and surrounding said shaft, a first one of said impellers being operatively disposed for rotation in said casing to establish a first predetermined pressure in a first one of said compartments and a second one of said impellers being operatively disposed for rotation in said casing to establish a second predetermined pressure in a second one of said compartments adjacent said first compartment, said first predetermined pressure being higher than said second predetermined pressure, said second impeller being disposed with its collar extending toward said first compartment, the improvement comprising a liquid seal structure including a portion of said casing extending between said first and second compartments, said casing portion surrounding a segment of said shaft and presenting an internal annular sealing surface in radially spaced concentric relation thereto, a sleeve concentrically mounted on said shaft segment between said casing portion and said shaft, means cooperating with said shaft and said sleeve for securing said sleeve in nonrotatable and axially slidable relation to said shaft, said sleeve having a part telescopically surrounding at least a portion of said collar of said second impeller, said sleeve presenting at each end thereof annular radially extending surfaces opened to said first and second compartments and presenting intermediate said ends a first external axially extending sealing surface and a second internal axially extending sealing surface, said second surface having a first inwardly directed flange means and an axially extending means, said first surface being in slidable sealing engagement with said internal surface of said casing portion and said flange means presenting a third surface in slidable sealing engagement with said shaft segment, said axially extending means being in slidable and nonrotatable engagement with said portion of said collar of said second impeller, and resilient means surrounding said shaft between said flange means and said portion of said collar of said second impeller, said resilient means being compressible into positive sealing engagement with said shaft segment and said flange means and said portion of said collar of said second impeller in response to the difference between said first and second predetermined pressures on said annular radially extending surfaces.

2. The liquid seal structure of claim 1 in which said second surface presents a first part in slidable sealing engagement with said shaft segment and a second part radially spaced from said first part of said second surface in slidable sealing engagement with said portion of said collar of said second impeller.

3. The liquid seal structure of claim 1 in which said sleeve presents intermediate said ends a first external circumferentially grooved axially extending sealing surface.

4. The liquid seal structure of claim 1 in which said first and second impellers are disposed in spaced back to back relation with their collars extending toward each other and said sleeve has parts telescopically surrounding at least a portion of each of said collars of said first and second impellers.

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