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CENTRIFUGAL PUMP SEALING SYSTEM FOR VISCOUS ABRASIVE LIQUIDS

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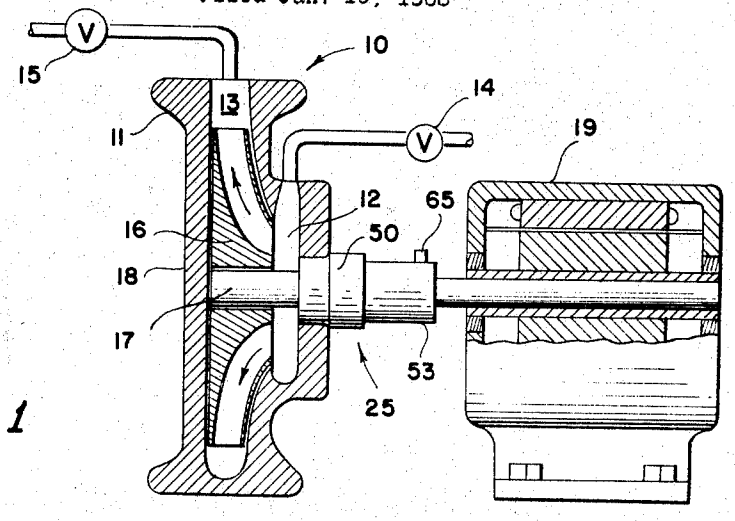

FIG. 1

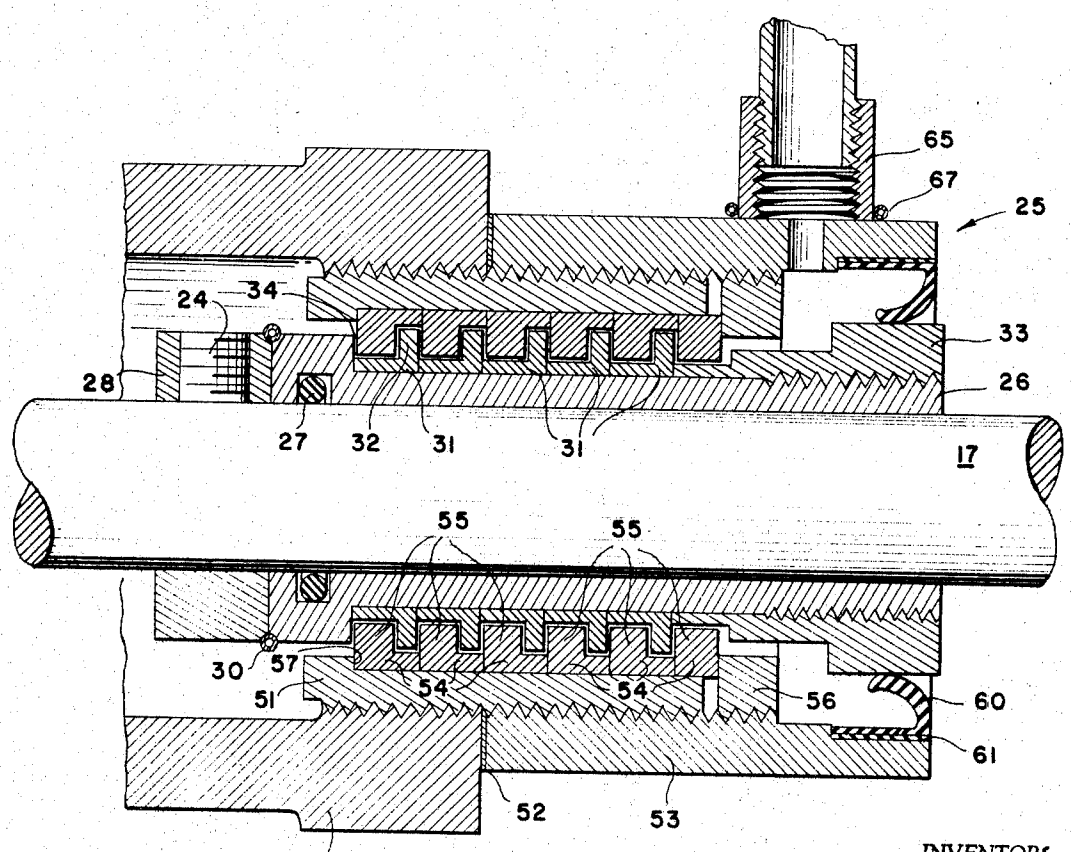

FIG. 2

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CENTRIFUGAL PUMP SEALING SYSTEM FOR VISCOUS ABRASIVE LIQUIDS

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ABSTRACT OF THE DISCLOSURE

A non-wearing sealing system for a centrifugal pump or the like for use in moving viscous and abrasive liquids, including a sealing unit having an outer portion connected to the casing of the device and an inner portion connected to the shaft, said portions being non-contacting and defining therebetween a continuously open tortuous or labyrinth passage. The outer end of this passage is at atmospheric pressure and may have a flexible lip-type seal element permitting external air to flow into the passage; and the inner end of this passage terminates adjacent the impeller inlet as applied to a centrifugal pump such that any flow of air through the passage is dependent upon the pressure conditions adjacent the inner end. Inflow to and outflow from the pump is controlled by valves or the like, thus varying the pressure inside the pump adjacent the inner end of the passage. A negative pressure may be effected to induce an inflow of air through the passage, thus sealing against leakage of the viscous abrasive liquid, while avoiding wear problems of contact type seals, or the pressures across the seal may be balanced to effect sealing.

Background—field of the invention

This invention relates to a sealing system for a fluid device, and in particular it relates to a system suitable for the impeller shaft of a centrifugal pump used for pumping viscous liquids, particularly those with abrasive qualities.

Background—environment of the invention

Special problems arise in the handling of viscous and abrasive liquids such as liquid fertilizer. These fertilizers are generally in the form of a highly viscous slurry, literally saturated with nutrients. Most of these slurries, or suspensions, as they are called, contain up to 2% of a colloidal clay to keep the materials in a homogeneous state. The slurries must be agitated occasionally to keep them from settling out or going into a thixotropic state which hinders movement of the material when being applied or transferred into application equipment. This material is not hard to move by the centrifugal principle if supplied to the pump at a positive pressure. However, it is very difficult to provide an effective seal around the impeller shaft. This problem is caused by the fact that the materials of the slurry are of almost molecular size and tend to get under or between any kind of sealing members; and since they are abrasive and because they have a tendency to build up, they tend to cause rapid and excessive wear on the sealing members and permit the abrasive liquids to penetrate to the pump bearings.

Background—description of the prior art

Various sealing arrangements have been provided in an attempt to prevent fluid leakage along the shaft of a centrifugal pump. For example, one arrangement employs face seals which seal by axial contact of polished surfaces. However, notwithstanding the fact that these polished surfaces have been made of ceramic, carbon steel, stainless steel or high carbon steel, ultimately the abrasive

particles of the slurry enter the spaces between the surfaces and cause deterioration.

Nor have conventional tight packings around the shaft been effective to stop leakage of the slurry. As in the case of the face seals, the abrasive and corrosive particles of the slurry tend to deteriorate the packing material.

Thus, considering the state of the prior art heretofore, there remains a need for providing an effective seal for use in pumping viscous, abrasive liquids.

Summary of the invention

Thus, the purpose of this invention is to provide a sealing system which overcomes disadvantages of sealing arrangements known heretofore.

Basically, according to the present invention, the conventional shaft seal is replaced by a sealing system which is substantially free of engaging, relatively movable sealing members, and the shaft has no bearings that could be exposed to the liquids. Thus, there are no tight spaces into which the abrasive particles of the slurry can enter to cause excessive wear. Rather, the sealing system of the present invention includes a continuously open passage along the shaft between the external atmosphere and the interior of the pump, and means for controlling the pressure and velocity of the main body of fluid in the pump so as in turn to control the pressure differential across the passage. As the pressure at the inner end of the passage adjacent the impeller inlet is reduced to or below the pressure of the surrounding atmosphere, the passage may be balanced in pressure, or external air may seep into the passage, preventing leakage of the said main body of fluid from the pump. Even if there should be some initial leakage, the bearings for the shaft are spaced from the seal away from the pump, either in or adjacent the driving motor, which itself is spaced a substantial distance from the seal.

In a preferred embodiment of the invention the sealing system is employed in a centrifugal type pump. A sealing unit is mounted between the casing and the shaft on the side of the pump chamber adjacent the impeller inlet and toward the drive motor. The sealing unit is designed as a labyrinth type seal having a continuously open passage between the portion of the sealing unit connected to the casing and the portion of the sealing unit connected to the shaft, such that the two portions of the sealing unit remain substantially free from contact with each other. An optional resilient lip seal at the outer end of this passage permits flow of external air into the said passage, the amount of any such flow being controlled by the differential pressure across the passage. This control is in turn brought about by the relationship of the sealing unit to the remaining structure of the centrifugal pump. The sealing unit and the remaining structure thus form the said sealing system. The shaft bearings are in or adjacent the motor so as to be remote from the seal, and preferably there are no bearings in the pump.

Specifically, the main inlet passage to the pump impeller is designed to pass by the inner opening of the said continuous passage. Consequently, since a pump for these liquids must usually have a positive pressure at its intake (i.e., no substantial suction capability), the pressure at this inner end of the passage is varied by controlling the flow of the main body of fluid entering the pump and leaving the pump. A further feature of the sealing system thus includes variable inlet and outlet valves which can be manipulated so as to create a positive or negative pressure at the shaft on the intake side of the pump adjacent the labyrinth seal.

The system would operate in the following manner. If the outlet valve is opened completely and the inlet valve is opened only partially, a negative pressure is created at the pump intake and around the shaft adjacent the inner

end of the seal passage. By following this procedure, it is possible to reduce the effective pressure at the inner end of the passage to a level substantially below atmospheric pressure thereby inducing air to flow through the lip seal and through the continuous passage into the liquid adjacent the impeller intake. It follows, of course, that the incoming pump fluid can also be regulated so that the effective pressure at the inner end of the continuous passage is equal to the surrounding pressure so that there is neither air seepage nor leakage through the continuous passage, or that the pressure may be slightly above atmospheric to permit a slight leakage of the liquid. However, this leakage would simply drop from the pump after passing through the labyrinth and would not reach the shaft bearings.

In a preferred embodiment of the invention the passage is formed as a zig-zag or corrugated annular passage between a first set of flange and groove rings connected to the housing and a second set of flange and groove rings connected to the shaft.

Thus, it is an object of this invention to provide a new and improved sealing system for a fluid flow device.

It is another object of this invention to provide an improved sealing system for pumping viscous, abrasive liquids in a centrifugal pump, which system is non-wearing as to the sealing unit itself and the shaft bearings.

Another object of this invention is to provide, in a fluid device, a new concept in sealing, namely, a system including a sealing unit operable in combination with the structure of the fluid device and the characteristics of the fluid flowing through the device for controlling the operation of the sealing unit.

It is still a further object of this invention to provide a centrifugal pump including a labyrinth type shaft seal having a continuously open passage between an outer end and an inner end, the inner end being located in the inlet passage of the pump, and the pump including variable pump inlet and outlet valves for controlling the pressure conditions of the pump fluid in the pump intake.

Other objects and the attendant advantages of the present invention will become apparent from the detailed description to follow together with the accompanying drawings.

Brief description of the drawings

There follows a detailed description of a preferred embodiment of the invention together with accompanying drawings. However, it is to be understood that this detailed description and the accompanying drawings are intended only for the purpose of illustrating a preferred embodiment, and that the invention is capable of numerous modifications and variations apparent to those skilled in the art without departing from the spirit and scope of the invention.

In the drawings:

FIGURE 1 is a cross-sectional view of a centrifugal pump employing the sealing system of the present invention.

FIGURE 2 is an enlarged sectional view of a portion of the pump shown in FIGURE 1.

Detailed description of the preferred embodiment

Referring now to the figures, wherein like numerals designate like parts throughout, FIGURE 1 shows a centrifugal pump **10** having a generally stationary casing **11** having an inlet **12** and an outlet **13**. Variable control valves **14** and **15** control the flow of fluid into and out of the pump. A rotating impeller **16** is mounted on a shaft **17** for rotary movement therewith for conveying the liquid to be pumped from the inlet passage **12** to the outlet passage **13**.

A motor **19** drives the right-hand end of the shaft and supports the shaft and impeller in a cantilever fashion. The shaft bearings are in the motor, and there are no bearings which can be exposed to the liquid. Alternatively, in addition to the motor bearings, shaft bearings such as shown in Beuhler U.S. Patent No. 2,859,698 could be provided for supporting the shaft. Such bearings would be connected to, but outside of, the pump casing, and spaced from the shaft seal so as to be clear of any leakage through the seal. A sealing unit **25** forms a seal between the right-hand end of the casing **11** and the shaft **17**. It will be noted, in particular, that the left-hand end of this sealing unit **25** terminates in the vicinity of the inlet passage **12** and the right-hand end of this sealing unit is exposed to the atmosphere.

Referring now to FIGURE 2, the sealing unit **25** includes a sleeve **26** affixed to the shaft **17** and housing an O-ring seal **27** which encircles the shaft **17**. To the left of this sleeve is an annular collar **28** having a threaded opening for receiving a set screw for holding the collar rigidly in place on the shaft. An O-ring **30** surrounds the junction between sleeve **26** and collar **28**. A plurality of annular ring members **31** each having grooves and outwardly radially extending flanges **32** are mounted on the sleeve **26** and urged to the left against the radial face **34** of the sleeve **26**. An inner holding nut **33** is then screwed onto the sleeve **26** to hold the rings **31** in place. These elements **26** through **34**, inclusive, form the first portion of the sealing unit, which portion is rotatable with the shaft **17**.

The sealing unit further includes an outer portion affixed to the stationary casing **11** including an outer gland member **50** having an internally threaded surface. Adjacent thereto and separated therefrom by gasket **52** is an outer coupling member **53** also having an internally threaded surface. An outer sleeve **51** having a threaded external surface engages both the gland **50** and the outer coupling member **53** to hold them in place. A plurality of outer ring members **54** having inwardly projecting flanges **55** are mounted on the internal surface of sleeve **51** and urged to the left against the radial face **57** on the sleeve **51** and held in place by an externally threaded outer holding nut **56** which is screwed to the left on the internal threads of coupling member **53**. It will be noted that the elements **50** through **57**, inclusive, form the outer portion of the sealing unit which is rigidly attached to the casing **11**.

With the sealing unit mounted in the above-described manner a continuous passage exists from the left-hand end of the sealing unit through the spaces between the ring members **31** and **54** to the right-hand end of the unit. An optional annular resilient lip seal **60** is connected to the cylindrical internal surface **61** on the member **53** and resiliently engages the outer cylindrical surface on the inner holding nut **33**. In the normal operation of the invention air may flow through the sealing unit from right to left, into the pump, or there may be no air flow, but, under proper control, liquid will not flow from the left to the right through the sealing unit. The lip seal is not indispensable for successful operation of the invention. However, for several reasons it is preferable to employ the lip seal. First, in the event that the pump is inadvertently operated in an abnormal manner the lip seal will prevent or at least minimize outward flow of liquid if at low pressure. Additionally, the seal controls the inward flow of air and limits the inward flow of atmospheric dust of other foreign matter into the seal area.

The sealing unit may also include an auxiliary fluid fitting **65** connected through passage **66** to the interior of the sealing unit and sealed by O-ring **67** for the purposes of cleaning out the continuous passage in the sealing unit.

In the operation of the invention valves **14** and **15** would be opened a predetermined amount and pump shaft **17** would be turned by motor **19**. The inner portion of the sealing unit will rotate with the shaft **17** while the outer portion remains stationary. Of course, the opening in fitting **65** would be closed. It is important

that the inner end of the continuous passage be located adjacent the inlet channel **12**. The pressure at this inner end of the passage will then be dependent upon the pressure of the liquid in the pump intake. For example, given a certain speed of the shaft **17** and the impeller **16**, the valve **15** may be fully opened and the valve **14** only partially opened, thus throttling the inlet, so that the pressure in inlet channel **12** is decreased, thereby decreasing the effective pressure at the inner end of the continuous passage. The effective pressure of the liquid at the left-hand end of the continuous passage will be, or can thus be made to be, equal to or less than the surrounding atmospheric pressure at the outer end of the channel so that air could pass through the lip seal **60** and through the continuous passage into the pump. This will effectively prevent the flow of the main pump liquid outwardly, through the sealing unit. Normally, this air passing into the pump causes no difficulty. However, if for some reason, it is thought undesirable to permit air to seep into the pump, the valve **14** may be opened further, thereby increasing the effective pressure in the pump intake to a level equal to the atmospheric pressure so that the differential pressure across the passage, and thus the flow through the sealing unit, is substantially zero.

Summarizing, the present invention relates to a sealing system including a sealing unit operable in combination with the remaining structure of the fluid flow device, including the inlet valve, the outlet valve and the arrangement of the inlet channel. With this system it is possible to create a zero pressure differential, or a negative pressured differential across the sealing unit and thereby cause external air to flow from the surrounding atmosphere into the pump, notwithstanding the fact that the stagnation pressure of the incoming liquid (the pressure of the liquid at zero velocity) is actually above atmospheric pressure, that is, there is a positive pressure to feed to the pump.

Of course, when the pump is shut down the valves **14** and **15** must be closed. Otherwise, the effective pressure of the fluid at the left-hand end of the continuous passage would in fact be the stagnation pressure of the liquid which is greater than atmospheric pressure. Consequently, fluid would flow outwardly through the seal and out of the sealing unit except to the extent that the flow could be prevented by lip seal **60**.

Although the invention has been described and illustrated in considerable detail to illustrate a preferred embodiment, it should be understood that the invention is capable of numerous modifications and variations apparent to those skilled in the art without departing from the siprit and scope of the invention as defined in the claims.

We claim:

1. In a centrifugal pump having a casing with an inlet opening, an outlet opening an impeller rigidly mounted on a shaft or rotary movement therewith relative to said casing, and an inlet channel from said inlet opening to said impeller; a system for sealing the pump comprising: a sealing unit having an inner portion secured to said shaft, and an outer portion secured to said casing, said inner and outer portions defining therebetween a substantially continuously open passage, said passage having an outer end and an inner end, said inner end normally communicating with said inlet channel such that the pressure at said inner end, and thus the pressure differential across the passage, is dependent upon the pressure of the fluid in the inlet channel, and means for varying and controlling the fluid passing through the channel from the inlet opening to the impeller, and thereby controlling the pressure in the channel and the pressure differential across said passage, and thus the leakage of fluid through said passage.

2. The invention of claim **1** wherein said means for varying and controlling comprises a variable inlet valve and a variable outlet valve for controlling the flow of fluid into and out of the pump.

3. The invention of claim **1** wherein each of said portions includes a plurality of annular grooves and annular radially extending flanges, and wherein the flanges of each portion extend into the grooves of the other portion to form an annular zig-zag opening which constitutes said passage.

4. The invention of claim **3** wherein the said inner tion comprises an internally threaded gland affixed to the casing and an internally threaded outer coupling member, both threadedly engaged with a hollow externally threaded sleeve, and said grooves and flanges of the outer portion being formed by a plurality of ring members held in place against the internal surface of said hollow sleeve.

5. The invention of claim **4** wherein the said inner portion includes an inner sleeve affixed to the shaft for rotation therewith, and said annular grooves and flanges of said inner portion comprises a plurality of ring members held in place against the external surface of said inner sleeve member.

6. In a fluid flow device for moving viscous abrasive fluids, and having a casing in which the fluid flows along a main flow path from an inlet opening to an outlet opening, and a shaft extending into the casing and having mounted thereon means for impelling the fluid from the inlet opening to the outlet opening, a system for preventing fluid flow between the shaft and the casing comprising: (a) a sealing unit having different portions connected to both the casing and the shaft and leaving a relatively small continuously open labyrinth passage therebetween, the passage having an inner end exposed to the said fluid flow path in the casing and an outer end opening outside the casing, and (b) means for varying and controlling the pressure of the fluid in the main fluid flow path adjacent the said inner end, thereby controlling the flow of fluid through the passageway.

7. A fluid flow device as set forth in claim **6** wherein said last mentioned means comprises means for regulating said inlet opening to vary the flow of liquid therethrough to the impelling means, and wherein the inner end of said passage is exposed to the flow path between said inlet opening and said impelling means.

8. A fluid flow device as claimed in claim **7** wherein the outer end of said passage is exposed to the atmosphere at least during the time when the pressure at the inner end thereof is at a predetermined level below atmosphere.

9. Apparatus as claimed in claim **1** wherein said outer end of said passage is normally closed by a resilient sealing means which is openable in response to pressure conditions in said passage lower than the exterrnal surrounding pressure by a predetermined amount.

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103—97; 277—56, 59