Jan. 26, 1971 S. BYLSMA 3,558,236

SELF-PURGING REGENERATIVE TURBINE PUMP

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Fig. 2

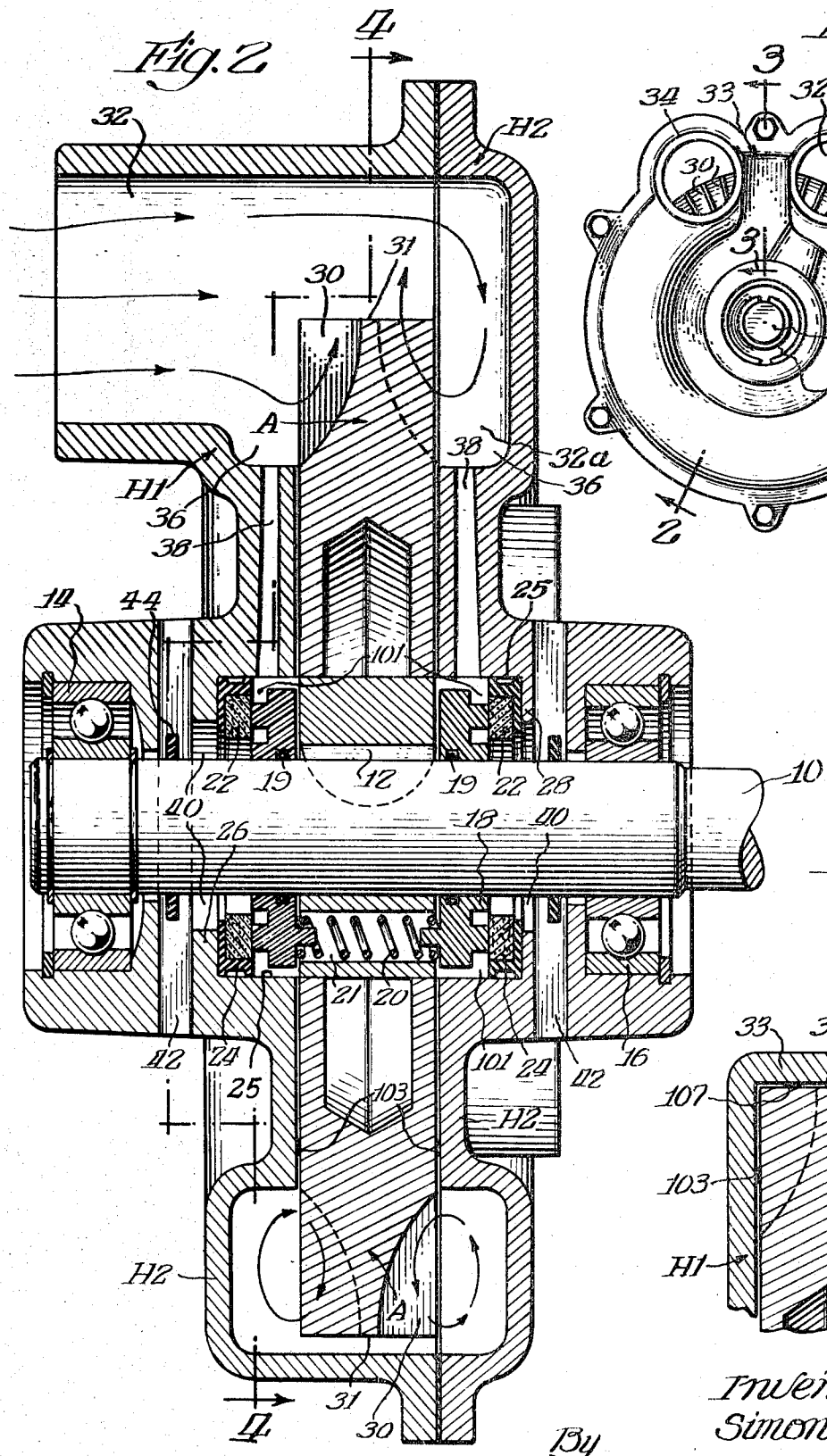


Fig. 1

Fig. 3

Inventor:
Simon Bylsma
By
Bair, Freeman & Molinare
Attys

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Fig. 4

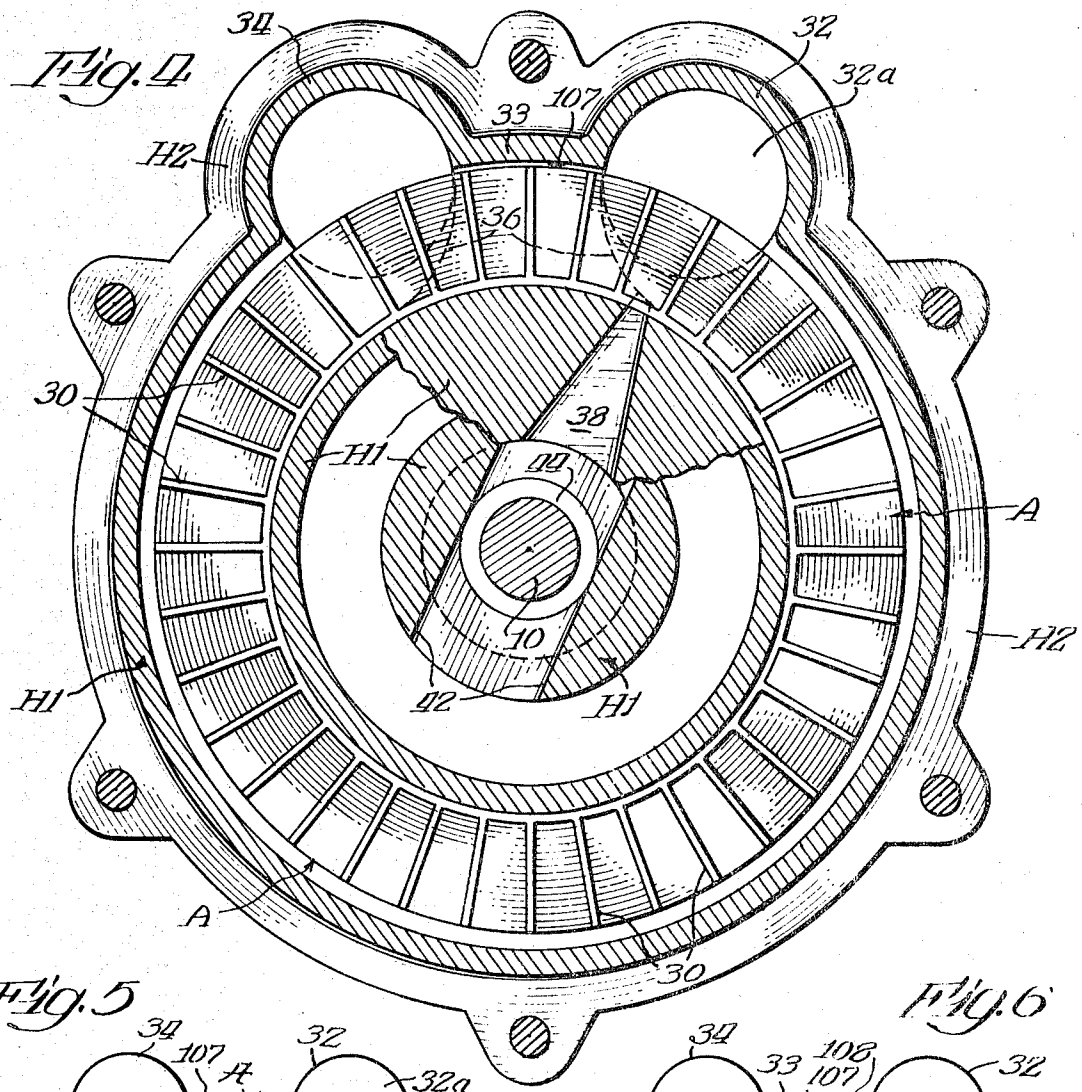


Fig. 5

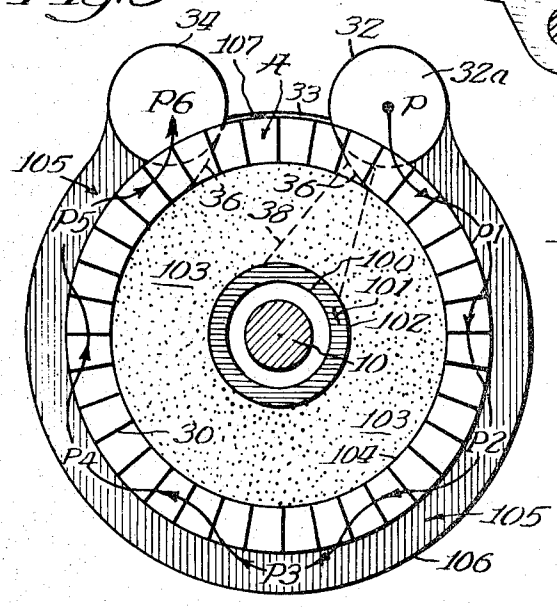
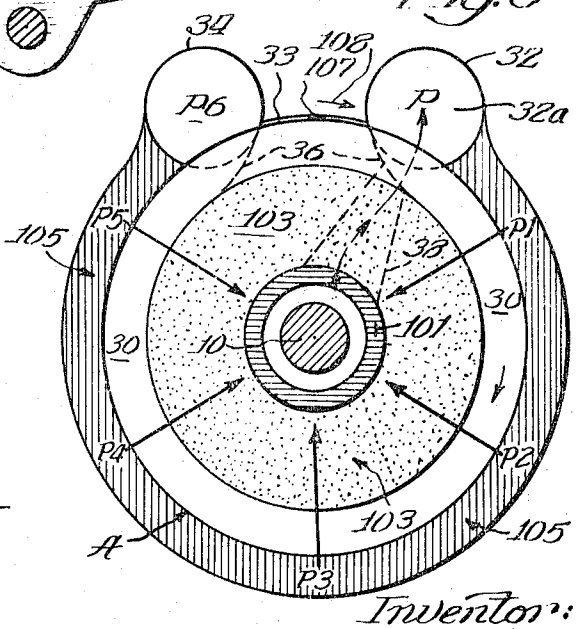


Fig. 6



Inventor:
Simon Bylsma

By Bair, Freeman & Molinare Attys

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3,558,236

SELF-PURGING REGENERATIVE TURBINE PUMP

Simon Bylsma, Des Moines, Iowa, assignor to Delavan Manufacturing Company, Des Moines, Iowa, a corporation of Iowa

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ABSTRACT OF THE DISCLOSURE

A self-purging regenerative turbine pump so constructed that internal clearance spaces and cavities are continuously purged during operation of the pump, thereby permitting the pumping of contaminated liquids. Clearance spaces between the ends of the impeller and the adjacent surfaces of the housing, and between the periphery of the impeller and the stripper wall of the housing are slightly thicker than the size of contaminants entrained in the liquid being pumped. The first-mentioned spaces communicate with a seal cavity, and the seal cavity has means of free hydraulic communication with the inlet of the pump to insure a continuous flow of purging liquid as long as the pump is in operation.

BACKGROUND OF THE INVENTION

A regenerative type of turbine pump is capable of developing higher pressures at relatively lower rotational speeds than centrifugal pumps. They are commonly used for pumping low viscosity liquids at pressures up to 250 p.s.i.g. and higher, with rotational speeds of 1750 r.p.m. and lower. This type of pump however, because of the operating characteristics just mentioned generally require close internal mechanical clearances between the impeller and the pump housing which makes them unsuitable for pumping liquids containing contaminants such as abrasive foreign particles.

Karassik and Carter, in their book, "Centrifugal Pumps" published in 1960 by F. W. Dodge Corporation, New York, on pages 158, 159, 160 and 161 (Library of Congress catalog card No. 60–16698) describe the operating principle of regenerative turbine pumps. On page 161 they state as follows:

"Because the satisfactory operation of the regenerative pump depends on the close clearance between the impeller and the separating wall or stripper, this pump is not too suitable for handling corrosive liquids or liquids containing abrasive foreign particles. * * * Solid particles * * * may also build up and wear upon the pump surfaces at the running clearances. * * * The regenerative pump should generally be used to handle clean, clear liquids."

Pumps used for agricultural spraying must pump high concentrations of insecticides and herbicides used as agitated slurries or suspensions of wettable powder in water. Accordingly turbine pumps have not been suitable for that service, and if so used they wear excessively. In previously manufactured turbine pumps, suspended solid substance would find its way into the accessible inner spaces of the pump where centrifugal force acting as a centrifuge causes the wet powdered particles to pack solidly in the voids, and particles would enter clearance spaces between close, relatively moving surfaces and clog and/or abrade them, thus causing the pump to malfunction or fail. Consequently regenerative turbine pumps have not been practical for agricultural spraying and it has been necessary to use centrifugal pumps which require expensive accessory gear or belt drives to greatly increase their rotational speed above that available from

the power take-off shaft of a farm tractor. This is because centrifugal pumps by their nature must rotate at much higher speeds to produce discharge pressures and flow rates equal to those from turbine pumps.

Accordingly an object of my present invention is to provide a regenerative turbine pump having means for purging inner cavities of contaminant during operation so that such contaminants will not accumulate and cause the pump to malfunction.

Another object is to provide a turbine pump which can be driven by direct attachment to the power take-off shaft of a farm tractor without the necessity for accessory gear or belt drives and yet which operates efficiently.

Still another object is to provide a turbine pump of the character herein disclosed which is relatively simple and inexpensive to manufacture.

A further object is to provide a turbine pump having bearings for the shaft thereof which are isolated by drain cavities from seal cavities of the pump so that the bearings cannot become damaged by trace quantities of water and contaminant which may leak past the shaft seals.

BRIEF SUMMARY OF THE INVENTION

The herein disclosed regenerative turbine pump is designed with self-purging clearance spaces in areas of the housing bounded by the inner surfaces of the housing adjacent the sides of the impeller, the adjacent side faces of the impeller, the periphery of the impeller adjacent the roots of its blades and the outer limit of the seal cavities, and in the area of the stripper wall bounded by the radial inner face of the wall, the periphery of the impeller and the inlet and outlet of the pump. These clearance spaces permit controlled flow of the liquid in which solid particles are entrained from high pressure areas of the pump to low pressure areas thereof, namely to the seal cavities of the pump from which substantially free flow of such fluid to the intake of the pump where negative pressure is developed afforded by the provision of hydraulic communication between the seal cavities and the negative pressure areas of the pump.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of a self-purging regenerative turbine pump embodying my invention.

FIG. 2 is an enlarged vertical sectional view thereof on the line **2—2** of FIG. 1, and is taken through the inlet of the pump.

FIG. 3 is a similar enlarged vertical sectional view on the line **3—3** of FIG. 1, and is taken through a stripper wall of the pump.

FIG. 4 is a sectional view on the line **4—4** of FIG. 2 on a reduced scale.

FIG. 5 is a diagrammatic view for explaning the operation of the pump and my arrangement for purging the internal cavities thereof during operation; and

FIG. 6 is a similar but more simplified diagram, the rotor blades of FIG. 5 being omitted to better show the internal clearance cavities and the flow of liquid for the purging operation.

DESCRIPTION OF THE PREFERRED EMBODIMENT

On the accompanying drawings I have used the reference characters **H1** and **H2** to indicate pump housing units which are gasketed and bolted together in well known manner as shown in FIGS. 1, 3 and 4. An impeller A is mounted in the housing **H1–H2** on a shaft **10**. The impeller is secured to the shaft as by a key **12**. The shaft **10** is journalled in a bearing **14** carried by the housing unit **H1** and a bearing **16** carried by the housing unit

H2. The right hand end of the shaft **10** may project to a suitable coupling for attachment to the power take-off of a tractor or any other suitable source of power.

Seal rings **18** and **24** are provided around the shaft **10** at opposite sides of the impeller A and coact with seal seats **22** of ceramic or the like under the action of several seal springs **20** carried in bushings **21** of the impeller A. The seal ring assemblies **18**, **22**, **24** are contained in counterbores **25** formed outwardly from the inner surfaces of the housing units H1 and H2 which terminate in internal flanges **26** and **28** of the housing units. O-rings **19** are provided for sealing purposes as between the seal rings **18** and the shaft **10**, and the seal rings **24** engage the flanges **26** and **28** of the housing units H1 and H2 respectively under the bias of the seal springs **20**.

The impeller A has blades **30** cut into its marginal periphery and on opposite sides of a center land **31** in the usual way. The housing unit H1 has an inlet **32** which as shown in the upper part of FIG. 2 communicates with an inlet cavity **32***a* of the housing unit H2. Arrows show the path of liquid entering the inlet and delivered to opposite sides of the impeller. Adjacent the marginal periphery of the impeller A and radially inward of the blades **30** are negative pressure chambers **36** in the housing units H1 and H2. Flow passageways **38** communicate these chambers with seal cavities **101** adjacent the shaft **10** for producing negative pressures therein for an important purpose which will hereinafter appear.

As shown in FIGS. 3 and 4 a stripper wall **33** is provided between the inlet **32** and the outlet **34** as usual in regenerative turbine pumps. At **40** (see FIG. 2) outboard seal cavities are positioned externally of the seal units **18**, **22**, **24** and I provide drain passageways **42** for the purpose of draining out any trace quantities of water and contaminant which may leak past the seal units. To aid in this respect slinger washers **44** are provided on the shaft **10** substantially aligned with the drain passageways **42** and the drain passageways have parallel sides as shown in FIG. 4. so they will not entrap liquid no matter in what clockwise position the pump may be.

Referring to FIG. 5, a diagram is shown somewhat similar to FIG. 4 wherein the seal cavity **101** is defined by circles **100** and **102** which represent the internal and external circumferences of the seal cavity. A third circle **104** represents the periphery of the impeller A at the roots of the blades **30** and a fourth circle **106** represents the internal diameter of the housing H1, H2. Between the circles **102** and **104** is a clearance area designated **103** and between the circles **104** and **106** is a pressure developing area **105**. The seal cavity **101**, the clearance area **103** and the pressure developing area **105** are washer-like in character and I have shown the seal cavity **101** shaded by horizontal lining, the clearance areas **103** by stippling and the pressure developing area **105** by vertical lining. There is also a clearance area **107** between the stripper wall **33** and the periphery of the center land **31** of the impeller A.

For the operation of a regenerative turbine, reference is made to the diagram in FIG. 5, wherein a succession of arrows shows the general path of the liquid being pumped, first from the negative pressure area P at the inlet **32**, **32***a* and one of the chambers **36** and into the blades **30** as shown by the arrows at the top of FIG. 2, whereupon the impeller blades engage the liquid and centrifugal force throws the liquid out to the periphery of the impeller and into the pressure developing area **105**. The liquid leaving the impeller blades has had velocity energy added thereto and leaves the impeller to produce a first pressure such as P1. The housing H1, H2 causes a gradual reduction of velocity with an accompanying increase in potential energy or pressure as indicated by the arrows at the bottom of FIG. 2, and the pump has thus generated the pressure indicated as P1. The shape of the housing as shown at the bottom of FIG. 2 is such as to impart a

rotating motion to the liquid as it leaves the impeller cavities as indicated by the arrows just referred to, and as the rotating motion of the impeller continues the liquid is guided back into the roots of the cavities and proceeds circumferentially around the housing as shown by the arrows in FIG. 5, adding energy to the liquid every time it leaves and reenters the impeller. For instance, pressures P2, P3, P4, P5 and P6 are indicated arbitrarily, the pressure at P2 being greater than at P1, the pressure at P3 being greater than at P2 and so on. The effect is a stagging progression whereby the final regenerated pressure at P6 is considerably greater than produced by centrifugal action alone as in ordinary centrifugal pumps.

In FIG. 6 the diagram of FIG. 5 has been simplified so that arrows to show the direction of purging fluid flow may be used. Since the flow passageway **38** is producing negative pressure in the seal cavity **101**, and pressures P1, P2, etc. are being developed in the pressure developing area **105**, there will be flow of liquid inwardly as indicated by radial arrows from P1, P2, etc., to the seal cavity **101**. By having the clearances throughout the area **103** slightly greater than the maximum size of the particles entrained in the liquid being pumped there is no interference with this purging flow, a certain percentage of the liquid being thereby recirculated from the pressure producing areas back into the inlet of the pump but at all times producing a flow as long as the pump is in operation which will actually purge the clearance spaces of any entrained solids instead of permitting them to abrade the relatively moving surfaces of the pump which face each other, and also eliminating any packing of particles into spaces such as found in the seal cavities of the pump. Likewise a similar clearance is provided in the clearance area **107** for purging purposes and wherein there is direct leakage flow of purging liquid across from the outlet **34** to the inlet **32** as indicated by the arrow **108**.

I have exhaustively tested a number of self-purging regenerative turbine pumps of the kind herein disclosed and they have successfully passed more than 700 hours at maximum rated pressure and capacity with enormous concentrations of kaolin clay (an extremely abrasive test material) in the water being pumped with satisfactory performance and substantially no wear caused by the abrasive material. Since there is a constant purging flow (made possible by clearance spaces great enough for entrained particles to pass freely between adjacent, relatively moving surfaces thereof) such flow is had without the abrasive action encountered when the spaces are insufficient to permit ready passage of the solid particles. By pressurizing the seal cavity **101** due to the flow as indicated by the radial arrows in FIG. 6 from the areas P1, P2, etc., such self-purging flow is assured when the seal cavities are also subjected to negative pressure applied by reason of hydraulic communication afforded by the flow passageway **38** from the seal cavity to the pump inlet.

By way of a general example; the clearances in the areas **103** and **107** may be 0.10" for most agricultural insecticides. Accordingly, if there is no liquid in the pump the impeller can contact one of the housing units H1 or H2 and there will be 0.20" clearance between the other side of the impeller and its housing unit. When pumping liquid however, the impeller becomes hydrostatically balanced and so centers itself between the adjacent housing faces with a clearance of .010" on each face, and runs free. Maximum clearance in the areas **103** and **107** are also limited by the specified efficiency of the pump. All of this can be taken into consideration in specifying a particular pump for a particular liquid to be pumped. Since there is a constant purging flow of the liquid, this of course reduces efficiency compared to very small clearances for the pumping of clear liquid, but some efficiency can be sacrificed to obtain the purging flow of liquid which prevents excessive wear in the parts of the pump, and the matter of efficiency, design clearances and specific liquids can all be related to each other and tabulated in such form

as to predict performance after these factors have been established by actual working conditions.

In summary, liquid enters the turbine impeller at the inlet and progressively is brought to higher and higher pressures which each cycle of recirculation into and out of the turbine blades. Accordingly pressure becomes progressively higher around the periphery of the impeller from inlet to outlet. The stripper wall **33** isolates high pressure areas from low pressure areas. The amount of leakage or bypass flow (for purging purposes) from high to low pressure areas, is limited by the closeness of the clearance at **107** between the limits of the impeller and the stripper surface, and a similar clearance **103** across the side faces of the impeller, the flow being in the direction of lesser pressure. The purging flow of course carries with it any suspended burden of wet powder or the like. By relating the closeness of the clearances to the particle size, the purging flow may be controlled. Different clearances can be produced in the process of manufacturing the pumps, and in the sale thereof the pumps can be rated in a progressive series also related to particle size and/or specific brand names of insecticides or the like.

Heretofore regenerative turbine pumps have had clearances between moving parts which were very close. Accordingly any suspended particles in the liquid being pumped tends to wear the metal pump parts by abrasion, and where cavities are large such as in proximity to the shaft, the particles tend to accumulate either by settling or by centrifuging action so they pack tightly and build up, thereby causing degradation and failure of the pump.

This difficulty is overcome in my pump by providing a return flow passage from the seal cavity to the pump inlet and by maintaining clearances large enough to permit a controlled leakage to provide constant purging circulation through all clearance spaces between moving parts, thus preventing damaging accumulations of contaminant. My pump is also designed so that any leakage of liquid which may seep past the shaft seals will be drained to the exterior of the pump housing and not damage the shaft bearings by corrosion, abrasion and/or contamination.

I claim as my invention:

1. In a regenerative turbine pump which has a housing with intake and outlet and a stripper wall between them, a shaft journalled in said housing, an impeller on said shaft and rotatable in said housing and having internal clearance spaces at least between the sides of said impeller and said housing, that improvement in combination therewith making said pump suitable for pumping a liquid having solid particles entrained therein which comprises: purging means for maintaining a positive flow of said liquid having said solid particles through said clearance spaces from a higher pressure to a lower pressure area in said housing during the operation of said pump to continuously purge said spaces.

2. The regenerative turbine pump in accordance with claim **1** wherein said pump includes a shaft seal cavity in said housing having sealing means therein around said shaft adjacent said impeller, said purging means including at least some of said clearance spaces communicating said seal cavity with said intake and outlet to maintain a positive flow of said liquid having said particles entrained therein through said seal cavity and each of said clearance spaces through which said positive flow of liquid flows has a thickness in excess of the maximum size of the particles entrained in the liquid.

3. A regenerative turbine pump in accordance with claim **1** wherein a drain cavity is provided in said housing between the bearing journalling said shaft in said housing and said sealing means in said seal cavity, and means for draining any liquid from said drain cavity which leaks past said sealing means and enters said drain cavity.

4. A regenerative turbine pump in accordance with claim **3** wherein said shaft is provided with a slinger washer aligned with said means for draining liquid from said drain cavity.

5. A regenerative turbine pump in accordance with claim **3** wherein said means for draining liquid from said drain cavity comprises a drain passage extending laterally of said drain cavity and having sides substantially coincident with the diameter of the drain cavity and parallel to each other to afford drainage of liquid regardless of the clockwise position of the pump.

6. The regenerative turbine pump in accordance with claim **1** wherein said purging means includes at least some of said clearance spaces communicating between said intake and outlet and said liquid is said liquid in which said particles are entrained.

7. The regenerative turbine pump in accordance with claim **1** wherein said clearance spaces have a thickness in excess of the maximum size of the particles entrained in the liquid.

8. In a regenerative turbine pump which has a housing with intake and outlet and a stripper wall between them, a shaft journalled in said housing, an impeller on said shaft and rotatable in said housing and having internal clearance spaces between said impeller and said housing, and a shaft seal cavity in said housing having sealing means therein around said shaft and adjacent said impeller; that improvement making said pump suitable for pumping a liquid having solid particles entrained therein which comprises: purging means for maintaining a controlled positive flow of said liquid having said solid particles entrained therein through said seal cavity between said outlet and said intake, through a first of said clearance spaces bounded by the inner surfaces of said housing adjacent the sides of said impeller, the adjacent side faces of said impeller, and the periphery of said impeller and said seal cavity, and a second of said clearance spaces between said stripper wall, the periphery of said impeller and the intake and outlet of said pump, said clearance spaces having thicknesses in excess of the maximum size of the particles entrained in the liquid being pumped by said pump, whereby said positive flow of liquid and entrained particles occur substantially continuously through said clearance spaces from high pressure areas to low pressure areas of said pump during operation thereof.

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HENRY F. RADUAZO, Primary Examiner

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