

Sept. 17, 1957

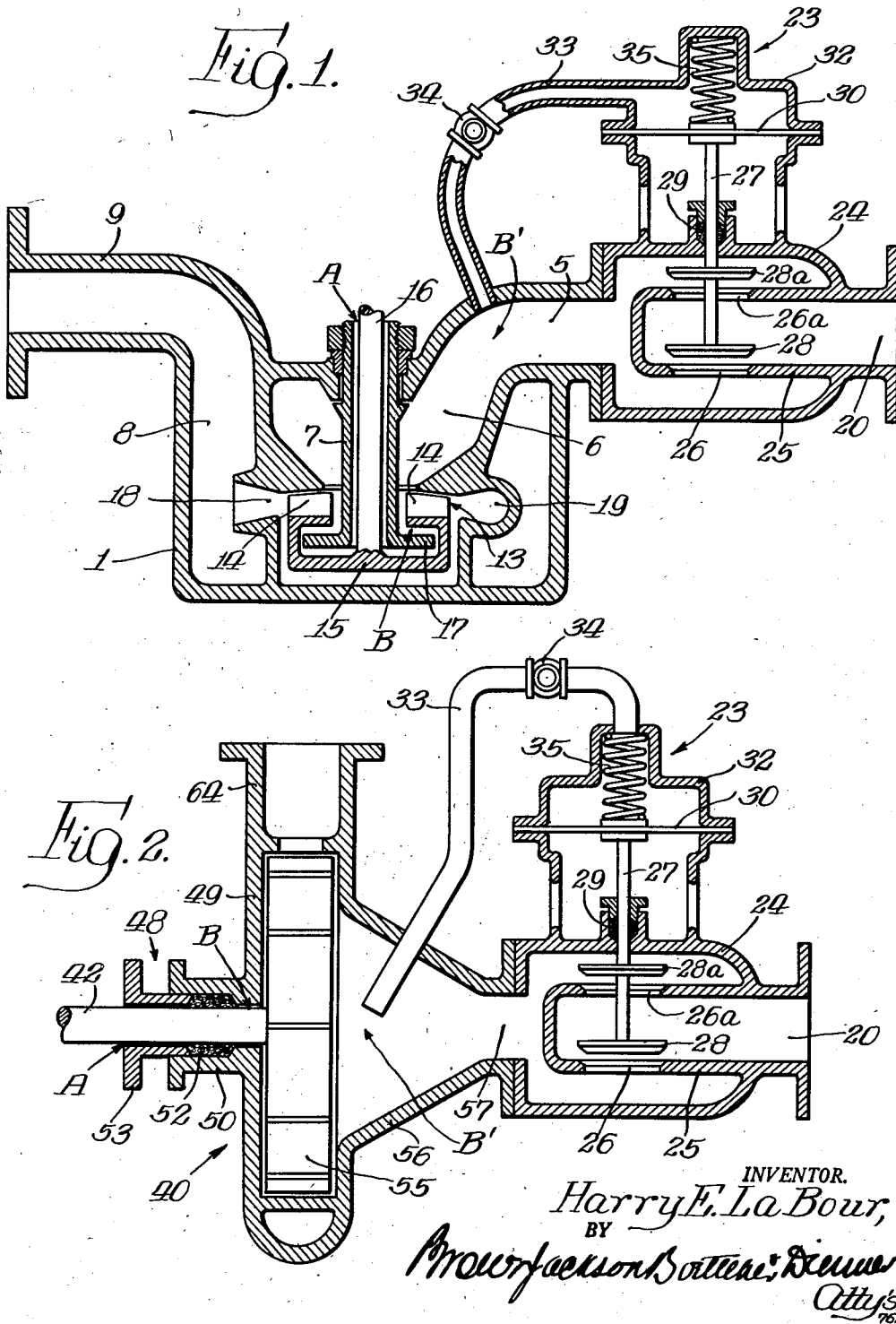
H. E. LA BOUR

2,806,433

LEAKAGE CONTROL FOR CENTRIFUGAL PUMP SHAFT SEALS

Filed July 26, 1952

4 Sheets-Sheet 1



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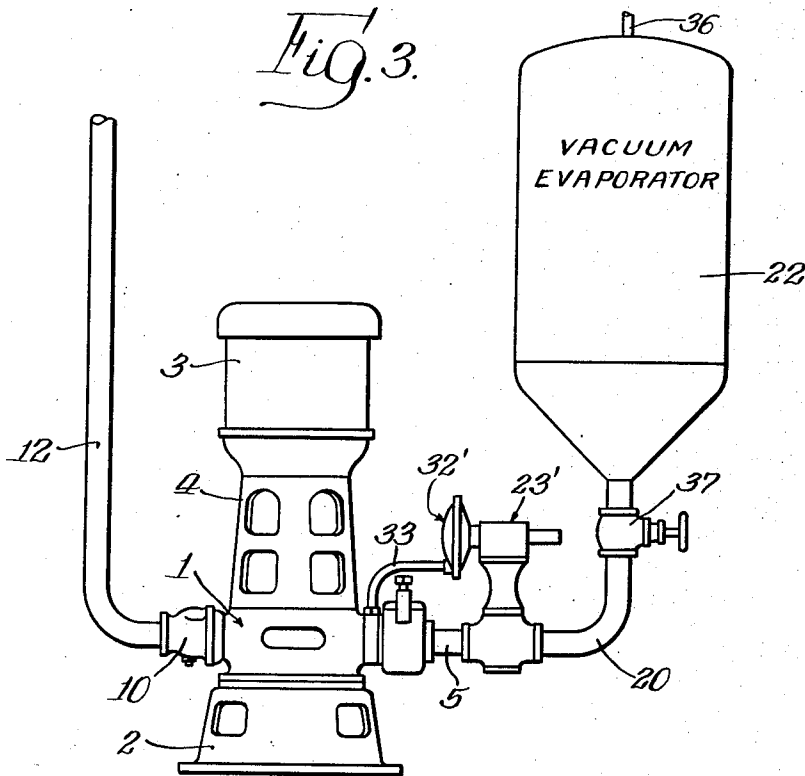
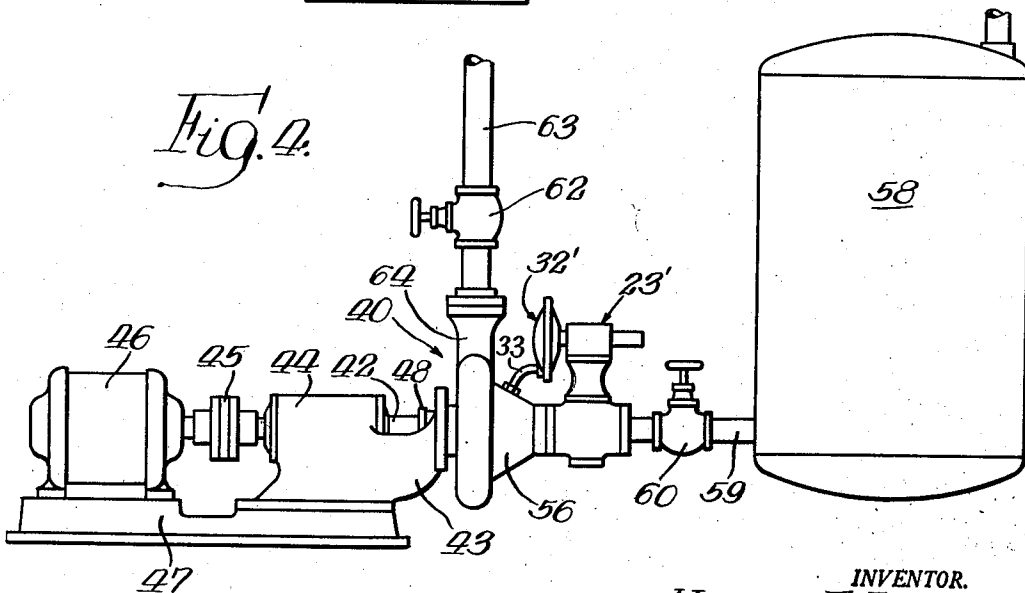
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LEAKAGE CONTROL FOR CENTRIFUGAL PUMP SHAFT SEALS

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4 Sheets-Sheet 2



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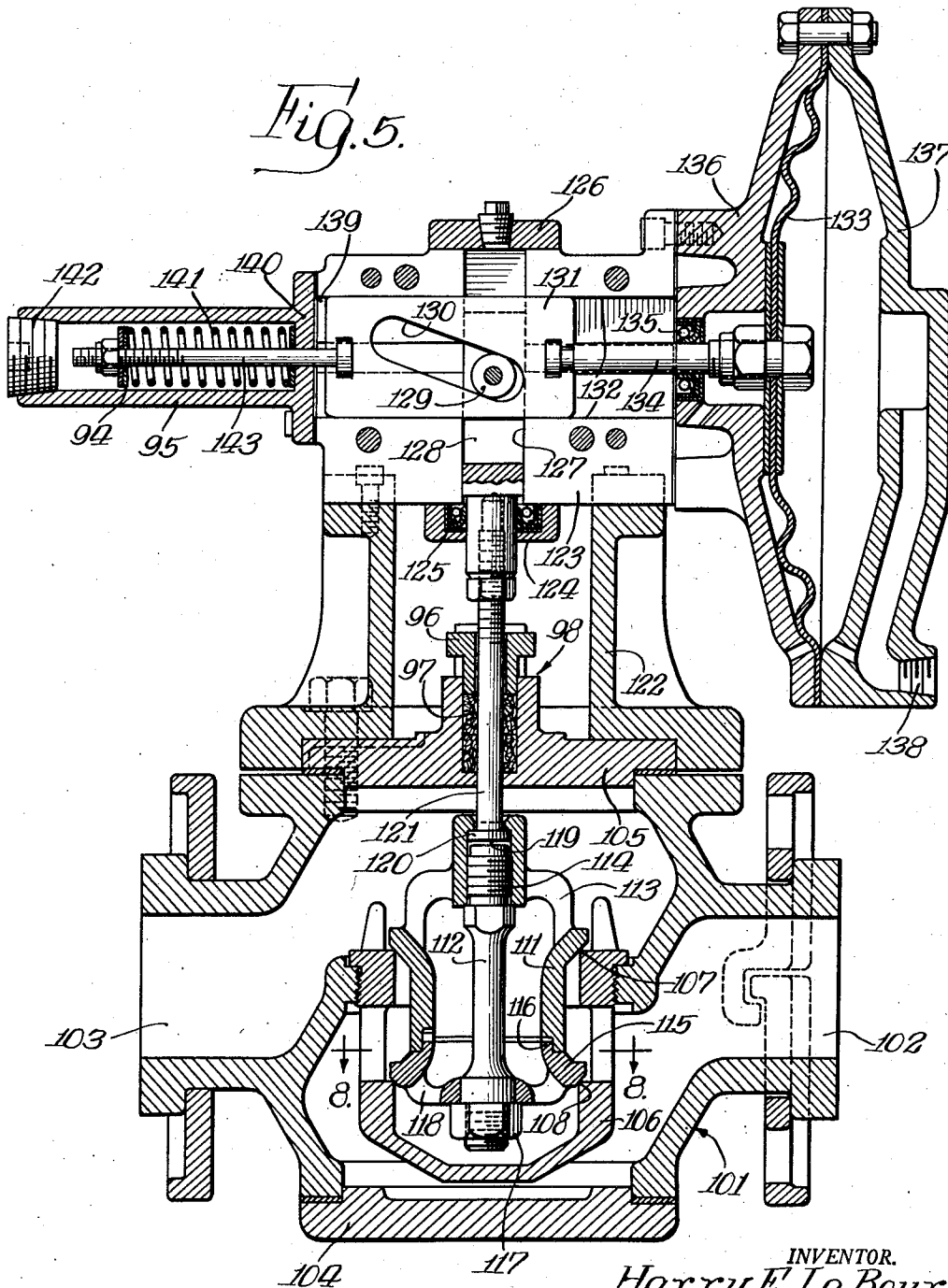
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LEAKAGE CONTROL FOR CENTRIFUGAL PUMP SHAFT SEALS

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4 Sheets-Sheet 3



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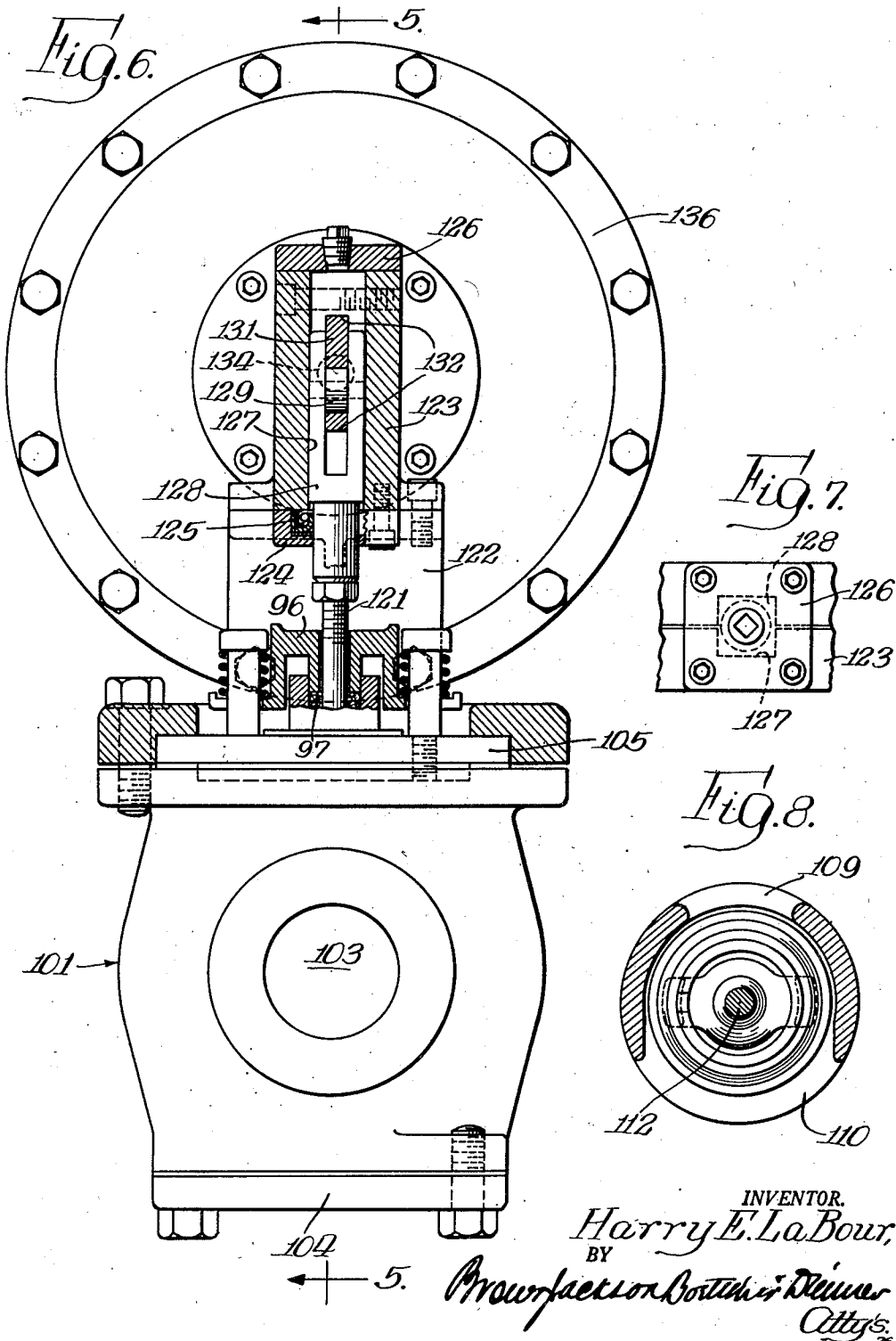
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LEAKAGE CONTROL FOR CENTRIFUGAL PUMP SHAFT SEALS

Filed July 26, 1952

4 Sheets-Sheet 4.



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2,806,433

LEAKAGE CONTROL FOR CENTRIFUGAL PUMP SHAFT SEALS

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Application July 26, 1952, Serial No. 361,053

4 Claims. (Cl. 103—97)

This invention relates to fluid pumps, and more particularly to the control of leakage at the shaft seal of a centrifugal or other rotary pump. The invention is particularly concerned with pumps having a rotary operating shaft extending out of the pump casing with which it is intended to make a fluid tight rotary joint or so called shaft seal, the inner end of which is subject to pressure variations in the pump casing due to variations in the pressure of the fluid supply, and the outer end of which shaft seal is subject to a non-related pressure, generally atmosphere.

I shall describe the invention and explain its principle in connection with a hydraulic centrifugal pump of known type, but the problem of control of seal leakage in rotary pumps and more specifically, centrifugal pumps, is not confined to a specific form of hydraulic pump, nor to specific forms of seals.

In the operation of the type G pump, which is a self-priming pump having a kinetic liquid seal, and which has a construction substantially as shown in my U. S. Patent No. 2,381,824, of August 7, 1945 (British specification No. 588,939), I observed that so long as the liquid supplied to the pump was delivered at a pressure not substantially higher than the pressure prevailing upon the outer end of the liquid seal, the liquid seal operated without outward loss of liquid. The seal in that pump is designed to be effective with a full vacuum inside of the pump casing, that is, a maximum pressure difference of 14.7 pounds per square inch. Since it is a self-priming liquid pump, so long as it must draw its supply from a lower level, the maximum pressure difference which can be imposed upon the said seal is said 14.7 pounds per square inch.

So long as the type G pump, or any similar self-priming centrifugal pump, operates either to lift liquid from a lower level or has its intake connected to a region in which a partial vacuum is to be maintained, as, for example, a vacuum evaporator, and the liquid is always delivered at sub-atmospheric pressure, there is no tendency for liquid to leak out through the seal because of the preponderance of outside pressure over inside pressure on the seal.

But if the pump, even though it be a self-priming pump, be connected to a source of liquid, the pressure of which imposed upon the pump intake may rise above atmospheric, then the prevailing pressure difference on the seal may be outwardly sufficiently to produce an escape of liquid at the seal. This escape of liquid is at all events undesirable, and it may be highly objectionable. For example, when the liquid is corrosive or toxic or valuable, leakage cannot be tolerated.

The said type G self-priming centrifugal pump above referred to would, because of its self-maintained liquid seal and other features of construction, be of great value in vacuum evaporator service, particularly because the packingless feature overcomes one of the principal sources of trouble with pumps in vacuum evaporator

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service, namely, the maintaining of a tight seal at the shaft. In this service, not only is the liquid frequently corrosive, but it is hot, and under normal circumstances the pump would be under vacuum.

The drawback to the use of the type G pump in vacuum evaporator service is that during the cycle of operation, there may be a gravity head of liquid (positive in value) on the suction of the pump. At other times, there will be a high vacuum at the same point. With the type G pump, the high vacuum is handled very satisfactorily, but positive pressure at the suction cannot be handled without the danger of passing liquid at the seal, and this is undesirable, and in some cases prohibitive. For a pump having a conventional fibrous packing seal, leakage of air inwardly on suction service, and leakage of liquid outwardly on gravity feed service may well occur. By keeping the pressure upon the inner end of the seal at the same pressure (atmospheric) as the pressure (atmospheric) upon the outer end of the seal, leakage does not tend to occur, even though the seal be not fluid tight. The impeller of the pump is the agent which by acting upon the fluid medium supplied to it, produces the desired pressure condition at the inside end of the seal. Through regulation of the inward flow of fluid medium, the pressure conditions produced by the impeller can be suitably controlled.

The object of the present invention is to perform a novel regulating function of the pressures imposed upon opposite sides of the pump seal by introducing a control of inflow of fluid medium in the intake of the pump, whereby the pressure produced by the impeller at the inner end of the seal may be maintained at or below atmospheric pressure, or may be maintained at any other desired value which will maintain either substantial equality of pressures at the opposite ends of the seal or a suitable differential according to which the outside pressure is higher than the inside pressure, whereby there will be no tendency for flow of fluid outwardly at the seal, and the seal will not pass fluid.

The invention aims to provide a combination of means for performing the aforesaid function automatically.

This invention utilizes the ability of the impeller acting upon the fluid being pumped when the fluid is supplied at atmospheric pressure or higher to create, in the region of the inner end of the seal, a pressure lower than atmospheric pressure by cooperation of a restriction to inflow. This flow restriction may be carried to a complete closure, i. e., shutoff, when the impeller ceases to remove the fluid from the casing, more particularly from the region of the inner end of the seal as, for example, when the pump is being shut down, or when it is not operating.

Normally, the seal is subject at its inner end to the minimum pressure (or maximum suction) prevailing in the casing. But the regulating function may be carried out automatically by reference to the pressure prevailing at some other selected point which will produce the desired pressure upon the inner end of the seal.

According to my invention, the controlling means or flow restriction valve in the intake or pump suction connection is set to maintain a minimum vacuum when there is a zero head on the supply side of the valve. When the vacuum rises above the minimum value, the valve is not required to produce a flow restriction, and under those conditions, performs no function and has no effect. The pump, under those circumstances, operates as though the valve were not there. Upon complete loss of vacuum at the pump suction, the valve moves toward closed position to protect the seal against overflow. This reaches maximum when the pump is shut down.

The invention is not confined to self-priming pumps,

but may be employed in connection with non-self-priming centrifugal pumps. Also the invention is not limited to liquid seals, but is applicable to pumps having the usual fibrous or solid packet stuffing boxes or similar rubbing seals. Thus, for example, a pump of the construction substantially as shown in my Patent No. 2,134,254, of October 25, 1938 (British specification No. 478,862), known as the type Q pump, presents a similar problem, under certain conditions of operation, and particularly where the liquid to be pumped is supplied under a head above atmosphere, or fluctuates so as at times to be above and at other times to be below atmosphere. Thus, for example, if a pump of the non-self-priming type be employed as a gravity feed pump attached to a storage tank or other source of supply above atmospheric pressure, the seal may be protected against leakage outwardly by means of the present invention. In case the liquid is highly volatile and toxic a self-priming pump cannot be located above the liquid level as the vacuum required to lift the liquid from below the pump and at the same time produce the necessary pressure for flow, causes so much vaporization of the liquid that little capacity can be obtained from the pump. In that case, a gravity feed pump, with fibrous packing or other mechanical seal, is preferable.

The pump in that case is located below the liquid level, and consequently, the stuffing box or seal must not only be abnormally tight and efficient, but must be encased and vented to prevent danger from explosion or from the toxic nature of the liquid or vapor evolved. In such case, by maintaining a slight vacuum within the pump at the point where the seal is exposed to internal pressure, in accordance with this invention all outward leakage is prevented. Such vacuum needs to be only very slight, that is, not enough to involve vaporization, but it must be definite and positive at all times. The shutoff provided by the system of my invention may be supplemented by hand operated valves or other shutoff valves as an additional precaution.

There are similar situations where a centrifugal pump is provided with a combination liquid seal while pumping, and an automatically applied rubbing seal or stopper or other closure for shutting off the gap between the casing and the shaft when the impeller comes to rest. As an example of such pumps, I refer to my copending U. S. application, Ser. No. 48,586, filed September 10, 1948, now matured into Patent No. 2,621,600 (or see Patent No. 1,346,924 to Wilfley). The maintenance of a slight preponderance of pressure of atmosphere over the pressure prevailing at the inner end of the seal by the flow restricting valve in the intake of the pump, insures in that case against liquid leakage out of the seal while the pump is running, and particularly against the loss of liquid in the interval between effective pumping and closure of the mechanical stopper as the pump is taken out of operation.

While the flow restricting valve may take various forms for performing this novel function, I prefer to use the specific form of valve shown in my copending application, Ser. No. 301,054, filed July 26, 1952, now matured into Patent No. 2,709,451, which valve is herein disclosed for the purpose of teaching the advantages of the present invention according to the best form of which I am now aware, said valve being claimed per se in the said copending application. I am aware that it has been proposed to employ means internally of the pump and casing, such as a secondary impeller, effective at a point adjacent the seal to produce a reduction in pressure at the inner end of the seal. Such devices are designed merely to produce a predetermined pressure difference through removal of the liquid from the vicinity of the inner end of the seal, but if the supply pressure at the inner end of the same fluctuates, then the resultant pressure at the inner end of the seal may still rise above and exceed the pressure at the outer end of the seal.

Now in order to acquaint those skilled in the art with

the manner of constructing and operating a device embodying my invention, I shall describe, in connection with the accompanying drawings, a specific embodiment of the same.

In the drawings:

Figure 1 is a diagrammatic illustration of a type G self-priming liquid sealed pump equipped with my invention;

Figure 2 is a diagram of a gravity feed type of pump employing fibrous or solid packing for the seal, and equipped with my invention;

Figure 3 is a diagram of connections of the pump shown in Figure 1 to a vacuum evaporator;

Figure 4 is a diagram showing the pump of Figure 2 connected to a storage tank for gravity feed therefrom;

Figure 5 is a longitudinal vertical section through the preferred form of valve;

Figure 6 is a side elevational view of the same with certain of the parts broken away to reveal the cam arrangement;

Figure 7 is a fragmentary top plan view of the closure for the guide of the valve plunger; and

Figure 8 is a fragmentary cross section taken through the valve body on the line 8—8 of Figure 5.

Referring now to Figures 1 and 3, the pump illustrated in these figures is the type G pump above referred to, which comprises a main pump body 1, seated upon a supporting pedestal 2, and surmounted by a driving motor 3, carried on a supporting bracket or column 4. Figure 3 illustrates in side elevation the commercial form of the type G pump which is shown in the sectional diagram of Figure 1.

The pump body 1 has an inlet or inlet passageway 5, which leads into an inlet trap 6. The trap 6 has a bottom opening in the form of an annular gap or space between a circular wall of the bottom of the trap 6 and the stationary sealing sleeve 7, which has its upper end sealed to the top wall of the inlet trap 6.

A discharge trap or gas separator 8 surrounds the inlet trap 6, and communicates with a discharge connection 9, which in the preferred form connects with a check valve 10, as shown in Figure 3, and a discharge pipe 12 leading to a suitable discharge point. Between the intake trap 6 and the separator 8, there is provided an impeller chamber 13, in which impeller chamber are disposed a series of blades 14 mounted upon a runner 15 carried by the impeller shaft 16. This runner 15 is in the shape of a flattened cylindrical box or drum upon the upper wall of which are mounted the impeller blades 14. The upper wall of the drum is open at the center so that it is annular in form, and it embraces loosely the sealing sleeve 7. The sealing sleeve 7 bears on its lower end an annular horizontal flange 17 which thus divides the sealing drum into upper and lower liquid retaining spaces joined at their outer peripheries so that a radial section at any point is U-shaped with the bottom of the U radially outward. The impeller blades 14 discharge through suitable throats 18 and passageways 19 which communicate with the gas separator space 8.

The entrainment of gas with liquid and peripheral re- entry of a liquid into the impeller for performing the gas pumping or evacuating function of the self-priming pump is well known to those skilled in the art.

Assuming that the pump shown in Figure 1 has performed the so called self-priming function, and is operating to move liquid from inlet passageway 5 through the trap 6, impeller blades 14, throats and passageways 18, 19, into the separator 8, and out the discharge connection 9, and assuming that the source of liquid supply is at a level lower than the pump, then the two sides of the liquid seal extending around the annular disc 17 and sleeve 7 are subjected to a pressure difference. The suction which the pump creates reduces the pressure at the point B, namely, at the radially inner end of the top leg of the kinetic liquid seal maintained between the flange

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or disc 17 and the heads of the drum 15. Atmospheric pressure as indicated at A prevails in the annular space between the impeller shaft 16 and the inside of the sleeve 7, and extends down to the lower leg of the kinetic liquid seal lying below the annular flange or disc 17. This kinetic seal is designed to be capable of withstanding the maximum vacuum which the pump can generate, and impose upon the liquid seal at the point B.

As shown in Figure 3, the pump 1 has its intake connection 20 connected to a vacuum evaporator indicated diagrammatically at 22. The evaporator 22 is normally under vacuum, but at certain times or phases of operation, a fluid pressure above atmospheric is impressed upon the intake connection 20, and in the absence of any control in said intake connection, the pressure will appear in the passageway 5 and the intake trap 6 of the pump. Although the evaporator 22 is located above the pump 1, so as to provide gravity flow of liquid evolved, the pump maintains a vacuum on the intake of the pump and on the intake side of the seal indicated at B during part of the cycle when the evaporator is under vacuum. However, if the vacuum evaporator 22 supplies liquid under gravity head, and at a rate which maintains a positive pressure above atmosphere in the passageway 5 and intake trap 6, then the pressure upon the inner end of the seal, as indicated at the point B, may rise above atmospheric pressure to the point where the seal will pass liquid outwardly.

In order to maintain the pressure at the inner end of the liquid seal, as at point B, at a value which will not rise above the pressure prevailing at A, in this instance, atmospheric pressure, I interpose a flow restricting and shutoff valve 23 indicated diagrammatically in Figure 1 and at 23' in Figure 3. The form of valve 23' is the preferred form, and it is shown in detail in Figures 5 and 6. Referring, however, to Figure 1, the valve 23 comprises a valve body 24 having the dividing wall 25 through which are formed the two valve openings 26 and 26a covered by a balanced valve comprising a stem 27 bearing the valve discs 28 and 28a movable in unison to and from the valve seats of the openings 26 and 26a. The stem 27 passes through a packing 29 and is connected to a diaphragm 30. The inner end of this packing is subject to the pressure prevailing on the pump side of valve 23. The lower surface of the diaphragm is open to atmosphere. The upper surface of the diaphragm is covered by a diaphragm cylinder or chamber 32, the inside of which chamber is subject to the pressure prevailing at B' in the intake passageway 5 by virtue of the connection 33 between said diaphragm chamber and the inside of the intake passageway of the pump. A needle valve or like flow restriction 34 may be placed in the tubular connection 33 to iron out or delay the effect of fluctuations in pressure, if desired. Such needle valve is optional. The diaphragm 30 is loaded by the spring 35, which may be adjusted to a suitable loading for normally holding the discs 28 and 28a over the valve openings 26 and 26a to close off the inlet passageway 20 from the inside of the casing of the pump. As soon as suction is produced in the intake side of the pump, as in the intake trap 6 and passageway 5, suction acting upon the diaphragm 30 against the pressure of the spring 35 will raise the valve discs 28 and 28a opening communication between the inside of the pump casing, that is, the suction side of the pump and the intake connection 20 leading to the liquid supply at the vacuum evaporator 22.

The operation of the system, diagrammatically illustrated in Figures 1 and 3, is as follows: Assume that the pump 1 has its intake passageway 5 and intake connections 20 with the valve 23 or the specific form of valve 23' connected in series between the vacuum evaporator 22 and the pump 1. The discharge connection 9 is connected through a check valve 10 to the discharge pipe 12. A shutoff valve 37 in the intake connection 20 normally isolates the pump from the vacuum evaporator when the parts are idle. Similarly, a manually operated shutoff

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valve may be included in the discharge pipe 12 to shut off all return flow either as a substitute for the check valve or as a supplement thereto.

Assume that the valves are open and the vacuum evaporator 22 is subject to vacuum and feeds liquid by gravity at a rate which does not quite fill the liquid capacity of the pump so that a vacuum is maintained in the inside of the pump casing on the suction side of the same, as at the point B', which is representative of the pressure prevailing at the point B on the inner end of the liquid seal of the pump.

So long as the pressure prevailing on the intake side of the impeller, and hence upon the inner end of the liquid seal, is less than atmospheric, or not more than the pressure upon the outside of the seal, there is no tendency for the seal to pass liquid outwardly. In that event, the valve 23 performs no function, and is open sufficiently to pass all the liquid required to be pumped without substantial restriction.

Under the circumstances that vacuum within the evaporator is insufficient resulting in a positive gravity head upon the intake side of the pump, so that there would be a preponderance of pressure on the inside end of the seal as compared with the pressure on the outside end of the seal, the valve 23 moves towards maximum flow restriction position, namely, towards closed position, and interposes a restriction to flow which immediately allows the pump to evacuate sufficient fluid to bring the pressure at the point B to the proper value, that is, not higher than the pressure at the outer end of the liquid seal, as represented by the pressure at A.

The pressure at point B' where the connection 33 is made is representative of the pressure at the point B and may be used as a variable pressure suitable for the regulating function of the valve 23. If desired, the connection of the pipe 33 to the interior of the pump at a point closer to the inner end of the liquid seal may be utilized, but I have found connection of the pipe 33 to the intake passageway 5 or to the top of the trap 6, as providing a satisfactory and reliable indication of the pressure upon the inner end of the kinetic liquid seal.

Thus, the pump 1, in combination with the vacuum control valve 23, will operate without leakage of air inwardly, or liquid outwardly at the seal, even though the pressure of liquid or other fluid medium supplied to the intake connection of the pump be below or above atmospheric pressure.

Referring now to Figures 2 and 4, I have shown a horizontal pump 40 having an impeller shaft 42. The pump casing itself is supported on a bearing bracket 43 which supplies a suitable bearing 44 for the pump shaft 42. The said shaft 42 is in turn connected through a coupling 45 to the motor shaft of a motor 46. The bracket 43 and the motor 46 may be mounted upon a suitable base plate 47 of known construction. The pump 40 may be any suitable form of non-priming centrifugal pump and the present diagrams relate to the type Q pump disclosed in the aforesaid U. S. Patent No. 2,134,254, employing an open impeller running concentrically in a channel having a plurality of discharge throats leading to a common discharge connection. However, any suitable known or preferred type of centrifugal pump employing a rotary joint or shaft seal may be utilized in this combination.

A packing gland 48 forms a running seal between the shaft 42 and the adjacent wall of the pump casing 49. This packing gland comprises a metallic sleeve 50 integral with the pump wall 49 and having a recess 52 for receiving a fibrous packing which is compressed in the pocket 52, and against the shaft 42 by the gland follower 53 by means such as is disclosed in the aforesaid patent or in any other preferred manner. On the intake side of the impeller 55, the casing 49 is shown as having a flared or conical wall 56 with an intake passageway 57 leading thereinto. This intake passageway 57 corresponds to the intake passageway 5 shown in Figure 1. An automatic

vacuum control valve 23 is interposed between the source of liquid supply, which in the present instance, as shown in Figure 4, is a liquid storage tank 58, and the intake side of the impeller 55. The liquid supply connection 59 from the storage tank 58 to the inlet passageway 57 of the pump 40 supplies liquid under a positive head, whereby the pump 40 may be subject to a positive pressure greater than atmosphere and the inner end of the packing gland 48, particularly at the point B, will be subjected, in the absence of the function of the control valve 23 or 23' to a greater pressure than atmospheric, which atmospheric pressure prevails at the outer end indicated at point A beyond the packing at 52. The discharge connection 64 of the pump casing is connected to a discharge pipe 63 and in the discharge pipe 63 there is disposed a shutoff valve 62 which may be a hand valve like the valve 60 on the inlet connection.

Assume that the storage tank 58 contains a highly volatile toxic liquid which does not permit the use of a self-priming packingless pump to move the same. Conventional gravity feed pumps have packing or mechanical seals at the shaft, and it is impossible to prevent some leakage at the shaft seal and such leakage is dangerous. The control valve 23 or 23', which is the same as that shown in Figure 1, or in Figure 3, being disposed in the intake connection between the source of liquid supply 58 and the pump casing, is set to maintain a slight vacuum at the pump suction at, for example, the point, B', namely, the inner end of the pipe 33, which in this case is projected inside the intake casing to a point which may be termed the eye of the impeller. The pressure at the point B' is representative or responsive to the pressure prevailing at the point B, namely, the inner end of the seal, and when the pressure at point B, or other suitably selected point at the intake side of the impeller, rises above a predetermined value, the valve body moves to a flow restricting position, such as to restore in the intake of the impeller and casing a suitably reduced pressure whereby the pressure upon the inner end of the packing gland 48 is not in excess of the pressure at the outer end of the said packing gland, and thereby the gland will not pass liquid outwardly.

The inner end of the suction connection 33 need not be extended to the very eye of the impeller, but may, in fact, terminate at any desired point inside the casing where a pressure representative of, or corresponding to the pressure prevailing at the inner end of the packing gland B occurs. I have found that a suitable controlling pressure may be selected at any point on the intake side of the impeller where there is no substantial restriction to flow between such connection and the impeller.

By maintaining a slight vacuum within the pump at the point where the seal is exposed at its inner end, all outward leakage is prevented. This vacuum needs to be only very slight, not enough to involve serious vaporization, but it must be positive at all times. When the pump is to be shut down, the automatic valve 23 or 23' closes off, but preferably the hand valves 60 and 62 are closed as an additional precaution, since all leakage is to be avoided.

In either embodiment, with the control valve in place, regardless of the supply pressure and regardless of the rate of flow through the pump, a slight vacuum is maintained at the eye of the impeller which communicates with the inner end of the stuffing box, and thereby outward leakage is prevented. This valve can be set for a minimum vacuum which remains substantially constant regardless of the rate of flow, so that normal operation with automatic adjustment of the valve to the rate of flow continues without further consideration by the operator.

While I have shown in Figures 1 and 2 a relatively simple form of automatic flow restricting valve, I have found in practice that for this particular service there is a tendency for an automatic valve to set up an oscillation which may be termed "hunting" to find a condition of balance. Also, due to certain irregularities of flow which are en-

countered in pumping liquids, it is desirable to build into the control valve means for preventing too rapid response to variations in pressure and means for preventing variations in flow from influencing the setting of the valve itself.

As illustrated in Figures 1 and 2, the response of the diaphragm 30 fluctuations in pressure on the intake side of the impeller may be stretched out or extended by a flow restriction in the tube 33 which communicates the said fluid pressure. Also, the flow restricting and shutoff valve may be and preferably is a balanced valve whereby the forces acting upon the valve as the same becomes a flow restriction are substantially equalized or are equalized fully.

I have found that by the utilization of a fluid dashpot the response of the pressure responsive element, such as the diaphragm 30, may be slowed, so that the regulatory effect of shifting the valve discs 28 and 28a or like control member will not cause overthrow and introduce oscillation or hunting.

In Figures 5 and 6, and indicated in outline at 23' in Figures 3 and 4, I have shown the preferred form of valve for the present service.

The specific valve 23' is intended to be suitable for use in chemical service, and as such, embodies certain specific requirements not necessarily involved in many applications of the invention herein claimed.

It is to be observed that in each embodiment the stuffing box of the flow control valve is located on the controlled side of the flow restricting valve, so that leakage at the same is prevented simultaneously with the prevention of leakage at the pump shaft seal. While the valve regulating diaphragm chamber is preferably connected to the point of highest vacuum source in the pump casing, such as at the eye of the impeller, it will generally be sufficient to connect the said diaphragm chamber to a point where pressure representative of that prevailing upon the inner end of the shaft seal prevails.

The specific form of valve shown in Figures 5 to 8, inclusive, and shown in outline at 23' in Figures 3 and 4, comprises a valve body 101 having an inlet 102 and an outlet 103. These connections are shown as flanged couplings, but obviously, other forms of connections may be employed. The body 1 of the valve is provided with a bottom opening which is closed by a cover plate 104 and the top opening is covered by a cover plate 105 which incorporates a stuffing box for the valve operating rod 121. The said stuffing box 98 may consist of a conventional gland having fibrous or other packing 97 compressed by the gland follower 96 of known construction. This packing for the rod 121 is on the pump side of the valve, so that the suction in the pump will protect this gland from leakage. The separable valve seat cage 106 is made in one piece, with two seats 107 and 108 and with two or more openings 109 and 110 between the seats. As will be seen from Figure 8, the lateral opening 110 is large enough to admit the lower section of the valve. The valve cage and assembled unit is inserted through the top of the valve body before the placing of the cover 105, and is threaded, or may be otherwise seated into the opening in the web of the valve body 101.

The double valve is made in two pieces to permit the seats being exactly the same diameter and area. This is necessary for an accurately balanced valve. The upper seat 111 is carried in the spacer by multiple arms 113 and threaded connection 114. Spacer 112 at its lower end carries the lower valve member 115 which is assembled by inserting the same through the opening 110 and engaging piloted joint 116 and drawn into firm contact by the nut 117. The lower valve member 115 has multiple openings 118 for the passage of liquid.

The spacer 112 has its upper end disposed within the hub of the upper valve member 111 at 119, and is arranged to be spaced slightly clear of the enlarged end 120 of the stem 121.

The operating mechanism for the balanced valve is at-

tached to the valve body through bracket 122, which at its upper end carries the cam housing 123, which is closed at its lower end by cover 124 equipped with the oil seal 125. Cover 126, shown in Figure 7, closes the upper opening in the cam housing in which the roller carrier member 128 plays.

Cam housing 123 has a vertical opening 127 between the upper and lower covers 126 and 124, and this opening 127 guides the roller carrier 128, which is attached to the stem 121 of the valve, and which roller carrier 128 carries a cam roller 129 operating in the inclined slot 130 in the cross head member 131, which latter slides in the cross guide slot 132 in cam body 123. At the right hand end, as viewed in Figure 5, the cross head 131 is attached to flexible diaphragm 133 through the medium of the cylindrical stem 134, which stem extends through the oil seal 135.

Diaphragm 133 has its periphery clamped between the housing member 136 and the cover or chamber member 137, which latter is provided with an inlet opening 138 for connection as by the tubular connection 33 to the highest vacuum source in the pump or to a point which has a pressure representative of the highest vacuum in the pump.

At the opposite end of cam housing 123 there is an opening 139 covered by a plate 140 which carries the adjusting spring 141, and which housing 123 is closed at its outer end by the threaded plug 142. The spring 141 is compressed between the bottom of the recess in the housing 140 and a head or anchor plate carried at the outer end of the stem 143. The spring 141 is connected to the cross head 131 through the stem 143.

The cam housing 123 is substantially filled with light oil, and is then sealed as by the plug in the cover plate 126 shown in Figures 5 and 7.

The operation of the valve is as follows: A connection 33 is run from opening 138 to the pump, preferably as near the pump seal opening as possible, but at least into the pump suction itself, that is, between the location of the valve 23' and the intake side of the impeller of the pump as shown in Figures 3 and 4. The valve 23' is inserted in the suction line of the pump with the opening 103 towards the pump and the opening 102 connected to the source of supply.

When the pump is not in operation, the spring 141 acting through the cam and roller holds the valve closed.

Now if the pump is started, movement of the impeller will tend to create suction in the intake. As soon as sufficient predetermined vacuum has been built up on the diaphragm 133, it will overcome the spring pressure of the spring 141, and begin to open the valve. This admits liquid to satisfy the suction to the extent permitted by the valve opening under the control of the diaphragm 133. The operation of the valve to maintain the predetermined slight suction on the intake side of the pump is entirely automatic, regardless of the pressure on the supply side of the valve. If the vacuum on the diaphragm 133 falls below the predetermined value, the valve will close until the vacuum increases and again opens the valve. If the pump is shut down, the spring will close the valve and hold it closed until vacuum again is present on the intake side of the pump effective upon the diaphragm 133.

In practice, it has been found that a vacuum as low as one inch of mercury will start to open the valve. The required amount of opening is of course controlled by the rate of flow through the valve which is in turn a factor of the pressure differential across the valve.

If the inlet to the valve is under vacuum, the valve stays open. If now, the inlet condition changes to pressure, that is, above atmosphere, the valve will adjust the opening to maintain the full rate of flow under the new pressure conditions always providing, however, that the desired vacuum condition effective upon the inner end of the pump seal is maintained. The valve functions smoothly and without surging. Pressure and flow impact of

liquid or other medium upon the valve itself is balanced, and is not effective to shift the position of the valve relative to its seat or relative to the diaphragm.

The slope of the cam 130 acting upon the roller 129 is preferably below the critical angle, so that the cam locks the position of the valve stem while free to move it by variations in pressure upon the diaphragm 133. It is not strictly necessary to make the cam and roller self-locking, since the mechanical advantage which the diaphragm has over the valve tends to produce sufficient resistance that surging or hunting of the valve does not occur.

While this particular form of valve is highly advantageous for the particular service of regulating the pressure upon the pump seal so as to reduce or avoid leakage, other forms of valve may be employed in this service.

In a centrifugal pump, the impeller tends to set up a pressure difference between the eye of the impeller and the tips of the blades or the periphery of the impeller. The inlet portion of the casing for the impeller will normally assume the same pressure as the eye of the impeller. Likewise, the inner end of the seal will be subject to the same pressure as the eye of the impeller. Employing the pressure in the intake portion of the casing as a control for the flow restricting valve has proven practical and satisfactory.

It will be noted that the specific pumps herein referred to and illustrated are open impeller pumps with concentric channels. These characteristics are preferred, but are not essential to the construction and operation of my invention.

By the utilization of the present invention, controlling the pressure difference upon the opposite sides of the seal, a seal of no great holding power may be used where heretofore seals of high holding power have been required.

I do not intend to be limited to the details shown and described, except as they are made essential by recitation of the appended claims.

I claim:

1. In a liquid pumping system, a centrifugal pump having an impeller, a casing therefor with a discharge connection and an inlet connection for liquid to be pumped, a flow control valve for said inlet connection for controlling the flow of fluid into the casing, an impeller operating shaft extending out of the pump casing through an opening therein, means for sealing the shaft to the casing, said sealing means being subject to varying pressure difference between the inside and the outside of said casing by variation of pressure in the casing adjacent the inlet connection, and a fluid pressure difference operated motor connected to the fluid pressure upon the outside of the casing for moving the valve to the unrestricted position and connected to the inlet side of the casing for moving said flow control valve to a position of flow restriction whereby said fluid difference operated motor will maintain the pressure at the inner end of the seal at or below that at the outer end of the seal.

2. A liquid pumping system according to claim 1 wherein the fluid pressure difference operated motor has a member subject on one side to fluid pressure in the inlet connection of the casing and to atmospheric pressure on the other side, and a spring cooperating with the pressure on the inlet side of the pump casing to move the valve in the direction of greater restriction of fluid flow.

3. A liquid pumping system according to claim 1 wherein the means for sealing the shaft to the casing is of a character to maintain a kinetic liquid seal between the wall of the casing and the impeller operating shaft.

4. A liquid pumping system according to claim 1 wherein there is a separator on the discharge side of the casing.

(References on following page)

2,806,433

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References Cited in the file of this patent

UNITED STATES PATENTS

1,028,098	Delaney	June 4, 1912
1,935,924	Tice	Nov. 21, 1933
2,353,871	Bowen	July 18, 1944
2,365,650	Shaw et al.	Dec. 19, 1944

2,381,823
2,381,824
2,602,467

5

109,611

12

La Bour	Aug. 7, 1945
La Bour	Aug. 7, 1945
Griswold	July 8, 1952

FOREIGN PATENTS

Great Britain	Dec. 24, 1918
---------------	---------------