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DYNAMIC SEAL FOR VARYING OPERATING CONDITIONS

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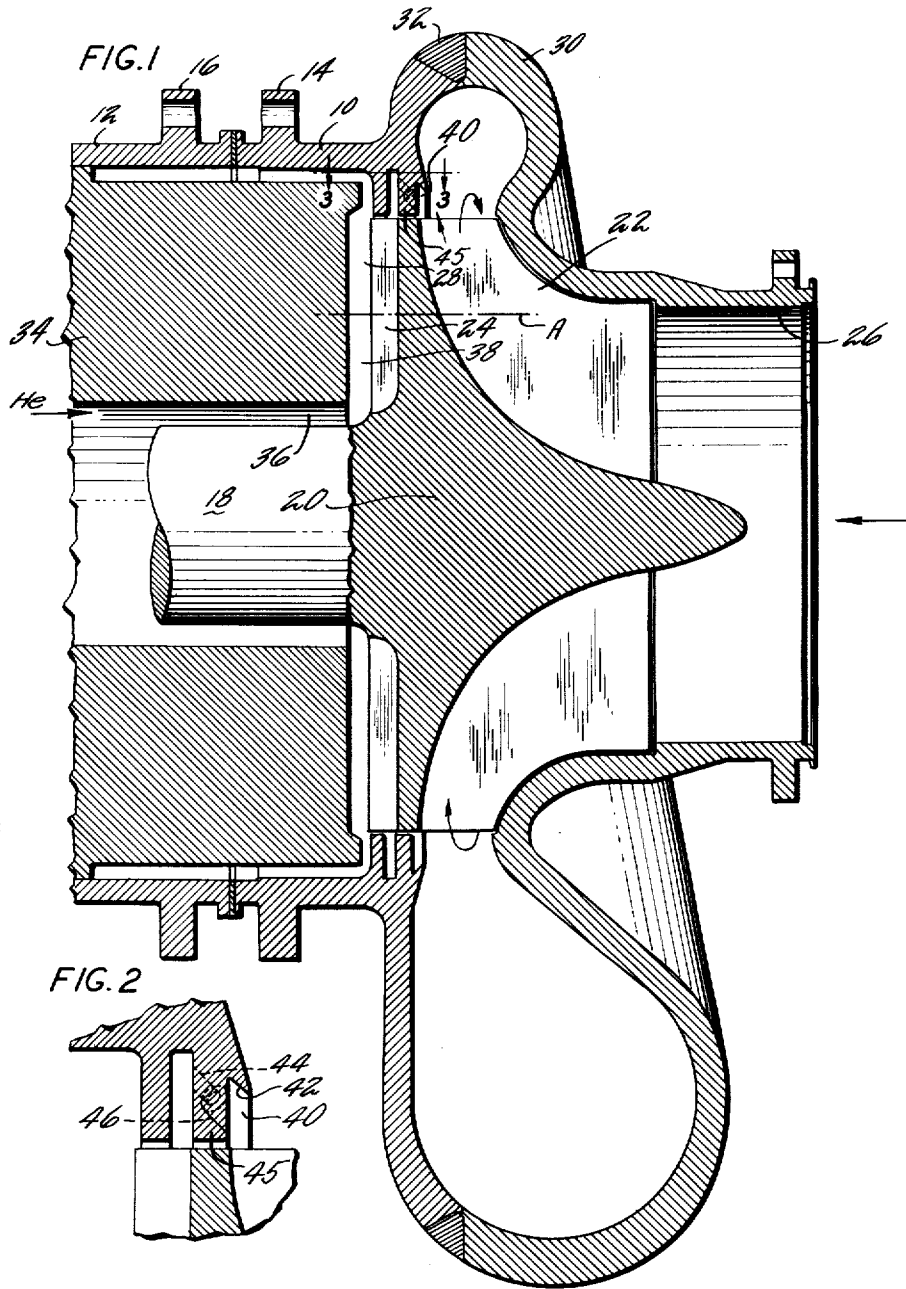


FIG. 2

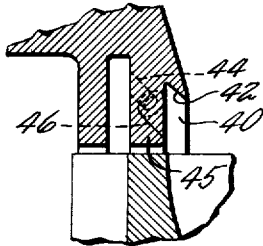


FIG. 3



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1

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DYNAMIC SEAL FOR VARYING OPERATING CONDITIONS

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This invention relates to pumps and particularly to dynamic seals for pumps which are used, for example, in the cooling systems of nuclear reactors for circulating liquid metals such as sodium or a mixture of sodium and potassium. In such a pump, helium or some other inert gas is used to provide a helium-liquid interface with the liquid which leaks past the impeller discharge periphery, providing a dynamic seal.

The same helium is used for the dynamic seal as is provided to pressurize the entire liquid system by means of a blanket in the expansion tank, such that the helium blanket pressure determines the impeller inlet static pressure. The required impeller inlet static pressure is dictated by the cavitation characteristics of the impeller. Consequently, the helium pressure acting on the dynamic seal is specified for considerations other than the optimum operation of the dynamic seal.

In such a pumping system two pumps are used simultaneously for reasons of safety. For normal two-pump operation the pressure conditions are satisfactory for maintaining an interface on the dynamic seals of the pumps. For one-pump-out operation, however, an interface will not maintain itself on the ordinary type dynamic seal since increased flow discharged from the impeller at a lower-developed head results in a lower discharge static pressure, while the helium pressure is increased to prevent cavitation in the impeller at the increased flow. Thus, under one-pump-out operation the helium pressure exceeds the liquid static pressure, the reverse of the conditions necessary to maintain the interface of the dynamic seal.

It is an object of this invention to provide a pump for this type of service in which an interface on the dynamic seal is maintained for both normal and one-pump-out operation.

A further object of the invention is to maintain a higher liquid-to-helium pressure ratio by providing a perforated ring adjacent the impeller tips for converting some of the dynamic pressure of the pump discharge to static pressure by diverting a small portion of the impeller discharge flow into the ring.

A still further object of the invention is to improve the performance of pumps of this type under all conditions of operation.

These and other objects and advantages of the invention will be evident or will be pointed out in connection with the following detailed description of a preferred embodiment of the invention illustrated in the accompanying drawing.

In this drawing:

FIG. 1 is a longitudinal vertical section through a centrifugal pump embodying the invention;

FIG. 2 is an enlarged detail of a part of the pump discharge chamber; and

FIG. 3 is a detailed section on line 3—3 of FIG. 1.

The pump shown in FIG. 1 consists of a generally cylindrical casing 10 which is connected to the main pump casing 12 by a bolted connection, a series of annularly arranged flanges 14 and 16 being provided on the two housings having aligned holes to receive the clamping bolts (not shown). A shaft 18 is extended into housing 10 and carries on its free end an impeller

2

including a hub 20 carrying integral impeller blades 22 and back vanes 24. The impeller, in effect, divides housing 10 into two chambers, one the main pump chamber in which the blades 22 rotate having axial inlet 26, and an auxiliary chamber 28 in which the back vanes 24 are disposed. Housing 10 also includes an annular pump discharge chamber 30 which surrounds the main pump chamber and receives the pump discharge from the blades 22. This chamber is in the form of the usual volute common in centrifugal pumps of this type. As will be evident from FIG. 1, the housing 10 is made in two parts, one of which includes the annular portion of the housing and a part of the discharge chamber housing 30, and the other of which includes the complemental part of the discharge chamber housing and the inlet housing. These parts are assembled by an annular weld 32 about the periphery of the pump discharge housing 30.

The auxiliary chamber occupied by the back vanes is largely filled by an annular boss 34 which projects into this chamber leaving only an annular axial passage 36 about the shaft and a communicating space 38 back of the back vanes. It is in the auxiliary chamber including the space 38 and the space in which the back vanes rotate that the dynamic seal is maintained. This seal is obtained by balancing helium gas under pressure which is introduced into the space 36 along the shaft against the static pressure of the liquid which leaks past the periphery of the impeller into auxiliary chamber 28. While the helium-liquid interface may move along the back vanes somewhat due to variations in the helium pressure and the liquid pressure, it should be maintained somewhere in the vicinity of the line A. It is the purpose of this invention to provide a construction which will ensure that the helium-liquid interface will remain substantially at this line under all conditions of operation of the pump and when this pump is operating singly or with a companion pump.

To this end the back wall of the pump discharge chamber 30 is provided with an annular scoop 40 (FIG. 2), the end wall 42 of which is oblique to the direction of flow of the fluid discharged from the impeller blades 22, so that a small portion of this flow is intercepted by the scoop 40. Further, a plurality of passageways 44 are provided in the ring 45 between this annular scoop and the auxiliary chamber 28 occupied by the back vanes 24. Each of the passageways 44 is further provided with a counterbore 46 where it communicates with the scoop 40. In the pump shown there are 324 passageways disposed around the ring 45 which forms the back wall of the scoop and is just beyond the outer periphery of the impeller. The ring inlet flow area made up of these 324 holes is more than twice the leakage area through the .015 inch clearance annulus between the impeller periphery and the housing. As a result, some of the dynamic head of the pump is converted to static pressure in the auxiliary chamber 28.

It will be noted that the passageways not only extend obliquely through the ring 48 as viewed in the sectional elevation of FIG. 1, but they are also oblique to the plane of the drawing, as indicated in FIG. 3, the inclination being in the direction of annular flow of the fluid in annular chamber 30.

Normally the pump is operating in parallel with another pump of identical characteristics and the pressure conditions are satisfactory for maintaining an interface on the dynamic seal at approximately the line A. For one-pump-out operation, however, the interface will not maintain itself on the ordinary type dynamic seal since increased flow through the impeller of the pump which is running at a lower-developed head results in a lower impeller discharge static pressure. The helium pressure

is also increased under these conditions to prevent cavitation in the impeller due to the increased flow. As a result the liquid static pressure falls just when the helium pressure is being increased.

By provision of the passageways in the annular scoop ring 45, some of the velocity pressure of the pump discharge is converted to static pressure which will act against the helium pressure to give a net liquid static pressure greater than the helium pressure, permitting the interface to remain on the seal.

The projecting portion 42 of the volute required to divert part of the flow will result in a slightly lower overall pump performance, but the successful operation of the dynamic seal warrants this loss.

It will be evident that as a result of this invention a centrifugal pump has been provided for this type of service which can be operated either singly or in parallel with another pump while maintaining the liquid-helium interface on the dynamic seal.

It will further be evident that this desirable result has been produced by a very simple structure which forms an integral part of the pump housing and is free from any undesirable maintenance problems.

While only a single embodiment of the invention has been shown, it will be understood that various changes in the construction and arrangement of the parts may be resorted to without exceeding the scope of the invention.

We claim:

1. In a centrifugal pump, a housing, a shaft extended into said housing, an impeller in said housing including a hub on said shaft and an impeller disc, said disc dividing said housing into a main pump chamber having an axial inlet and an auxiliary chamber surrounding said shaft, main impeller blades on said hub in said main chamber, back vanes on said hub in said auxiliary chamber, said housing having an annular pump discharge chamber surrounding said blades, scoop means on said housing to intercept a portion of the flow from said impeller blades, and passage means connecting said scoop means with said auxiliary chamber.

2. In a centrifugal pump, a housing, a shaft extended into said housing, an impeller in said housing including a hub on said shaft and an impeller disc, said disc dividing said housing into a main pump chamber having an axial inlet and an auxiliary chamber surrounding said shaft, main impeller blades on said hub in said main chamber, back vanes on said hub in said auxiliary chamber, said housing having an annular pump discharge chamber surrounding said blades, and means for converting some of the dynamic head of the fluid pumped into static pressure in said auxiliary chamber including a plurality of passageways connecting said pump discharge chamber at the tips of said blades with said auxiliary chamber, said passageways being inclined toward the direction of the fluid discharged by said blades.

3. In a centrifugal pump, a housing, a shaft extended into said housing, an impeller in said housing including a hub on said shaft and an impeller disc, said disc dividing said housing into a main pump chamber having an axial inlet and an auxiliary chamber surrounding said shaft, main impeller blades on said hub in said main chamber, back vanes on said hub in said auxiliary chamber, said housing having an annular pump discharge chamber surrounding said blades, and means for converting a portion of the dynamic head of the fluid pumped into static pressure in said auxiliary chamber including a plurality of passageways arranged around said pump discharge chamber, each having one end adjacent the tip path of said blades and having its other end communicating with said auxiliary chamber.

4. In a centrifugal pump, a housing, a shaft extended into said housing, an impeller in said housing including a hub on said shaft and an impeller disc, said disc dividing said housing into a main pump chamber having an axial inlet and an auxiliary chamber surrounding said shaft,

main impeller blades on said hub in said main chamber, back vanes on said hub in said auxiliary chamber, said housing having an annular pump discharge chamber surrounding said blades, said pump having means for converting a portion of the dynamic head of the fluid pumped into static pressure applied to said auxiliary chamber including passageways in a side wall of said pump discharge chamber leading to said auxiliary chamber for intercepting a portion of the flow discharged from said blades.

5. In a centrifugal pump, a housing forming a chamber, a shaft extended into said chamber, said shaft having a hub and an impeller disc dividing said chamber into main and auxiliary chambers, said hub having blades disposed in said main chamber, said housing having a pump discharge chamber surrounding said main chamber, said hub having back vanes in said auxiliary chamber, means for maintaining an interface in said auxiliary chamber between the material being pumped which leaks around the impeller tips from said main to said auxiliary chamber and a pressure fluid introduced into said auxiliary chamber about said shaft, and means including passageways between said pump discharge chamber and said auxiliary chamber for converting some of the dynamic head of the fluid pumped into static pressure in said auxiliary chamber.

6. In a centrifugal pump, a housing, a shaft extended into said housing having an impeller, said impeller including a hub and an impeller disc dividing said housing into a main chamber on one side of said impeller and an auxiliary chamber on the shaft side of said impeller, said impeller having pumping blades in said main chamber and back vanes in said auxiliary chamber, said housing having an annular pump discharge chamber surrounding said main pump chamber, means for introducing a fluid under pressure into said auxiliary chamber to balance the static pressure of the pumped fluid which has leaked around the outer periphery of said impeller and form a dynamic seal in said auxiliary chamber, and means including a plurality of bleed passageways between said pump discharge chamber and said auxiliary chamber for varying the static pressure on the leakage fluid in said auxiliary chamber in response to variations in velocity of the pump discharge.

7. In a centrifugal pump, a housing, a shaft extended into said housing having an impeller, said impeller including a hub and an impeller disc dividing said housing into an auxiliary chamber on the shaft side of said disc and a main pump chamber on the other side of said disc, said impeller having pumping blades in said main chamber and back vanes in said auxiliary chamber, said housing having a pump discharge chamber surrounding said main pump chamber, means for introducing a fluid under pressure into said auxiliary chamber to balance the static pressure of the pumped fluid which leaks around the outer periphery of said impeller and form a dynamic seal in said auxiliary chamber, and means for diverting a small portion of the flow discharged by said impeller into said discharge passage including passageways having their inlets adjacent the tips of said impeller blades and connecting said discharge passage with said auxiliary chamber.

8. In a centrifugal pump, a housing, a shaft extended into said housing, an impeller on said shaft, said impeller including a disc dividing said housing into main and auxiliary chambers, said impeller having blades in said main chamber and back vanes in said auxiliary chamber, a pump discharge chamber surrounding said blades, said housing having a ring surrounding said impeller disc, said ring having an annular scoop for intercepting a portion of the fluid discharged from said blades, and a plurality of passageways through said ring for connecting said scoop to said auxiliary chamber.

9. In a centrifugal pump having a housing, an impeller in said housing, said impeller including a disc dividing said housing into main and auxiliary chambers, said im-

5

peller having blades in said main chamber and back vanes in said auxiliary chamber, a pump discharge chamber surrounding said main chamber, said housing having an inwardly directed flange terminating adjacent said impeller disc, a plurality of passageways through said flange at spaced points about its periphery, said passageways connecting said pump discharge chamber and said auxiliary chamber, and annular scoop means on said housing projecting toward said impeller blades for intercepting fluid discharged from said blades.

10. In a centrifugal pump having a housing, an impeller in said housing, said impeller including a disc dividing said housing into main and auxiliary chambers, said impeller having blades in said main chamber and back vanes in said auxiliary chamber, a pump discharge chamber surrounding said main chamber, said housing having an inwardly directed annular flange terminating adjacent said impeller disc, said flange providing a wall separating said auxiliary chamber from said pump discharge chamber, a plurality of passageways located about the periphery of said flange connecting said auxiliary

6

chamber and said pump discharge chamber, and means for converting part of the velocity head of the fluid discharged by said blades into static pressure comprising an annular scoop on said flange projecting into said pump discharge chamber so as to intercept a part of the fluid discharged by said blades, said passageways having their ends which connect with said pump discharge chamber opening into said scoop.

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