United States Patent [19]

Wolters

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[45] **Aug. 28, 1973**

[54] **CENTRIFUGAL PUMP**

[75] Inventor: **Tjako Aaldrik Wolters,** Vianen, Netherlands

[73] Assignee: **Ballast-Nedam Groep N.V.,** Amsterdam, Netherlands

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[30] **Foreign Application Priority Data**

Aug. 4, 1970 Netherlands.....7011545

[52] **U.S. Cl.**..... **415/110,** 277/74, 415/170 A, 415/113

[51] **Int. Cl.**..... **F04d 29/08,** F04d 7/00

[58] **Field of Search**..... 415/104, 169, 170 A, 415/171, 172, 111, 113, 112, 110; 277/74, 75, 72

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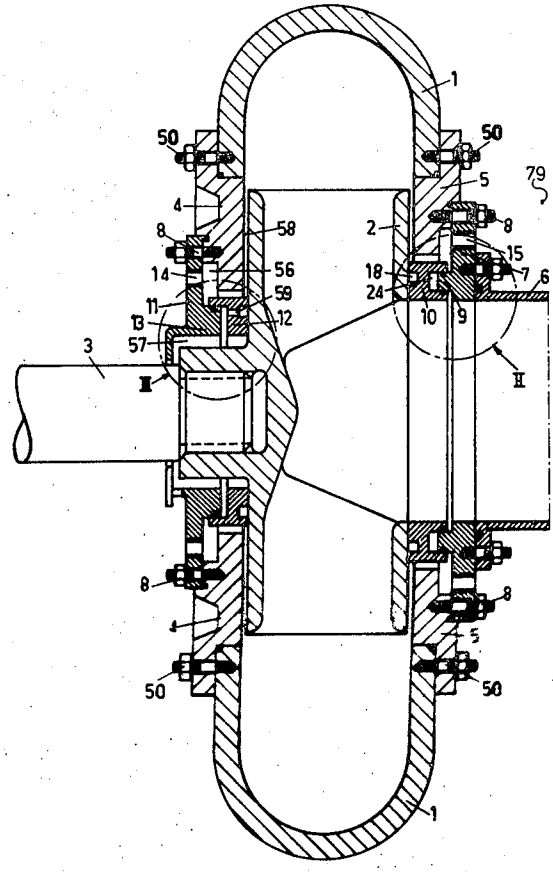
Primary Examiner—Henry F. Raduazo
Attorney—Snyder, Brown & Ramik

[57] **ABSTRACT**

A centrifugal pump with at least one sealing ring, having two faces divided from each other by a space, of which faces a first face is positioned at the high-pressure zone and a second face at the low-pressure zone. By communicating the space with the low-pressure zone the high-pressure is decreased along the first face upto the low-pressure. The required actuating force for contacting the sealing ring with the co-acting face is therefore small, so that the specific face surface pressure and therewith the wear of the face are small.

20 Claims, 15 Drawing Figures



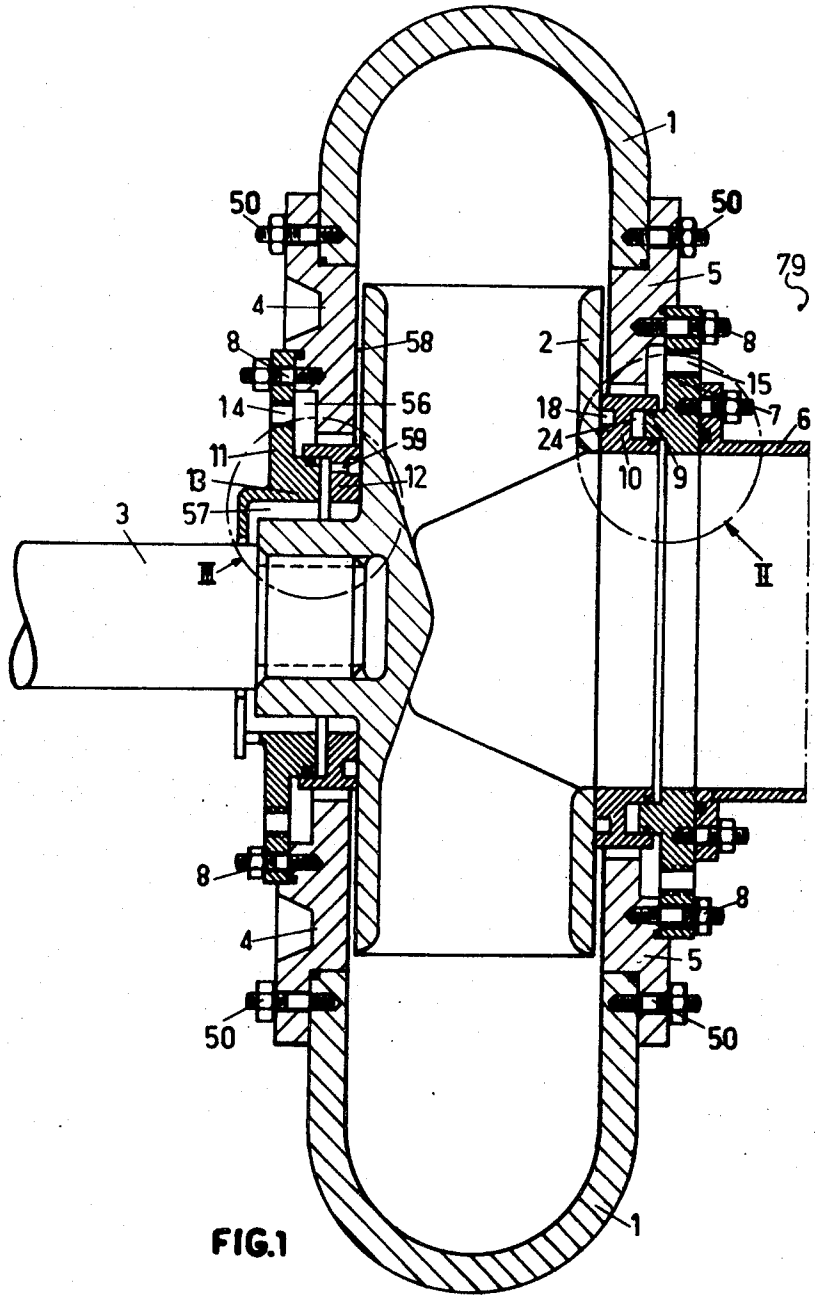


FIG.1

INVENTOR

TJARD ALDRIK WOLTERS

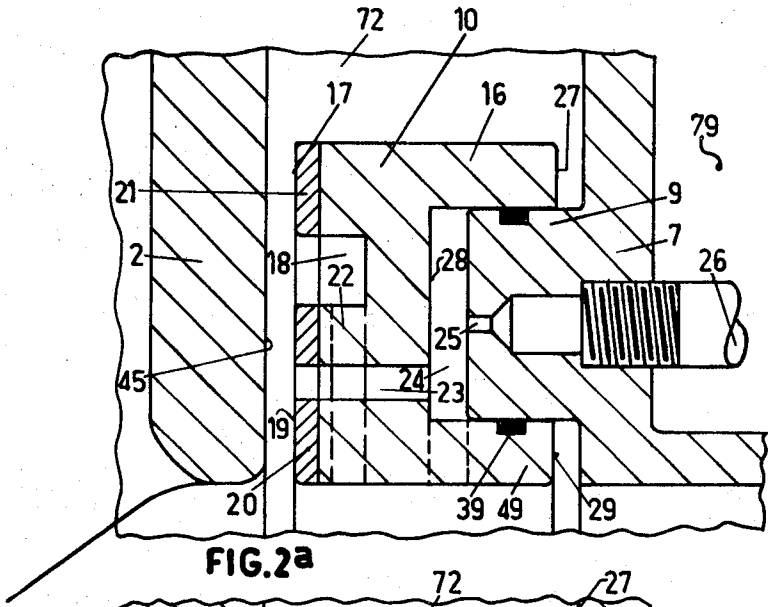


FIG. 2a

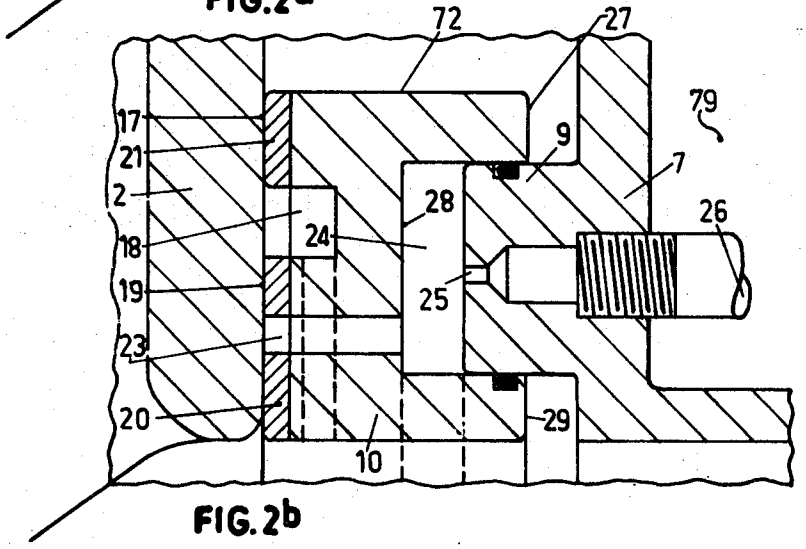


FIG. 2b

INVENTOR

TJAKO AALDRIK WOLTERS

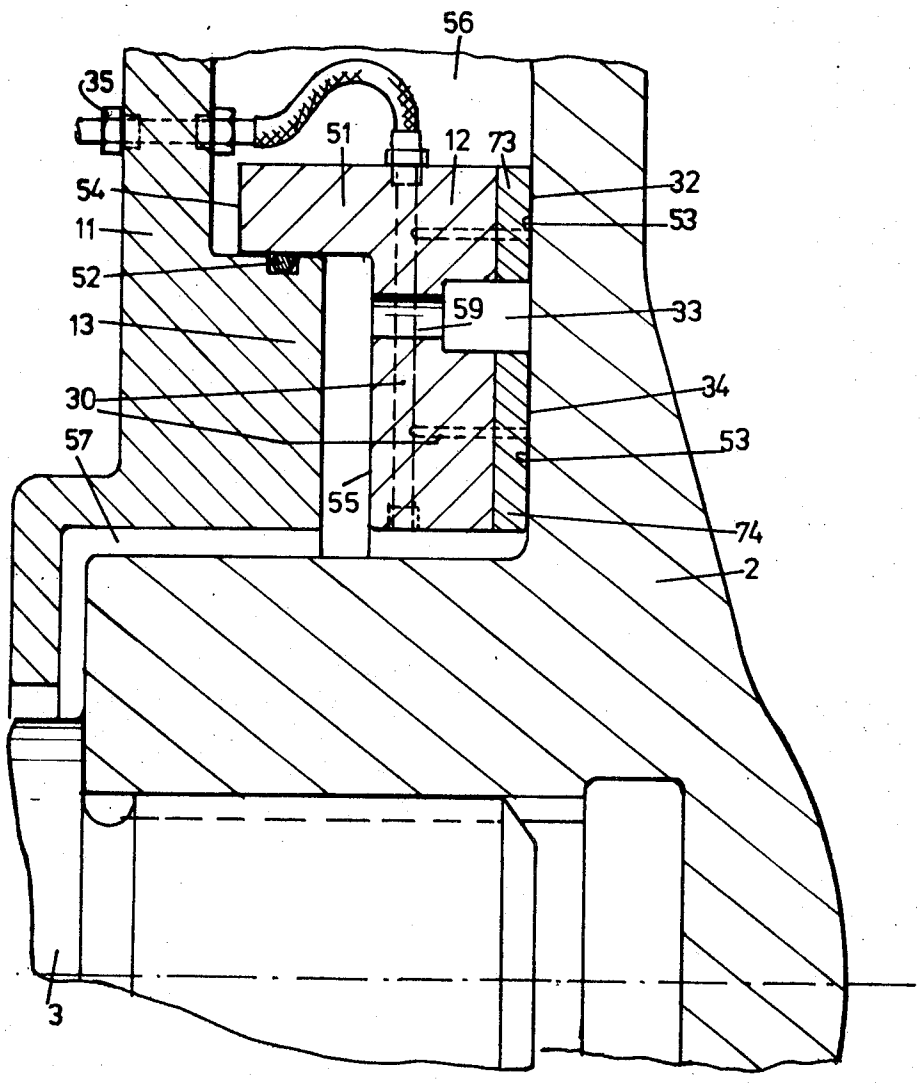


FIG.3

INVENTOR

TIJAKO AALDRIK WOLTERS

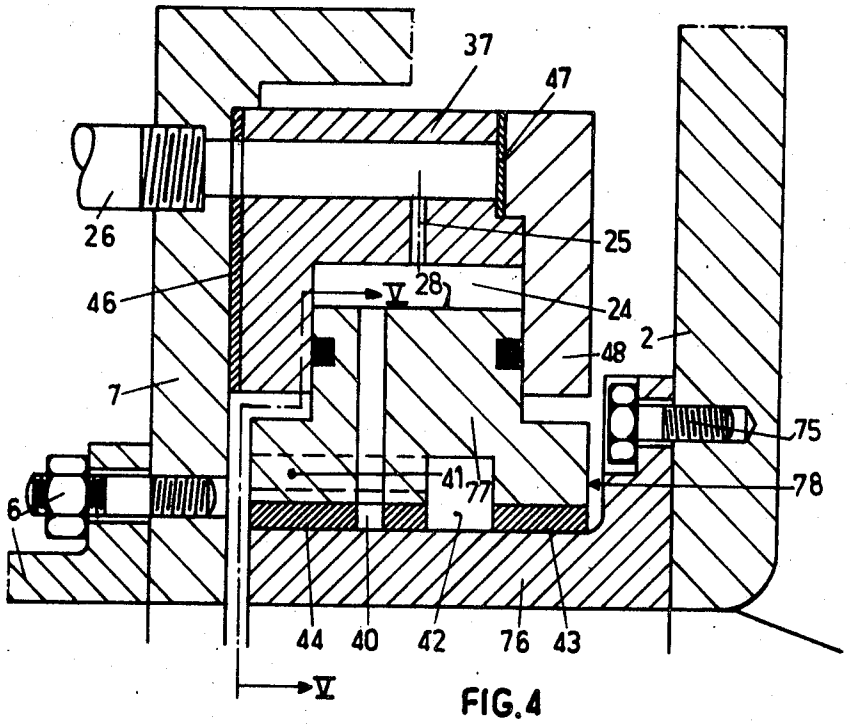


FIG. 4

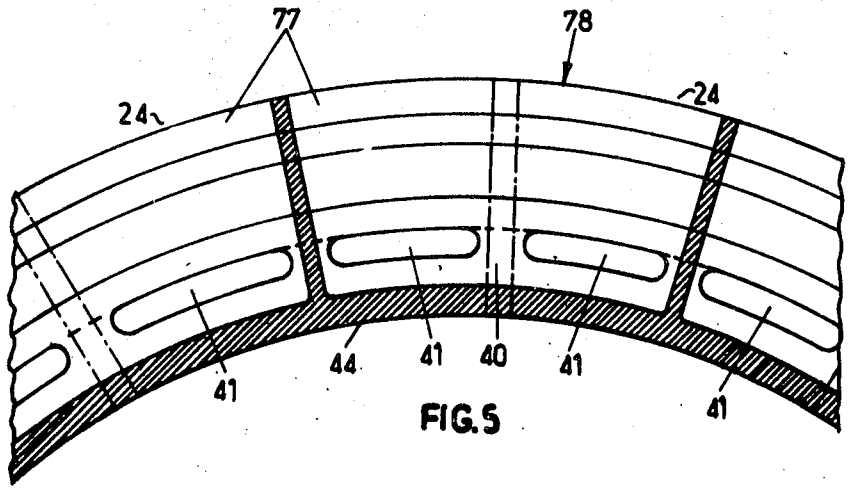


FIG. 5

INVENTOR

TIAKO AALARIK WOLTERS

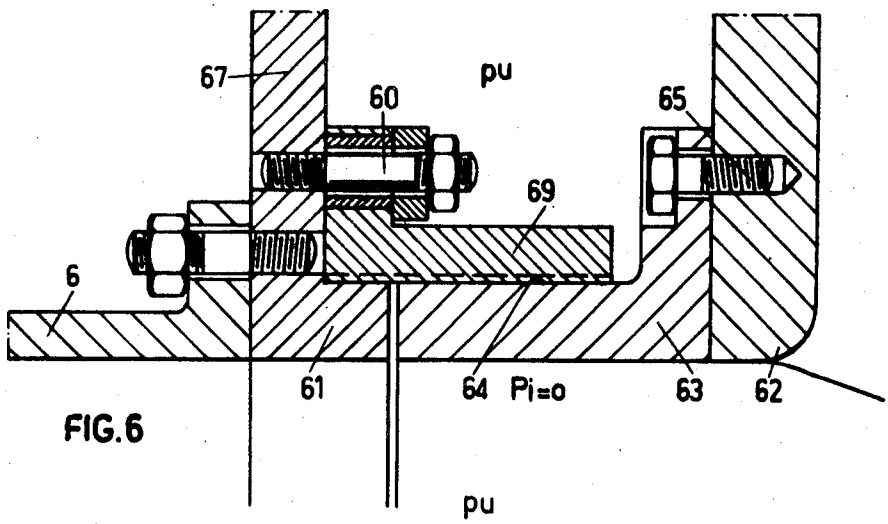


FIG.6

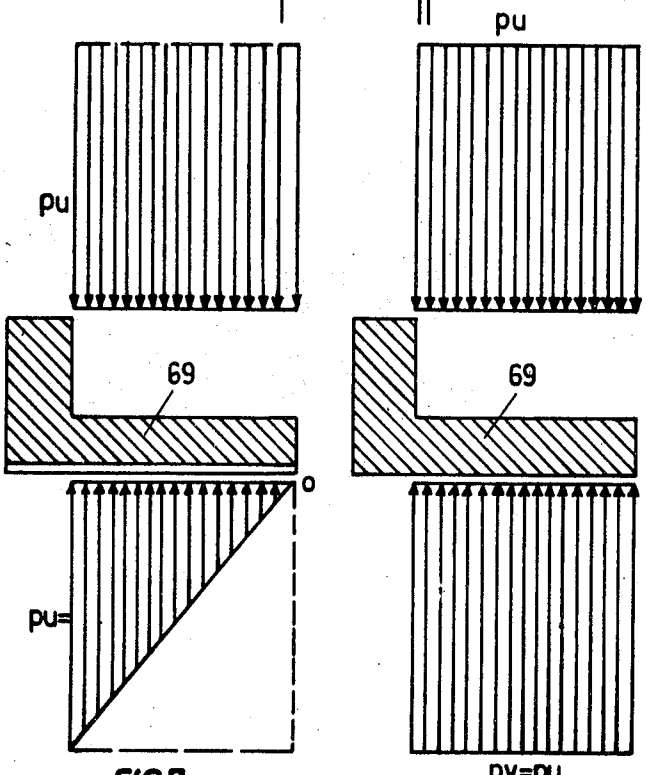


FIG.7a

FIG.7b

INVENTOR

TJARD AALDRIK WOLTERS

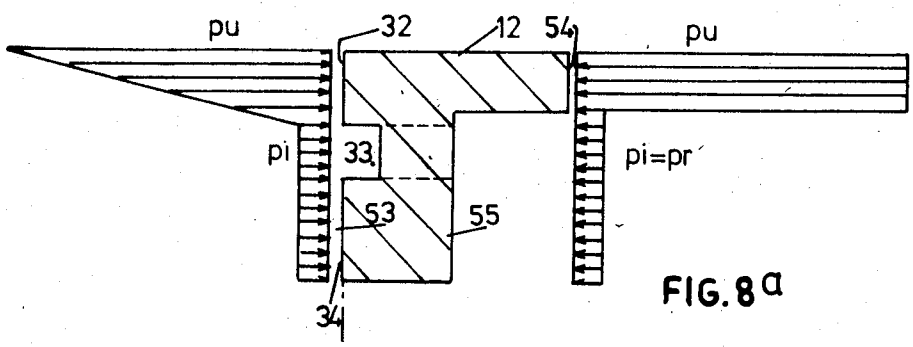


FIG. 8a

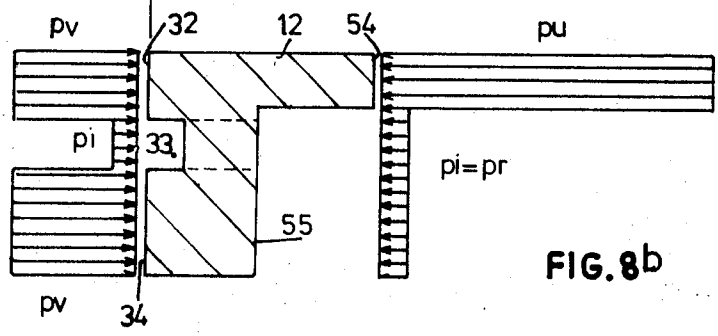


FIG. 8b

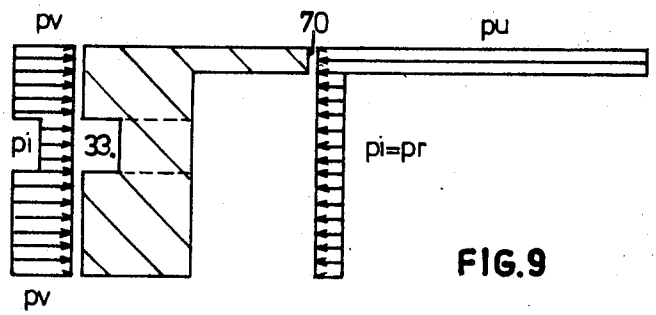


FIG. 9

INVENTOR

FRANZ MAGDEAU WALTERS

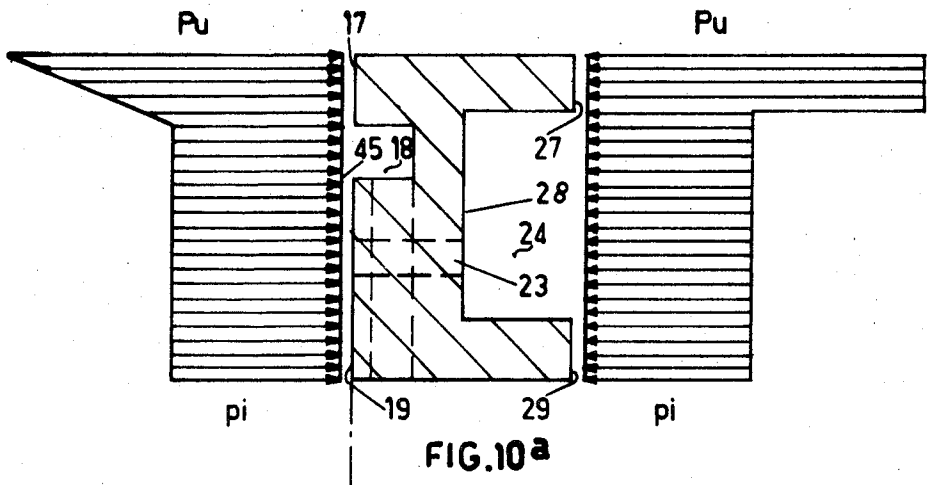


FIG.10a

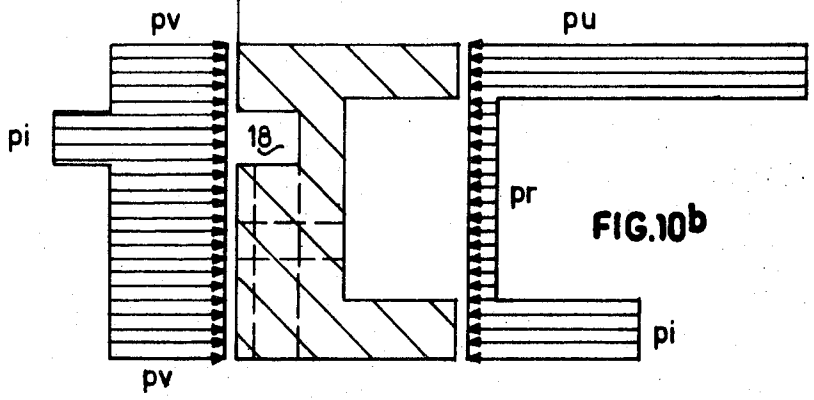


FIG.10b

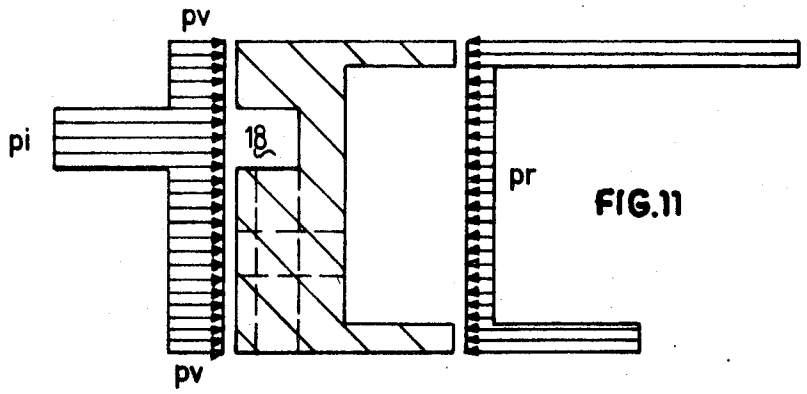


FIG.11

INVENTOR

TJIPKO ADELBERT WOLTERS

CENTRIFUGAL PUMP

The present invention relates to a centrifugal pump, comprising a casing, at least one impeller mounted for rotation in said casing and at least one seal for limiting leakage between the rotating impeller and the casing, said seal having sealing means with at least two faces spaced from each other by a space, viz. a first face positioned adjacent a high-pressure zone and a second face positioned adjacent a low-pressure zone, said faces forming part of one and the same sealing ring having at least one back surface influenced by high-pressure and at least one back surface influenced by low-pressure.

A centrifugal pump of this kind is known from the British patent specification 803,871.

In this known centrifugal pump the space communicates with the high-pressure zone. The sealing ring is so shaped that the width of the gap between the faces of the sealing ring on the one hand and the co-acting plane face on the other is adjusted at a predetermined value. The presence of said gap is a goal for decreasing the wear of the faces. This known type of seal has the disadvantage of leakage due to said gap, which is maintained during the full operation period of the centrifugal pump.

The invention has the object of providing a centrifugal pump, in which leakage as well as wear of the seal is decreased.

To this aim the invention provides a centrifugal pump, comprising a casing, at least one impeller mounted for rotation in said casing and at least one seal for limiting leakage between the rotating impeller and the casing, said seal having sealing means with at least two faces spaced from each other by a space, viz. a first face positioned adjacent a high-pressure zone and a second face positioned adjacent a low-pressure zone, said faces forming part of one and the same sealing ring having at least one back surface influenced by high-pressure and at least one back surface influenced by low-pressure, characterised in that the space communicates with said low-pressure zone.

With this centrifugal pump the high-pressure is reduced up to low-pressure over only a part of the total surface of said faces of the sealing ring, resulting in that the threatening force threatening of pushing the sealing ring in the direction away from the coacting face is small, owing to which the resulting actuating force exceeding the threatening force and constituted by the high-pressure on the first back surface and the low-pressure on the second back surface may be small. This small actuating force is supported on the total surface of the faces of the sealing ring, resulting in a small specific face surface pressure. Owing to the sealing ring contacting the co-acting face with a low specific face surface pressure the leakage as well as the wear are decreased.

Preferably the centrifugal pump according to the invention, particularly a centrifugal pump operating with high inlet- and even higher exhaust pressure, is characterised in that said second face communicates with a control space separated from the low-pressure zone said control space communicating via throttle means with a control pressure source, said sealing ring having a third back surface influenced by the control pressure of the control space.

Even in case the centrifugal pump operates with high pressures the specific face surface pressure may be low

besides short periods of increased specific face surface pressure, whereas in spite of these low specific face surface pressures the contact of the faces and the co-acting faces is controlled self-adjustably during operation, even during pressure shocks which may arise owing to cavitation of the centrifugal pump.

The invention will be elucidated in the following description with reference to a drawing.

In the drawing show:

FIG. 1 an axial section through a preferred embodiment of a centrifugal pump according to the invention,

FIGS. 2*a* and 2*b* on larger scales each the detail II of FIG. 1 in various positions of the seal,

FIG. 3 on a larger scale the detail III of FIG. 1,

FIG. 4 a longitudinal section of a detail of another centrifugal pump according to the invention having a seal with cilindrical faces,

FIG. 5 a section over the line V—V OF FIG. 4,

FIG. 6 a longitudinal section of a detail of a known centrifugal pump having a conventional seal with a cilindrical face,

FIGS. 7*a* and 7*b* each a schematic view of the equilibrium of forces of the sealing ring of FIG. 6 in two different positions,

FIGS. 8*a* and 8*b* each a schematic view of a sealing ring for a centrifugal pump according to the invention with the equilibrium of forces concerning the sealing ring of detail III, in two different positions,

FIG. 9 a schematic view corresponding with FIG. 8*b* concerning another embodiment of a seal of a centrifugal pump according to the invention,

FIGS. 10*a* and 10*b* each a schematic view of the equilibrium of forces exerted on the sealing ring of the positions of FIGS. 2*a* and 2*b* respectively, and

FIG. 11 a schematic view corresponding with FIG. 10*b* concerning another embodiment of a seal of a centrifugal pump according to the invention.

The centrifugal pump according to the invention shown in FIG. 1, which is particularly adapted for pumping a suspension of sand and water, comprises a casing 1 and an impeller 2 driven by a shaft 3. A front cover 5 attached at the casing 1 by means of bolts 50, a rear cover 4 attached at the casing 1 by means of bolts 50, a front flange 7 attached at said front cover 5 by means of bolts 8 and a rear flange 11 at the rear cover 4 by means of bolts 8 and letting pass the shaft 3, constitute parts of the casing 1. A supply line 6 is connected to the front flange 7.

In FIG. 3 the special sealing means III of the seal between impeller 2 and rear cover 4 are shown on large scale. Said sealing means comprise a guide collar 13 forming part of the rear flange 11 and a sealing ring 12 having a collar 51 mounted slidably in axial direction on the guide collar 13 and being sealed relatively to said guide collar 13 by means of an O-ring 52. The sealing ring 12 has two faces spaced from each other by a space 33, viz. a first face 32 positioned adjacent the exhaust zone of the pump and thus adjacent the high-pressure zone of the sealing means and a second face 34 positioned adjacent the atmospheric pressure zone of the pump and thus adjacent the low-pressure zone of the sealing means. The faces 32 and 34 cooperate with co-acting face 53 and are actuated to abut it as a unit by the sum of the actuating forces, exerted on a first back surface 54 and a second back surface 55. The first back surface 54 is influenced by the high-pressure zone

56 and the second back surface 55 by the low-pressure zone 57.

The high-pressure zone 56 is constituted by an annular space 56 communicating through an inlet 14 with a source of purgating water, having such high-pressure that it prevents the suspension of sand and water of reaching the sealing means through the gap 58 between impeller 2 and rear cover 4.

The space 33 communicates with the low-pressure zone 57 through a passage 59.

The faces 32 and 34 are supplied with grease through grease supply 35 and connecting passages 30.

For clearly comparing the conventional seal and the seal of the centrifugal pump according to the invention FIG. 6 shows an impeller 62 provided with an annular ring 63 connected to the impeller 62 by means of bolts 65. The flange 67 having a collar 61 supports by means of bolts 60 a sealing ring 69 having a L-shaped longitudinal section.

In the annular space at the outside of the sealing ring 69 the inlet pressure Pu prevails (see FIGS. 7a and 7b). When the sealing ring 69 comes free from the annular ring 63, for instance due to movements of the impeller 62 the pressure Pu decreases in the gap between the sealing ring 69 and the coacting face 64 up to the inlet pressure Pi which is equal to zero (FIG. 7a). When the sealing ring 69 comes into contact with the co-acting face 64 of the ring 63 the sealing ring 69 is actuated thereon by the high-pressure Pu, resulting in that the specific face surface pressure Pv in this case is as high as the high-pressure Pu.

With the sealing rings 12 of the centrifugal pump according to the invention a much lower specific face surface pressure Pv is obtained (FIGS. 8a and 8b).

If the faces 32 and 34 of the sealing ring 12 would be free from the co-acting face 53 of the impeller 2, the high-pressure Pu would be decreased up to the low-pressure Pi along the first face 32 owing to the space 33 communicating with the high-pressure zone Pu through the gap between the first face 32 and the co-acting face 53. This first face 32 is then actuated by a resultant pressure $Pu - Pi/2$, whereas the second face 34 is actuated by the low-pressure Pi. The first back surface 54 of the sealing ring 12 is actuated by the high-pressure Pu and the second back surface 55 by the low-pressure Pi. The axial lengthes of the first back surface 54, the second back surface 55, the first face 32 and the second face 34 are so great relatively to each other, that the resultant of the actuating forces at the back surfaces 54 and 55 just exceeds the resultant of the forces on the faces 32 and 34 when the sealing ring 12 might be free from the co-acting face 53 (FIG. 8a). As soon as the faces 32 and 34 abut the impeller 2 the situation of FIG. 8b is created. The pressures Pu and Pi on the back surfaces 54 and 55 press the sealing ring against the impeller 2, resulting in a specific face surface pressure Pv on the faces 32 and 34. Comparison with FIG. 7b shows clearly that the specific face surface pressure Pv of FIG. 8b is appreciable lower, resulting in a decreased wear.

In the embodiment of FIG. 9 the specific face surface pressure Pv is further reduced, owing to the first back surface 70 being smaller than the first back surface 54 of FIGS. 8a and 8b. The area of the first back surface 70 is preferably so determined that the total actuating forces on the first and second back surfaces just exceed the sum of the forces on the faces 32 and 34.

In the examples described above the inlet pressure of the centrifugal pump has a small value. The advantages of the invention are more considerable with centrifugal pumps having an inlet pressure with a great value. This will be elucidated with reference to FIGS. 2a, 2b, 10a and 10b. The sealing means of the seal II of the centrifugal pump of FIG. 1 comprise a guide collar 9 forming part of the front flange 7 and a sealing ring 10 having collars 16 and 49 engaging the guide collar 9 slidably in axial direction and being sealed by means of O-rings 39. The sealing ring 10 has two faces spaced from each other by means of a space 18, viz. a first face 17 positioned adjacent the exhaust side, that is the high-pressure zone of the centrifugal pump and a second face 19 positioned at the inlet side, that is the low-pressure zone of the centrifugal pump. The faces 17 and 19 cooperate with co-acting face 45 and are actuated as a unit against it by the sum of the actuating forces exerted on a first back surface 27, a second back surface 29 and on a third back surface 28 influenced by the high-pressure Pu, the low-pressure Pi and control pressure Pr of a control space 24 respectively. The second face 19 communicates with the control space 24 through passages 23. The control space 24 communicates through throttle means 25 and a passage 26 with a control pressure source, for instance atmosphere. Collars 16 and 49 support the first and second back surfaces 27 and 29. The wall 28 of the control space 24 constitutes the third back surface 28. The space 18 communicates with the low-pressure zone through passages 22.

In the position of the sealing ring 10 shown in FIGS. 2a and 10a it is free from the impeller 2. The pressure Pu is decreased up to pressure Pi along the first face 17, as in space 18 the pressure Pi prevails. In the control space 24 the pressure Pi prevails, due to passages 23 supplying said pressure Pi and due to throttle means 25 preventing escape therefrom. The back surface 27 is influenced by pressure Pu from the space 72, whereas the back surfaces 28 and 29 are influenced by pressure Pi.

The equilibrium of forces on the sealing ring 10 is in FIG. 10a determined by the comparison of the term:

$Pu - Pi/2 \times$ Area $17 + Pi \times$ Area (18+19) exceeding the term:

$Pu \times$ Area $27 + Pi \times$ Area (28+29), resulting in that the sealing ring 10 with faces 17 and 19 is moved onto the impeller 2. As soon as the faces 17 and 19 do contact the impeller 2, the passages 23 are shut off and the pressure Pi may escape from the control space 24, resulting in the pressure Pr prevailing in this space 24. This situation is shown in FIGS. 2b and 10b. The forces exerted on the back surfaces are divided over the total area of the faces 17 and 19, resulting in a specific face surface pressure Pv being considerably lower than the inlet pressure Pi. The embodiment of FIG. 11 shows that the specific face surface pressure Pv may even be more reduced due to well proportioned surface areas.

The faces 17, 19, 32 and 34 consist of linings 21, 20, 73 and 74 respectively of wear resistant rubber like material.

The high-pressure zone adjacent the sealing ring 10 communicates through inlet 15 with said source of purgating water.

In FIGS. 4 and 5 a radial seal for a centrifugal pump according to the invention is shown. An annular ring 76 is attached at the impeller 2 by means of bolts 75. The

front flange 7 supports rings 37 and 48 connected to each other free of leakage by means of packings 46 and 47. The control space 24 communicates through passage 26 and throttle means 25 formed by a narrow opening with the control pressure source, for instance atmosphere 70. A first face 43 is spaced from a second face 44 by means of a space 42 communicating with inlet pressure P*i* through passages 41. The faces 43 and 44 consist of wear proof rubberlike material vulcanised on the sealing ring elements 77. Said sealing ring elements 77 constitute together with said rubberlike material an annular sealing ring with cilindrical faces 43 and 44. The face 44 communicates with the control space 24 through passages 40. Due to this construction of the sealing ring it may expand for adaption to possible irregular operation, while a contact of the faces 43 and 44 with a low specific face surface pressure P*v* according to the invention is assured.

What I claim is:

1. A centrifugal pump comprising a casing, at least one impeller mounted for rotation in said casing and at least one seal for limiting leakage between the rotating impeller and the casing, said seal having sealing means with at least two faces spaced from each other by a space, a first of said faces being positioned adjacent a highpressure zone and a second of said faces being positioned adjacent a lowpressure zone, said faces forming part of one and the same sealing ring movable transversely to said faces, and said sealing ring having at least one back surface influenced by the pressure of said high pressure zone and at least one back surface influenced by the pressure of said lowpressure zone, said space communicating with a region of pressure considerably lower than the pressure of said high pressure zone.

2. A centrifugal pump as claimed in claim 1, characterised in that said second face communicates with a control space separated from the low-pressure zone, said control space communicating via throttle means with a control pressure source, said sealing ring having a third back surface influenced by the control pressure of the control space.

3. A centrifugal pump as claimed in claim 1, characterised in that said space communicates with said low pressure zone.

4. In a centrifugal pump having a casing and an impeller mounted for rotation in said casing, said impeller including a seal-engageable face leading transversely thereof from a high pressure region of said pump to a low pressure region, and a sealing ring movably carried by said casing for movement toward and away from said seal-engageable face, said sealing ring comprising:

a body having a pair of annular faces facing and adapted to engage said seal-engageable face of the impeller, said annular faces being separated by a channel, said body having a pair of rear faces opposite to and parallel with said annular faces, one of said rear faces being exposed to said high pressure region and the other of said rear faces being exposed to said low pressure region;

seal means engaging said body between said rear faces thereof for pressure isolating said rear faces from each other; and

means for maintaining said channel at a pressure substantially less than that of said high pressure region.

5. In a centrifugal pump as defined in claim 5 wherein the means last mentioned communicates said channel with said low pressure region.

6. In a centrifugal pump as defined in claim 4 wherein said seal-engageable face is cylindrical.

7. In a centrifugal pump as defined in claim 4 wherein said seal-engageable face is flat and annular.

8. In a centrifugal pump as defined in claim 4 wherein the areas of said rear faces and the area of the bottom said channel are balanced with respect to the pressures acting thereon to establish a low residual sealing force pressing said annular faces against said seal-engageable face.

9. In a centrifugal pump as defined in claim 8 wherein the means last mentioned communicates said channel with said low pressure region.

10. In a centrifugal pump as defined in claim 8 wherein said seal-engageable face is cylindrical.

11. In a centrifugal pump as defined in claim 8 wherein said seal-engageable face is flat and annular.

12. In a centrifugal pump having a casing and an impeller rotatably mounted in the casing whereby fluid tends to leak out of the casing past said impeller due to high pressure developed by said pump, sealing means interposed between the casing and the impeller and movably carried by one of them for movement normal to the direction in which fluid tends to leak into engagement with the other of said casing and impeller, said sealing means comprising:

an annular member surrounding said impeller and having a pair of annular faces adapted to engage said other of said casing and impeller, recess means separating said annular faces for defining a bottom wall area of first selected area, said member having a pair of rear faces opposite from said annular faces one of which is of second selected area and the other of which is of third selected area, said one rear face communicating with a high pressure region in said pump and said other rear face communicating with a low pressure region;

seal means for isolating said rear faces from each other; and

means for communicating said recess means with low fluid pressure;

said first, second and third selected areas being balanced with respect to the pressures acting on them to establish a low residual sealing force pressing said annular faces against said other of said casing and impeller preventing said leakage of fluid past said impeller.

13. In a centrifugal pump as defined in claim 12 wherein said sealing means engages said impeller, said impeller having a cylindrical surface portion with which said annular faces are engaged.

14. In a centrifugal pump as defined in claim 12 wherein said sealing means engages said impeller, said impeller having a flat annular surface portion with which said annular faces are engaged.

15. In a centrifugal pump as defined in claim 12 wherein said member is provided with a third rear face of selected area disposed between said one and said other rear faces; said seal means isolating all three of said rear faces from each other; and means for maintaining a control pressure on said third rear face.

16. In a centrifugal pump as defined in claim 15 including passage means in said member communicating said third rear face with one of said annular faces.

17. In a centrifugal pump having a casing and an impeller rotatably mounted in said casing whereby to generate a fluid high pressure region within said casing which tends to leak fluid past said impeller, and sealing means for preventing such leakage, said impeller having an annular surface across which fluid tends to leak and cooperating with said sealing means and said sealing means being movably carried by said casing for movement perpendicular to such surface into and out of engagement therewith, said sealing means comprising:

a ring having a pair of annular surfaces opposed to said annular surface of the impeller, one of which is disposed on a high fluid pressure side of the sealing means and the other of which is disposed on a low fluid pressure side of the sealing means;

recess means separating said annular surfaces for defining a fluid pressure relief when said annular faces are out of engagement with said annular surface of the impeller;

passage means for communicating said recess means with a region of low pressure whereby when said annular faces are out of contact with said annular surface of the impeller leakage fluid may flow only past said one annular surface into said recess means to establish a pressure gradient across said one annular face while the recess means and said other annular face are subjected only to that low pressure with which said recess means is communicated thereby imposing but little force tending to separate said sealing means from said annular surface of the impeller;

said sealing ring having a pair of rear faces opposite from said annular faces, one of said rear faces being continuously exposed to high fluid pressure and the other of said rear faces being continuously exposed to low fluid pressure;

seal means engaging said sealing ring for pressure isolating said rear faces from each other; and

the areas of said rear faces being such as tends always to override any separating force between the annular surface of the impeller and said sealing means while producing a low residual force pressing said annular faces against said annular surface of the impeller.

18. In a centrifugal pump as defined in claim 17 wherein said annular surface of the impeller is in the form of a cylindrical surface.

19. In a centrifugal pump as defined in claim 17 wherein said annular surface of the impeller is flat.

20. In a centrifugal pump as defined in claim 17 including a third rear face on said sealing ring between the first two mentioned rear faces, said seal means pressure isolating all of said rear faces from each other; and means communicating said third rear face with a source of control pressure.

* * * * *