

March 26, 1940.

I. C. JENNINGS

2,195,174

PUMP

Filed Dec. 30, 1935

4 Sheets-Sheet 1

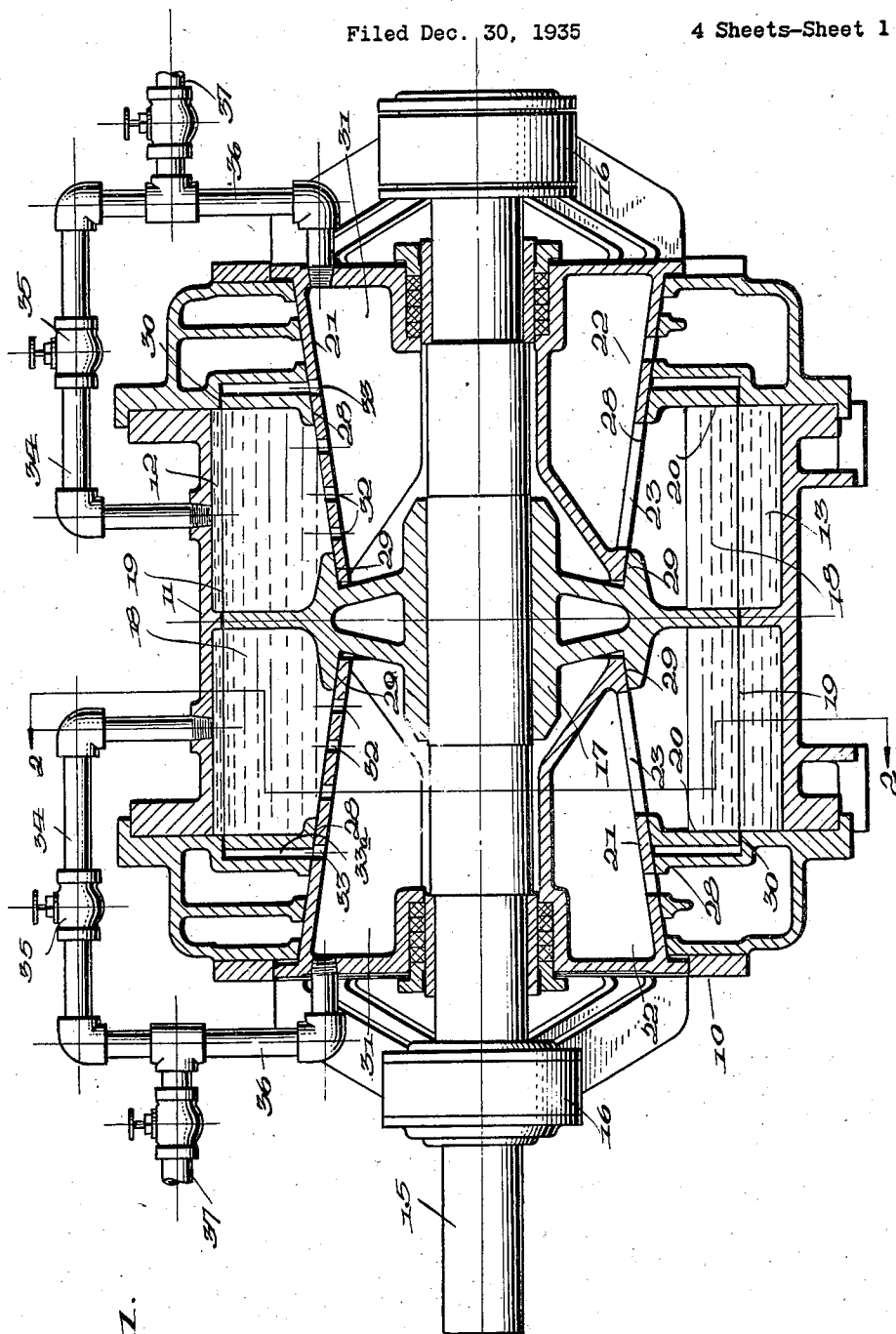


Fig. 1.

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4 Sheets-Sheet 2

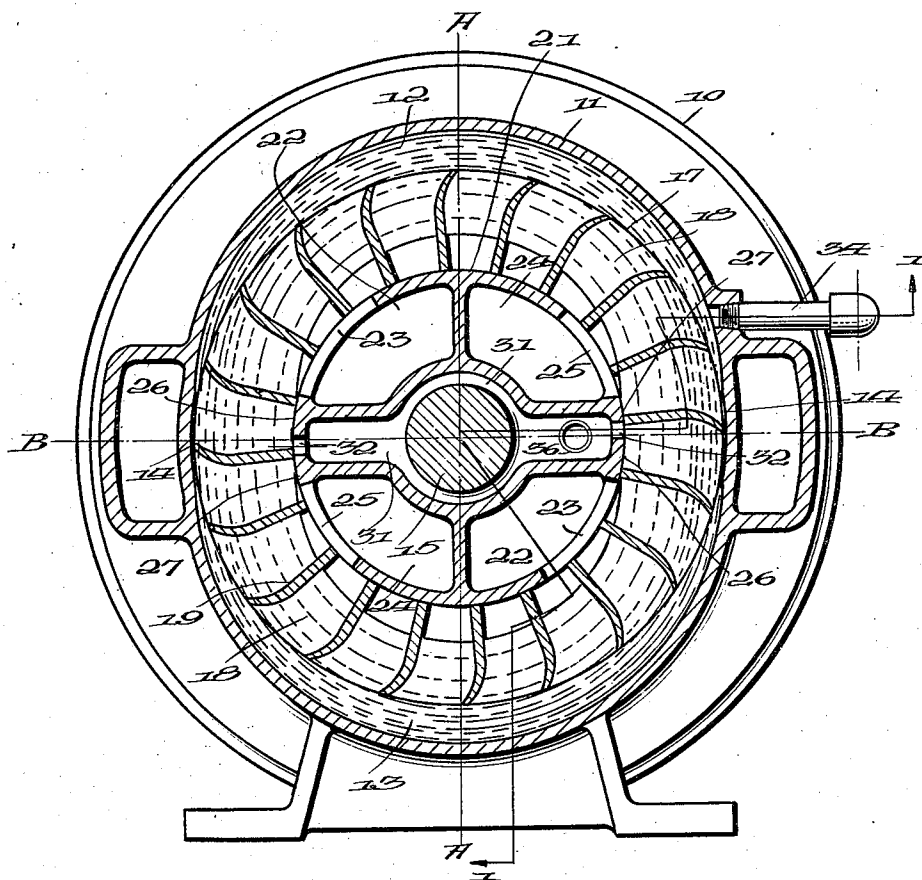


Fig. 2.

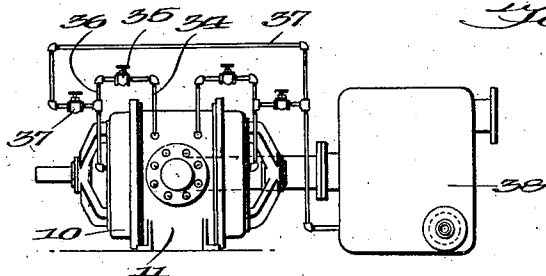


Fig. 3.

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4 Sheets-Sheet 3

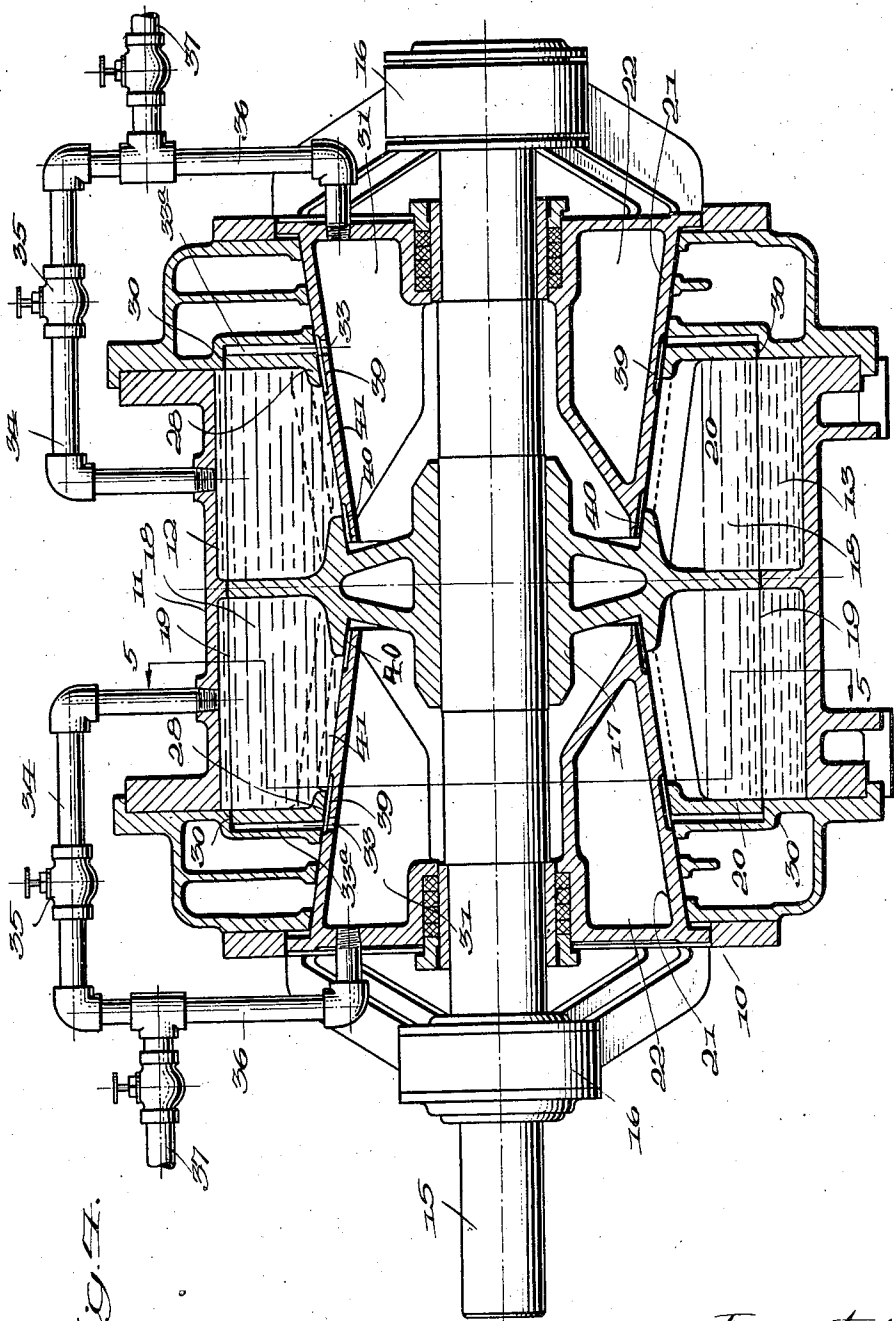


Fig. 17.

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4 Sheets-Sheet 4

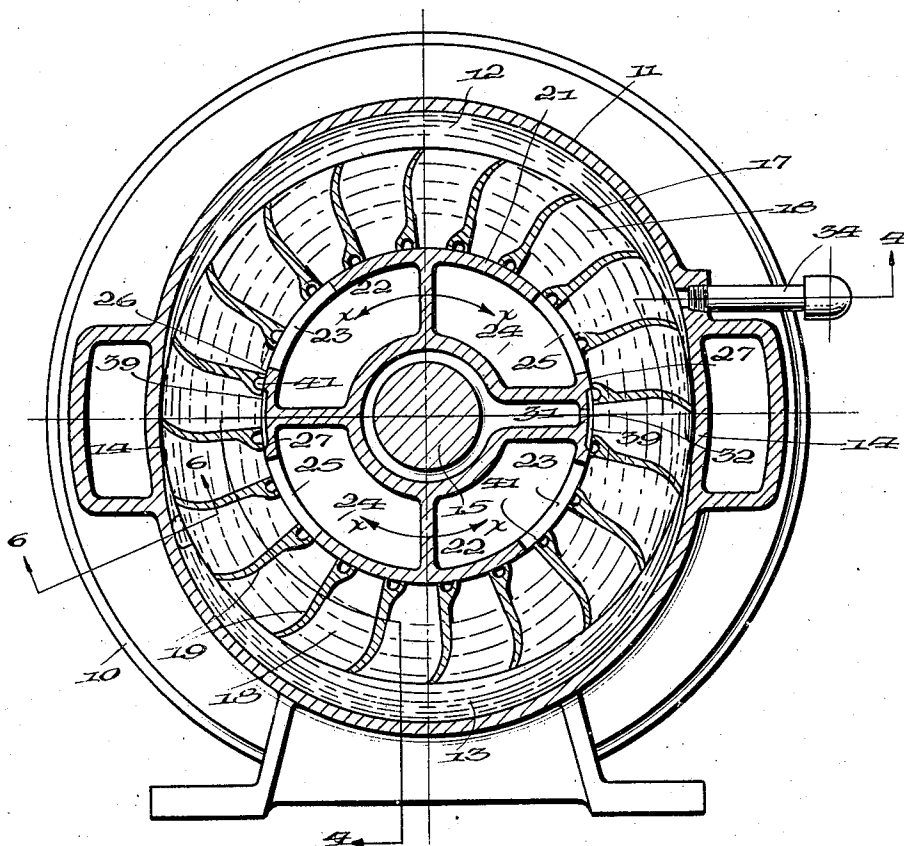


Fig. 5.

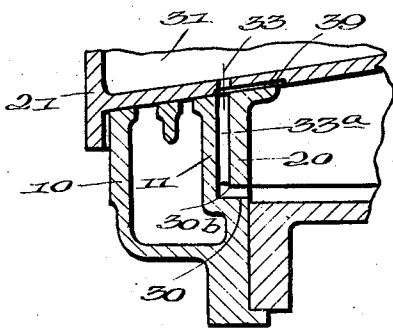


Fig. 6.

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UNITED STATES PATENT OFFICE

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Application December 30, 1935, Serial No. 56,815

41 Claims. (Cl. 230—79)

This invention is directed to fluid piston pumps or compressors, and more particularly to hydro-turbine pumps of the type employing a rotating water or other liquid ring as a pumping or displacing medium, in which the liquid of the ring alternately enters and recedes from a series of displacement chambers formed as peripheral buckets in a rotor revolving within an eccentric casing.

10 The well known "Nash" type of compressor is a good illustration of a pump having displacement chambers operating in a ring of liquid, and more specifically the invention relates to improvements and developments in the Nash pump described in United States Letters Patent to Jennings, No. 1,718,294 of June 25th, 1929, and No. 1,797,980 of March 24th, 1931, which disclose a circular rotor operating within an eccentric casing, the rotor being journaled upon tapered or conical port members extending within side portions of the revolving rotor. The herein described invention is not limited specifically to this type of pump, reference being made thereto for illustrative purposes.

25 Pumps of this nature have been found very satisfactory in the handling of air and gas, although they will also handle denser fluids. However, it has been found that while these pumps operate very satisfactorily in building up pressures to twenty or thirty pounds gage, when it is desired to increase the pressures above this point, there is a tendency toward leakage within the pump, resulting in impaired efficiency.

30 Running clearances between the rotor and pump casing, and between the rotor and the conical port member, or members upon which it is journaled are necessary to prevent binding, and even with the greatest accuracy of manufacture, this clearance is enough to result in an appreciable leakage as pressures increase, unless some means is taken to prevent it. The leakage of air or gas is of course many times greater than the leakage of a denser medium, such as a liquid, and as stated, these pumps are frequently used to handle air and gas.

45 Accordingly, it is an important object of the present invention to seal all of these running clearances against leakage. Preferably this is effected by directing a sealing liquid to the points of possible leakage, at a pressure greater than that tending to cause the leakage.

50 It is another object to reduce leakage of the liquid used as an operating medium, and to replenish losses thereof during normal operations,

simultaneously with the sealing of the running clearances.

It is a further object to obtain a sealing effect of such a nature that running clearances may be made much greater than heretofore, thereby reducing the cost of manufacture and increasing the efficient life of the pump.

Still another object contemplates a method of sealing effective to prevent leakage constantly, throughout the life of the pump, regardless of wear caused by the handling of gritty material, or caused by corrosion.

Another object comprises means to supply sealing liquid by recirculation of water from the discharge separator for the pump, although such liquid may be obtained from extraneous sources, when feasible.

Other objects include the features of structure disclosed in the aforesaid Jennings patents, as related to the unique sealing means forming a feature of the present disclosures.

To the attainment of the foregoing and other objects which will appear, reference may be made to the accompanying sheets of drawings showing certain forms and modifications of the invention, and in which:

Fig. 1 is a section through the pump taken on line 1—1 of Fig. 2;

Fig. 2 is a vertical transverse section taken on the line 2—2 of Fig. 1;

Fig. 3 is a reduced plan view of a pumping unit and separator, illustrating a piping arrangement for supplying sealing liquid;

Fig. 4 is a section similar to Fig. 1, but showing a modified sealing arrangement, and taken on the line 4—4 of Fig. 5;

Fig. 5 is a vertical transverse section taken on the line 5—5 of Fig. 4; and

Fig. 6 is a section taken on the line 6—6 of Fig. 5.

In the operation of these compressors or pumps, the liquid ring, rotated by the rotor, follows an operating path defined by the eccentric internal contour of the casing. The liquid first recedes from the center of the rotor or bottom of the displacement buckets, into lobes formed on major axes of the casing, and this recession constitutes the suction stroke of the compressor, drawing air, gas or other fluid which is to be handled by the pump in at the bottoms of the buckets. Then as the peripheral portions of the buckets approach the minor axes of the casing, the operating liquid ring is forced inward, into the bucket, to perform its compression stroke.

This action takes place several times during a single rotation of the rotor, depending upon the number of lobes formed in the pump casing. In the present illustration two lobes are illustrated, separated by lands at the ends of the minor axis of the casing.

Between the point where the periphery of the rotor and the casing approach each other, and the point where they separate as the rotor approaches a major axis, there is built up a differential in pressure which is somewhat greater than the differential in pressure between the inlet to the pump and the outlet, as built up by the compressor at its final discharge to the outlet. Unless the rotating liquid ring is forced into the rotor buckets at the high pressure point without material leakage, or loss of pressure, there will be a corresponding loss in efficiency in the operation. This leakage may occur at a number of points, and it is a feature of the present invention to minimize leakage from the high pressure points to the low pressure points, thus obtaining maximum efficiency, and permitting the building up of higher pressure differentials than heretofore thought possible in pumps of this nature.

Referring now to the drawings, in which like reference numerals refer to like parts, it will be seen that the pump comprises generally a stator 10, including an eccentric pump chamber 11 having enlarged portions or lobes 12 and 13, separated by lands 14—14 at opposite sides of the casing. The line A—A illustrates a major axis of the pump chamber through the lobes, and the line B—B is a minor axis through the lands.

Although but two lobes are illustrated, one on either side of the minor axis B—B, it will be obvious that the invention is applicable to pump casings having any desired number of lobes.

A driving shaft 15, extending through the casing, is supported by bearings 16—16 at either end thereof, and serves to support and drive a rotor 17, of generally cylindrical shape in cross section. This rotor is provided with a number of peripheral buckets or displacement chambers 18, formed by radial vanes 19, the outer edges of which are forwardly curved. If desired the vanes or blades 19 may be stream-lined to facilitate the circulation of operating liquid into and out of the buckets.

In the preferred construction the buckets will be enclosed by shrouds 20—20, connecting the blades 19.

Extending inwardly of the chamber 11 are a pair of tapered hubs 21 upon which the rotor is journaled, said hubs being constructed to form inlet and discharge passages for the pump.

The inlet passages 22 (one for each lobe), are suitably ported as at 23 for cooperation with the open bottoms of the rotor displacement buckets 18, and the outlet or discharge passages 24 are similarly ported as at 25.

At the two lands 14, the spaces between the blades or vanes 19 of the rotor and the casing are filled with operating liquid. As the rotor advances, the liquid is not only turned by the rotor, but also, is thrown out into the lobes by centrifugal force, and air, gas, or other medium being handled, is drawn in through the ports 23. Upon further advancement, the shape of the casing forces the liquid back into the rotor buckets, and this liquid, acting as a piston, in each bucket, compresses and forces the gas out through the discharge ports 25.

Maximum efficiency demands that as many as

possible of the displacement chambers be at work, and therefore the space between the inlet and discharge ports is made as narrow as possible, opposite a land 14; preferably this space occupies only a minimum of one displacement chamber. However, on one side of this space, as at the point 26, the interior of the chamber is subjected to inlet pressures, whereas the other side is subjected, as at the point 27, to the full discharge pressure, thus building up a pressure differential. But inasmuch as the space between the points 26 and 27 is made as small as possible, and at times there may be interposed but a single blade between the full discharge pressure and the lower inlet pressures, it follows that there is great tendency for leakage across this space from point 27 to 26, due to running clearance, despite the fact that the liquid ring substantially fills the rotor buckets or chambers at these points.

There is also a chance for leakage at various points of contact between the revolving rotor and the stationary cones as indicated at the points 28 and 29 (Figs. 1 and 4). Due to pressures developed in the lobes 12—13 it is also possible that leakage will occur at the points 30, that is at the periphery of the shrouds 20.

In order to overcome, or offset leakage at these various points, a sealing liquid under pressure is distributed to such points, either from an extraneous source of supply, or by recirculation of liquid from within the pump at its maximum pressure. To this end the tapered hubs or cones 21 are formed respectively with central passages 31, the walls of which are ported as at 32, whereby sealing fluid introduced under pressure to the passage 31 is free to escape to the points 26, 27, 28 and 29.

Other ports 33 communicate with the space 33a between the shrouds 20 and the interior of the pump chamber wall, whereby sealing liquid can flow to the points 30, thus taking care of all running clearances between the rotor and the interior of the chamber.

This sealing water or liquid being under greater pressure than the average pressure in the lobes, prevents the escape of liquid from the lobes where it is doing work, into the annular space 33a between the rotor and the chamber wall, which would otherwise result in some reduction in volume. This arrangement also makes possible the introduction of make-up liquid into the lobe at the point where it will recompense for possible loss of liquid which may be discharged through the outlet ports 25 with the air or other fluid being pumped.

Again, the introduction of sealing liquid at these points makes it possible to operate the pump with greater running clearances, than heretofore thought necessary, without in any way affecting the efficiency of the pump.

The sealing water may be introduced into the central passages 31 by means of piping shown particularly in Figs. 1, 3 and 4, wherein a lobe is tapped at its point of highest pressure, by a pipe 34. The liquid at this point is under the greatest pressure due to the fact that the ring is forced ahead by the rotor, and forced into the rotor by the wedging action between the rotor and the narrowing casing. This pressure is greater than that at the outlet ports 25, or in the discharge separator (which is substantially at the same pressure), because the water in re-entering the rotor is forced in against centrifugal force, by the forward driving effect of the blades or vanes of the rotor, the rotor driving the liquid into the

narrowing space between the rotor and the casing.

The pipe 34 is connected by a valve 35 to piping 36, which is tapped into the end of a central passage 31.

This arrangement is effective to recirculate fluid from the lobe to the central passage and back to the lobe by way of the rotor. If desired the piping 36 may be connected to any convenient extraneous source of liquid under pressure, by the valved pipe line 37. One such source is illustrated in Fig. 3, wherein the line 37 is connected to the bottom of the discharge separator 38, receiving liquid which is subjected to the full discharge pressure.

Referring now particularly to Figs. 4 and 5 there will be found a slightly modified structure for providing a liquid seal. Instead of the row of ports 32, the exterior of the hub or cone 21 may be grooved at 39 and 40, to establish communication between the interior of the central passage 31 and the channels 41 at the root of each individual blade or vane 19. This ensures a supply of sealing liquid from both sides of each blade throughout the channels 41, making an effective seal between each side of the vanes between the ports 23 and 25. These grooves 39-40, and channels 41 are supplied with liquid around the hub of the rotor, and through the ports 33, which additionally supply the annular space 33a between the rotor and the pump chamber wall.

A similar arrangement of grooves may be used over the area of the cone indicated by the arrows X-X (Fig. 5) between the ports 23 and 25, although a seal at this point is relatively less important than at the other points heretofore discussed, as there is a gradual distribution of pressure over a number of blades, and the differential pressure between the sides of an individual blade is not as great as is the case at the points 26 and 27.

Fig. 6 illustrates a modification wherein sealing water may be supplied from the point of greatest pressure within a lobe, but without resort to exterior piping. In this form, the annular space 33a between the rotor and the stator is utilized as at 30b to receive water beyond the shroud 20, such water flowing through the port 33 into the central passageway 31 of the hub or cone 21. The groove 39, as heretofore, receives some of this water under pressure to seal the running clearance between the rotor and the cone 21.

In some cases it will be found desirable to introduce clean sealing liquid from an outside source under pressure, through the port 33 into the space 33a between the sides of the rotor and the casing, allowing it to escape through the clearance at the periphery of the rotor, at the points 28, 29 and 30, Fig. 1. In this way extraneous material such as fiber or paper pulp, which may be handled by the compressor, is prevented from lodging between the sides of the rotor and causing undue friction.

Having thus described the invention, the operation and advantages thereof will be readily apparent. Once the pump is in operation the tendencies toward leakage, which are produced by a pressure differential between discharge pressures and intake pressures are offset by supplying a sealing liquid, at a higher pressure than set up by such differential, to the points where leakage might occur. This higher pressure is obtained either by supplying liquid from an extraneous source under a predetermined pressure, or by re-

circulating liquid under pressures greater than the discharge pressure, such liquid being obtained by tapping the interior of the pump at the point where centrifugal forces are being overcome by the wedging or crowding action produced by the converging relation between the rotor and stator.

Advantage is taken of the fact that a liquid such as water, will not leak as readily as a less dense medium such as air, and all running clearances are hence sealed with a liquid.

It has been found by actual test that sealing methods as described make possible the use of double the clearance between the rotor and the stator without any reduction in volume of the medium being handled, thereby reducing manufacturing costs. It has also been found that where heretofore it was possible to obtain up to twenty to thirty pounds gage as a maximum for efficient operation, it is now possible to build up pressures around one hundred pounds gage. Operating expenses are not increased as in the preferred form the liquid is constantly recirculated; in fact, due to the increased efficiency, operating costs are actually reduced.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing, and a rotor therein having displacement chambers cooperative with the pumping liquid to create a pressure differential between the inlet and outlet sides of the pump, of means to seal the inlet side of the pump from the outlet side thereof, comprising means to create and apply a pressure in opposition to the pressure differential of the pump, whereby to minimize leakage between the inlet and outlet sides of the pump.

2. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing, a rigid hub extending therewithin, and a rotor journaled on said hub and having displacement chambers cooperative with the pumping liquid to create a pressure differential between the inlet and outlet sides of the pump, of means to seal the inlet side of the pump from the outlet side thereof comprising means to direct a sealing liquid to clearances between the rotor and the hub, and to other clearances between the rotor and the casing, in opposition to said pressure differential whereby to minimize leakage between the inlet and outlet sides of the pump.

3. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing, and a rotor therein having a hub and having displacement chambers cooperative with the pumping liquid to create a pressure differential between the inlet and outlet sides of the pump, of means to seal the inlet side of the pump from the outlet side thereof, comprising means to supply a sealing liquid at pressures at least as great as the discharge pressures in the pump and to direct said sealing liquid to rotor clearances between the inlet and outlet sides of the pump, at points spaced from the hub of the rotor whereby to minimize leakage at such points.

4. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing, and a rotor therein having displacement chambers cooperative with the pumping liquid to create a pressure differential

- between the inlet and outlet sides of the pump, of means to seal the inlet side of the pump from the outlet side thereof, comprising means to direct a sealing liquid to the clearance spaces between the sides and periphery of the rotor and the casing, in opposition to said pressure differential, whereby to minimize leakage past such points.
5. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing having a lobe along a major axis and a land along a minor axis, and a rotor therein having displacement chambers cooperative with the pumping liquid to create a pressure differential between the inlet and outlet sides of the pump, of means to withdraw part of the pumping liquid from said lobe and to return same to the casing adjacent said land, and to direct said liquid as it returns to clearance spaces between the rotor and the casing at a pressure at least as great as the pressure differential generated within the pump whereby to minimize leakage between the inlet and outlet sides of the pump.
6. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing having a lobe along a major axis and a land along a minor axis, and a rotor therein having displacement chambers cooperative with the pumping liquid to create a pressure differential between the inlet and outlet sides of the pump, of means to withdraw part of the pumping liquid from said lobe at the point of greatest pressure in the lobe and to return same to clearance spaces between the rotor and the casing at a pressure at least as great as the pressure differential generated within the pump whereby to minimize leakage between the inlet and outlet sides of the pump.
7. The combination in a pump of the type using liquid in its pumping action, of a lobe casing and a rotor therein having displacement chambers cooperative with the pumping liquid, of means to control leakage between the inlet and outlet sides of the pump, comprising means to supply a sealing liquid to points of leakage and in opposition to the leakage at a pressure at least equal to the discharge pressure of the pump.
8. In a hydro-turbine pump, the combination with a casing having a hub extending inwardly thereof, inlet and discharge passages extending through said hub, a rotor journaled on said hub and having displacement chambers, said chambers and hub being formed with cooperating ports for inlet to and discharge from the pump, of means for directing a sealing fluid, under pressure at least equal to the normal pressure differential of the pump, to running clearances between said rotor and hub, in opposition to the normal pressure differential of the pump, substantially centrally thereof, and adjacent the ends of the hub, including a fluid receiving passage extending through the hub and ports effective to establish communication between said passage and the rotor.
9. In a hydro-turbine pump, the combination with a casing having a hub extending inwardly thereof, inlet and discharge passages extending through said hub, a rotor journaled on said hub and having displacement chambers, said chambers and hub being formed with cooperating ports for inlet to and discharge from the pump, of means for directing a sealing fluid to running clearances between said rotor and hub, including a fluid receiving passage extending through the hub, said hub being provided with fluid receiving grooves on its external surfaces, means establishing communication between said grooves and said fluid receiving passage, and said rotor being journaled across said grooves.
10. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing having a ported hub, a rotor turning on said hub and having peripheral displacement chambers cooperative with the pump liquid and the ported hub, of means for directing a sealing liquid to running clearances between said rotor and hub, said hub being provided with fluid receiving grooves on its external surfaces, means establishing communication between said grooves and said means for directing the liquid, and said rotor being journaled across said grooves.
11. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing having a ported hub, a rotor turning on said hub and having peripheral displacement chambers cooperative with the pump liquid and the ported hub, of means for directing a sealing liquid to running clearances between said rotor and hub, said hub being provided with fluid receiving grooves on its external surfaces, means establishing communication between said grooves and said means for directing the liquid, and means for directing a sealing liquid to those points of the casing closest to the periphery of the rotor.
12. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with a lobe casing and a rotor in said casing having peripheral displacement chambers cooperative with the pumping liquid, of separating means connected to the discharge of the pump, and means to supply a sealing liquid from said separating means to points of leakage between the inlet and outlet sides of the pump, whereby to minimize such leakage, cool the pumping liquid and make up losses in said pumping liquid.
13. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing having a ported hub, a rotor turning on said hub and having peripheral displacement chambers cooperative with the pumping liquid and the ported hub, of means for directing a sealing liquid, in opposition to the normal pressure differential of the pump, to those points of the casing closest to the periphery of the rotor, and means for directing a sealing liquid to the running clearances between said rotor and hub.
14. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing having a lobe, and a rotor in said casing having displacement chambers cooperative with the pumping liquid to create a pressure differential between the inlet and outlet sides of the pump, of means to withdraw part of the pumping liquid from said lobe at the point of greatest pressure therein and return same to points of leakage between the inlet and outlet sides of the pump, including a conduit extending from said point of greatest pressure in the lobe to said points of leakage.
15. In a hydro-turbine pump, an eccentric casing, a rotor operative therein, an inlet region and an outlet region, means including said rotor to develop pressures in the discharge region greater than those in the inlet region, and means to direct a sealing liquid, in opposition to said

developed pressures, to intermediate points between said inlet and outlet regions whereby to reduce leakage therebetween.

16. In a hydro-turbine pump, an eccentric casing, a rotor operative therein, an inlet region and an outlet region, means including said rotor to develop pressures in the discharge region greater than those in the inlet region, and means to direct a sealing liquid to intermediate points between said inlet and outlet regions, at a higher pressure than the pressure differential of said regions whereby to reduce leakage therebetween.

17. The method of sealing a rotary liquid ring pump against leakage between the inlet and outlet regions which comprises withdrawing a portion of the liquid of said ring from the point of highest pressure in a lobe of the pump, and recirculating same by directing said portion to a point of leakage, under pressure and in opposition to flow of liquid past said point.

18. In a hydro-turbine pump of the type using liquid in its pumping action, a stator provided with passages for the reception of sealing liquid, a tapered hub within the stator, a rotor cooperative with said hub, means establishing communication between said passages and running clearances between said rotor and hub, and between said passages and running clearance adjacent the periphery of said rotor, and means to introduce liquid under pressure to said passages, whereby to seal all of said running clearances between said rotor and stator against leakage.

19. In a hydro-turbine pump of the type using liquid in its pumping action, a stator provided with passages for the reception of sealing liquid, a tapered hub within the stator, a rotor cooperative with said hub, means establishing communication between said passages and running clearances between said rotor and hub, and between said passages and running clearance adjacent the periphery of said rotor, means to introduce liquid under sufficient pressure, to said passages to seal all of said running clearances between said rotor and stator against leakage, and to force some of said liquid through said clearances, whereby to make up losses in pumping liquid and to lower the operating temperatures of the pump.

20. The method of sealing a rotary liquid ring pump against leakage between inlet and outlet regions at points approximating maximum pump pressures, supplying losses in operating medium and maintaining low operating temperatures, which comprises recirculating a portion of the operating medium under pressures at least as great as the maximum pressure developed in the pump past said points and back to the main body of operating medium.

21. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing, a hub extending there-within, and a rotor journaled on said hub and having pump vanes defining displacement chambers cooperative with the pumping liquid to create a pressure differential between the inlet and outlet sides of the pump, of means to seal the inlet side of the pump from the outlet side thereof, comprising means to direct a sealing liquid to clearances between the rotor and the hub, and other clearances between the rotor and the casing, in opposition to said pressure differential whereby to minimize leakage between the inlet and outlet sides of the pump, said directing means including ports in said hub effective to establish communication between the interior of

said hub and said rotor adjacent the bases of said vanes.

22. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing, a hub extending there-within, and a rotor journaled on said hub and having pump vanes defining displacement chambers cooperative with the pumping liquid to create a pressure differential between the inlet and outlet sides of the pump, of means to seal the inlet side of the pump from the outlet side thereof, comprising means to direct a sealing liquid to clearances between the rotor and the hub, and to other clearances between the rotor and the casing, in opposition to said pressure differential whereby to minimize leakage between the inlet and outlet sides of the pump, said directing means including channels extending respectively along the roots of the individual vanes.

23. In a hydro-turbine pump, the combination with a casing having a ported hub, inlet and discharge passages extending through said hub, a rotor journaled on said hub and having blades forming displacement chambers cooperative with the ported hub, of means for directing a sealing fluid to running clearances between said rotor and hub, and across the surfaces of said blades, including channels extending respectively along the roots of the individual blades, whereby to minimize leakage within the chamber past said clearances.

24. In a hydro-turbine pump, the combination with a casing having a hub extending inwardly thereof, inlet and discharge passages extending through said hub, a rotor journaled on said hub and having vanes forming displacement chambers, said chambers and hub being formed with cooperating ports for inlet to and discharge from the pump, of means for directing a sealing fluid to running clearances between said rotor and hub, including a fluid receiving passage extending through the hub, said hub being provided with fluid receiving grooves on its external surfaces, and said rotor being channeled along the respective bases of said vanes, said rotor being journaled across said grooves.

25. In a hydro-turbine pump of the type using liquid in its pumping action, the combination with an eccentric casing having a ported hub, a rotor turning on said hub and having peripheral displacement chambers cooperative with the pumping liquid and the ported hub, said chambers being separated by radially disposed blades, of means for directing a sealing liquid in opposition to the normal pressure differential of the pump, to those points of the casing closest to the periphery of the rotor, and means for directing a sealing liquid to the running clearances between said rotor and hub, said directing means including channels extending respectively along the roots of the individual vanes.

26. In a wet type gas pump employing a liquid piston arranged for rotation within a piston chamber, a rotor, a port member extending into the sides of said rotor and having inlet and outlet ports communicating therewith, and a passage to conduct water from the piston chamber to the peripheral surface of said port member and direct it into the spaces between the contiguous surfaces of said port member and said rotor.

27. In a wet type gas pump of the type employing a liquid piston, a casing, a rotor mounted within said casing, port members extending into the sides of said rotor and having inlet and outlet ports communicating therewith, a confined body

of sealing water disposed peripherally of each said port member to provide a seal between contiguous surfaces of the rotor and the port members, and means to replenish said body of water to make up losses therefrom.

28. In a wet type gas pump employing a liquid piston, a casing, a rotor mounted therein and having a multiplicity of vanes defining a plurality of displacement chambers, each of said vanes having a groove in its inner face, a port member having inlet and outlet ports communicating with said rotor and having a sectional groove in its peripheral surface, said first mentioned groove and said sectional groove being in communication when said vanes are contiguous with the surface of said port member, and means to supply sealing water to said groove.

29. In a wet type gas pump of the type employing a liquid piston, a casing, a rotor mounted within said casing, port members extending into the sides of said rotor and having inlet and outlet ports communicating therewith, a sectional groove in the peripheral surface of each said port member, and means to supply sealing water to said grooves.

30. In a wet type gas pump of the type employing a liquid piston, a casing, a rotor mounted within said casing, port members extending into the sides of said rotor and having inlet and outlet ports communicating therewith, a confined body of sealing water disposed peripherally of each said port member intermediate said inlet and outlet ports to provide a seal between contiguous surfaces of the rotor and the port members, and means to replenish said body of water to make up losses therefrom.

31. In a hydro-turbine pump of the type using liquid in its pumping action, a stator provided with passages for the reception of sealing liquid, a rotor cooperative with said stator and effective to create a pressure differential between the inlet and outlet sides of the pump, means establishing communication between said passages and running clearance between the rotor and stator, remote from the periphery of the rotor, and means to introduce sealing liquid to said passages, under pressure greater than said pressure differential, whereby to seal all of said running clearances against leakage.

32. In a hydro-turbine pump of the type using liquid in its pumping action, a stator provided with passages for the reception of sealing liquid, rotor supporting means within the stator, a rotor cooperative with said supporting means, means establishing communication between said passages and running clearance between the rotor and its supporting means, and between said passages and running clearance adjacent the periphery of said rotor, and means to introduce sealing liquid under pressure to said passage, whereby to seal all of said running clearances between said rotor and stator against leakage.

33. In a hydro-turbine pump of the type using liquid in its pumping action, a stator provided with passages for the reception of sealing liquid, a rotor cooperative with said stator, and effective to create a pressure differential between the inlet and outlet sides of the pump, means establishing communication between said passages and running clearances between the rotor and stator, and means to introduce sealing liquid to said passages, in opposition to said pressure differential, and under pressure at least as great as said pressure differential, whereby to seal said running clearances against leakage.

34. In a hydro-turbine pump of the type using liquid in its pumping action, a stator provided with passages for the reception of sealing liquid, a port member, a rotor cooperative with said port member, arranged to revolve within the stator, means establishing communication between said passages and running clearances between the rotor and said port member, and means to introduce sealing liquid under pressure greater than the normal pressure differential of the pump, to said passages, whereby to seal said running clearances against leakage.

35. In a pump of the type using liquid for its displacing medium, a stator, a port member in said stator, a rotor cooperating with said port member, said rotor being provided with shrouds having a close running clearance with the stator, at their periphery, means to introduce sealing liquid under pressure between the shrouds and the casing, in opposition to the normal pressure differential of the pump, whereby to seal the running clearance between the periphery of the shrouds and the stator.

36. In a pump of the type using liquid for its displacing medium, a stator, a port member in said stator, a rotor cooperating with said port member, and rotatable within the stator for pumping purposes, and means to introduce sealing liquid under pressure greater than the normal pressure differential of the pump, to inner points of running clearance between the port member and the rotor, whereby to seal said running clearance.

37. In a pump of the type using liquid for its displacing medium, a stator, a port member in said stator, a rotor cooperating with said port member, and rotatable within the stator for pumping purposes, said rotor being provided with shrouds having a close running clearance with the stator at their periphery, and means to introduce sealing liquid under pressure between the shrouds and the casing, and to inner points of running clearance between the port member and the rotor, in opposition to the normal pressure differential of the pump, whereby to seal all of said running clearances between the rotor, the stator and the port member.

38. In a hydro-turbine pump of the type using liquid in its pumping action, a stator formed with a plurality of lobes separated by lands and thereby forming in effect a plurality of pumps within a single casing, said stator being provided with passages for the reception of sealing liquid, a rotor cooperative with said stator and effective to create a pressure differential between the inlet of one lobe and the outlet of an adjacent lobe, means establishing communication between said passages and running clearances between the rotor and stator at the lands, and means to introduce sealing liquid to said passages, under pressure at least as great as said pressure differential, whereby to seal said running clearances against leakage at points opposite the lands.

39. In a hydro-turbine pump of the type using liquid in its pumping action, a stator formed with a pumping lobe and a land therefor, said stator being provided with passages for the reception of sealing liquid, a rotor cooperative with said stator and effective to create a pressure differential between the inlet and outlet sides of the pump, means establishing communication between said passages and running clearances between the rotor and stator at the land, and means to introduce sealing liquid to said passages

under pressure at least as great as said pressure differential, whereby to seal said running clearances against leakage at points opposite the land.

40. In a hydro-turbine pumping system of the type wherein liquid is used for the pumping action, the combination of pumping means including a lobe and a land with a second pumping means including a lobe and a land operatively co-operative with said first pumping means, and rotor means effective to create a pressure differential between the inlet of one lobe and the outlet of the other lobe, and means to introduce sealing liquid to points between said inlet of one lobe and said outlet of the other lobe under pressure at least as great as said pressure differential,

whereby to seal said inlet and outlet against leakage therebetween.

41. In a hydro-turbine pump of the type using liquid in its pumping action, a lobe casing having a pumping lobe, and an inlet region and an outlet region, a rotor operative in said casing, and means to seal the pump against leakage between the inlet and outlet regions, including means to withdraw a portion of the pumping liquid from the point of highest pressure in the lobe of the casing and recirculate same by directing said withdrawn portion of the liquid to a point of leakage in the lobe casing, under pressure, and in opposition to flow of fluid past said point.

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CERTIFICATE OF CORRECTION.

Patent No. 2,195,174.

March 26, 1940.

IRVING C. JENNINGS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, first column, lines 59 and 60, claim 8, strike out the words and comma "in opposition to the normal pressure differential of the pump," and insert the same after the word and comma "hub," in line 62, same claim; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of May, A. D. 1940.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.