P. A. PETERSON.

BALANCING OF CENTRIFUGAL PUMPS.

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1,151,965.

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Fig. 3.

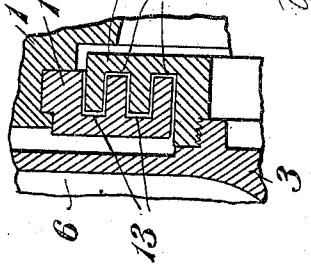


Fig. 2.

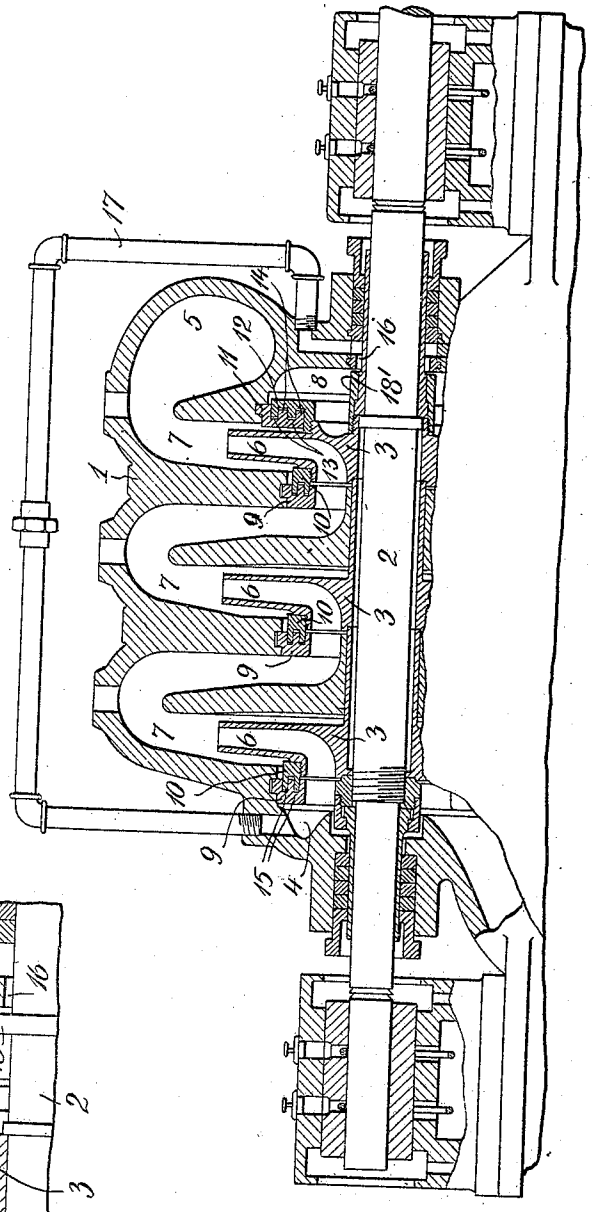
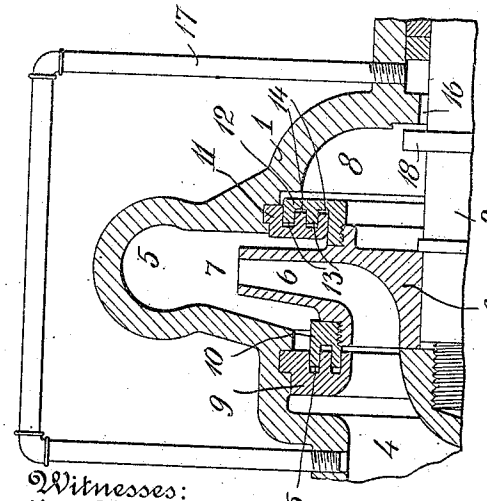


Fig. 1.



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BALANCING OF CENTRIFUGAL PUMPS.

1,151,965. Specification of Letters Patent. Patented Aug. 31, 1915.

Application filed August 12, 1913. Serial No. 784,433.

To all whom it may concern:

Be it known that I, PER ARVID PETERSON, a subject of the King of Sweden, and a resident of Trenton, in the county of Mercer and State of New Jersey, have invented certain new and useful Improvements in Balancing of Centrifugal Pumps, of which the following is a specification.

My invention relates to means for the automatic balancing of centrifugal pumps against end thrust, and comprises means whereby centrifugal pumps, either of the one stage or of the multistage type, are balanced against end thrust at all times, making the provision of thrust bearings unnecessary.

The objects of my invention are to maintain the impellers of centrifugal pumps in perfect balance at all times, to avoid the use of thrust bearings, to reduce wear and leakage in such pumps to a minimum, and to simplify the construction of such pumps.

I will now proceed to describe my invention with reference to the accompanying drawings, and will then point out the novel features in claims.

In the drawings: Figure 1 shows a fragmentary axial section of a single stage centrifugal pump embodying my invention, the axial clearance between the labyrinthine packing rings being exaggerated, and Fig. 2 shows a similar section of a multistage centrifugal pump embodying my invention, the axial clearance being similarly exaggerated; and Fig. 3 is a detail axial sectional view of the labyrinthine packing rings at the rear of the impeller, and on a larger scale than the previous views, showing the radial and axial clearance between the labyrinthine packing rings.

Referring first to Figs. 1 and 3, 1 designates the casing of a centrifugal pump, 2 the impeller shaft of such a pump, 3 an impeller mounted on such shaft, 4 the usual admission duct and 5 the usual discharge chamber. The impeller is provided with the usual passages 6, receiving liquid from the admission duct 4 and discharging into the space 7 and thence into the discharge duct 5. In rear of the impeller there is, as customary, a balancing chamber 8.

On the inlet side of the impeller I have indicated the usual labyrinthine packing comprising a stationary labyrinthine ring 9 and a rotating labyrinthine ring 10, the latter mounted upon the impeller and rotating with it; the two rings, 9 and 10, having intermeshing flanges providing a labyrinthine passage in the usual manner.

At the rear of the impeller I have indicated other labyrinthine rings, 11 and 12, ring 11 being stationary and ring 12 being mounted upon and rotating with the impeller; these rings 11 and 12 likewise having intermeshing flanges providing a labyrinthine passage; but the rings 11 and 12 face in directions opposite that which has been the practice heretofore in centrifugal pumps; for according to former practice it has been common for the stationary impeller ring on the rear side of the impeller to have its flanges facing toward the impeller; and correspondingly, according to former practice, the rotating labyrinthine ring on the rear side of the impeller has had its flanges facing from the impeller; whereas just the reverse is true of the construction herein illustrated and described.

The impeller shaft is allowed slight play for longitudinal motion; which movement will reduce or increase, as the case may be, the distance between the ends of the flanges 13 of ring 12 and the ends of the corresponding grooves of ring 11, and will correspondingly decrease or increase, as the case may be, the distance between the ends of the flanges 14 of the stationary ring 11, and the ends of the corresponding grooves in ring 12. Of course as the distance between the ends of flanges 13 and 14 and the ends of the corresponding grooves increases, the distance between the flanges 15 of the ring 10 and the ends of the grooves of the ring 9, will increase, and vice versa.

In the operation of this pump, since the pressure at 7 is necessarily greater than the pressure at 4, while the pump is in operation, there is a tendency for leakage from space 7 between rings 9 and 10 back into the inlet 4 and a corresponding tendency for leakage from space 7 between rings 11 and 12 back into balancing chamber 8; and this latter leakage, if no vent were provided from chamber 8, would lead to a pressure in chamber 8 equal to that in space 7; therefore I provide a passage 16 between the casing 1 and the impeller shaft, and a duct 17 connecting this passage 16 with the inlet

duct 4 of the pump. I also provide on the impeller shaft a throttling ring 18, the purpose of which will be explained below.

It will be seen that in the construction shown if there be an excess of thrust toward the right the impeller will move slightly to the right, increasing the distance between the flanges of rings 12 and 11 and the ends of the grooves in which those flanges are located; and so permitting increased flow between the rings 12 and 11, while at the same time the throttling ring 18 will restrict the flow from chamber 8 through passage 16, with a resulting building up of pressure in the balancing chamber 8 sufficient to restore equality of thrust in both directions; conversely, if the thrust toward the left be greater than that toward the right, the impeller will move slightly to the left, decreasing the distance between the ends of the flanges of rings 11 and 12 and the ends of the grooves in which those rings are located, and correspondingly decreasing the distance between the flanges of the rings 9 and 10 and the ends of the grooves in which those flanges are located, and decreasing the throttling of passage 16 by throttling ring 18, with a resulting decrease of pressure in balancing chamber 8.

Heretofore, in centrifugal pumps provided with labyrinthine packing, it has been customary to provide radial clearance between the flanges of the stationary and the rotary labyrinthine rings and the grooves in which such flanges are located; such clearance amounting in some cases to as much as one sixty-fourth of an inch. Such clearance has necessarily resulted in considerable leakage into the balancing chamber and into the inlet duct of the pump. It has also been common to employ a balancing duct, through the impeller, connecting such balancing chamber in rear of the impeller with the inlet portion of the impeller; and the area of such balancing duct should be proportionate to the leakage through the labyrinthine packing into the balancing chamber. But this leakage cannot be calculated with any degree of accuracy, being affected by a great many factors, one of which is contraction of the flow through the rings, the coefficient of which cannot be determined with any degree of accuracy. Further the flow through the balancing ducts is also affected by many factors, such as contraction, velocity of water entering the impeller, and velocity of impeller; and several of these factors are variable; for which reason it has been commonly considered necessary to provide thrust bearings for the impeller, notwithstanding the presence of a balancing chamber in rear of the impeller, and notwithstanding the provision of a balancing duct through the impeller. Moreover, in these former pumps, the leakage through the labyrinthine packing into the balancing chamber has been of a progressively increasing nature, owing to inevitable wear of the labyrinthine rings; for which reason it has been found necessary to renew at frequent intervals these labyrinthine rings, as otherwise the thrust may increase to a dangerous extent and also decrease capacity and efficiency of the pump materially.

According to my invention I provide end clearance for tightening between the ends of the flanges of the labyrinthine rings and the ends of the grooves in which such flanges are located; which end clearance varies according to the position assumed by the impeller at any instant, usually from 1/64″ as a maximum to a few thousandths of an inch, according to the size of the balancing ducts and position assumed by the impeller at the moment. The scale of Figs. 1 and 2 is too small to permit the showing, to anything approaching scale, of the relation of radial to axial clearance; and indeed, in these figures, in order to indicate axial clearance at all, it has been necessary to greatly exaggerate such axial clearance; but in Fig. 3, the relation of axial clearance to radial clearance is indicated with some approximation to their normal relative values, though even in this figure it has been necessary to exaggerate both clearances considerably; the radial clearance being, usually, less than 1/64″ and the axial clearance being, in practice, less than this amount, ordinarily, as previously explained.

The axial clearance is the factor which principally controls the leakage into the balancing chamber 8, this axial clearance being normally, as previously stated, less than the radial clearance; but the horizontal or axially extending portions of the passages between the flanges of the labyrinthine packing rings also exerts an important limiting action upon the leakage, (the width of these horizontal or axially extending passages, such width being that of the radial clearance between the flanges, being small,) because of the great resistance which such narrow passages exert to the flow of water, and because the leakage passages between the labyrinthine packing rings are very tortuous.

Since, according to my invention, the throttling action in the labyrinthine rings by which the automatic balancing of the pump is effected, occurs mainly between the ends of the flanges of the labyrinthine rings, and the ends of the grooves in which such flanges run, wear of these flanges has very little effect on the leakage between these rings, since the impeller automatically assumes a position whereby the leakage is regulated to give the required pressure in the balancing chamber, and therefore in practice renewal of the labyrinthine rings

is very seldom required. It also follows from my invention, that the smaller be the area of cross section of the balancing duct or ducts 16 and 17, the smaller is the leakage which can be taken care of by these ducts and consequently a smaller axial clearance will automatically be established between the ends of the flanges of rings 12 and 11, and the ends of the grooves in which such flanges run. Of course, there is a minimum permissible clearance between the ends of these flanges and the ends of the grooves in which they run, which minimum clearance may vary under different conditions of use; and the area of the balancing duct or ducts 16 and 17 should be proportioned in the design of the pump, to give that minimum axial clearance of the flanges of the labyrinthine rings 11 and 12 which the conditions of use require.

For various reasons, it is often advantageous to have in the balancing chamber 8 a pressure much greater than the pressure in the inlet of the impeller. To insure such greater pressure in the balancing chamber, the rear impeller labyrinthine ring 12 is made of greater diameter than the front impeller labyrinthine ring 10; for in order to balance the impeller the pressures per unit area acting on the left hand side of the impeller multiplied by the areas upon which such pressures act should be equal to the pressures per unit area acting on the right hand side of the impeller multiplied by corresponding areas. If the diameter of the rear impeller labyrinthine ring 12 is made of the same diameter as the front impeller labyrinthine ring 10, it can easily be seen that approximately suction pressure has to prevail in balancing chamber 8 in order to balance impeller. If the diameter of the rear impeller ring be made greater than the diameter of the front impeller ring and if suction pressure should then exist in balancing chamber 8, the total force acting on the left of the impeller will be greater than the total force acting on the right of the impeller, consequently there will be a thrust toward the right. In order to counteract this thrust and make the impeller balanced it will be necessary to have a pressure greater than the suction pressure in balancing chamber 8. This pressure may be selected to suit the operating conditions and the diameter of the rear impeller ring can easily be calculated when the pressure, which is desired in balancing chamber, has been selected. Since, as I have shown above, the impeller automatically assumes a position such that the leakage between rings 11 and 12 is regulated to preserve that pressure in the balancing chamber which keeps the impeller in balance, it follows, that with a rear impeller ring 12 of greater diameter and area than the front impeller ring 10, a greater pressure will be maintained in the balancing chamber 8 than the pressure at the inlet of the impeller.

The throttling ring 18 is not always essential, but it is desirable in many cases, particularly when a pump, designed for working against a high head, is running for a time on a low head, as, for example, when starting up, or is operating on a variable head. In such case, except for the throttling ring 18, the impeller might be unbalanced momentarily, and with thrust on the impeller toward the right in Fig. 1; but the throttling ring, by regulating the escape from the balancing chamber 8, causes pressure to build up quickly in this balancing chamber and to an extent sufficient to keep the impeller structure in balance.

In Fig. 2 I have illustrated my invention as applied to a three stage centrifugal pump. It will be obvious that the number of stages of such pump might be greater or less than they are shown. The construction is the same as in Fig. 1, except that labyrinthine packing is provided on the rear side of the last impeller only, and except that a balancing chamber 8 is provided on the rear side of such last impeller only; the balancing duct 17 extending from the left hand or front side of the first impeller to a passage 16 communicating with the balancing chamber 8 on the rear side of the last impeller. In the construction shown in Fig. 2 the throttling ring, there designated by numeral 18′, is carried by the last impeller, instead of by the impeller shaft. The operation of the pump shown in Fig. 2, as to automatic balancing, is the same as that of the pump shown in Fig. 1.

I am aware that the automatic balancing as to end thrust of the impellers of single stage and multistage pumps has been proposed heretofore; but so far as I know this is the first instance of automatic balancing obtained by throttling action between the ends of flanges of labyrinthine packing rings, and the ends of grooves in which such flanges work, regulated by automatic axial motion of the impeller.

In a companion application, filed August 12, 1913, Ser. No. 784,432, I have illustrated a centrifugal pump embodying the same generic invention as does the pump herein illustrated and described, the construction of the pump of my said application filed August 12, 1913, Ser. No. 784,432 being similar to that of the pump herein illustrated and described, except that instead of employing balancing ducts 16 and 17 connecting the balancing chamber 8 with the inlet duct of the pump, I have provided a balancing duct extending through the impeller from the balancing chamber to the inlet portion of the impeller, and except that, in the multistage pump shown in my

said companion application filed August 12, 1913, Ser. No. 784,432, labyrinthine packing is provided between the stages of the pump. The construction of this present case is preferable in multistage pumps wherein the difference in pressures existing in discharge duct 7 of last impeller and balancing chamber 8 is not extremely great. If this difference in pressures is too great, excessive wear of the rings may occur, and in such a case I prefer to use the construction shown in my companion application. The claims generic to the constructions of this application, and of my said companion application, are found in this application.

The principle of automatic balancing herein illustrated and described are applicable to steam and other fluid pressure turbines and blowers. Hence, in one of the following claims I have employed the term "pressure engine" as inclusive of centrifugal pumps, blowers, and steam and other fluid pressure turbines, and have employed the term "rotor" as generic to the impeller structure of a centrifugal pump, to the impeller structure of a blower, and to the rotary member of a fluid pressure turbine.

What I claim is:—

1. A pressure engine comprising in combination a casing having a flow passage within it and a rotor within said casing mounted for slight axial motion therein as well as for rotary motion, there being a balancing chamber between the impeller and casing, of means for controlling leakage with respect to such balancing chamber comprising labyrinthine packing rings, one carried by the casing and the other by the rotor, and one provided with a cylindrical flange and the other with a corresponding cylindrical groove adapted to receive such flange, there being end clearance between the end of such flange and the base of such groove, that side of the rotor labyrinthine ring which coacts with the casing labyrinthine ring facing toward the rotor, whereby axial movement of the rotor, due to unbalanced thrust, tends to restore balance of thrust by increase or decrease, as the case may be, of flow between such labyrinthine rings.

2. A centrifugal pump comprising in combination a casing having a flow passage within it and an impeller within said casing mounted for slight axial motion therein as well as for rotary motion, there being a balancing chamber on the rear side of such impeller and between the impeller and casing, of means for controlling leakage from the flow passage of such casing to said balancing chamber comprising labyrinthine packing rings, one carried by the casing and the other by the impeller, and one provided with a cylindrical flange and the other with a corresponding cylindrical groove adapted to receive such flange, there being end clearance between the end of such flange and the base of such groove, that side of the impeller labyrinthine ring which coacts with the casing labyrinthine ring facing toward the impeller, whereby axial movement of the impeller, due to unbalanced thrust, tends to restore balance of thrust, by increase or decrease, as the case may be, of flow between such labyrinthine rings.

3. A centrifugal pump comprising in combination a casing having a flow passage within it and an impeller within said casing mounted for slight axial motion therein as well as for rotary motion, there being a balancing chamber on the rear side of such impeller and between the impeller and casing, of means for controlling leakage from the flow passage of such casing to said balancing chamber comprising labyrinthine packing rings, one carried by the casing and the other by the impeller, and one provided with a cylindrical flange and the other with a corresponding cylindrical groove adapted to receive such flange, there being end clearance between the end of such flange and the base of such groove, that side of the impeller labyrinthine ring which coacts with the casing labyrinthine ring facing toward the impeller, a duct permitting escape from such balancing chamber, and means axially movable with the impeller, controlling flow through such duct.

4. A centrifugal pump comprising in combination a casing having a flow passage within it and an impeller within said casing mounted for slight axial motion therein as well as for rotary motion, there being a balancing chamber on the rear side of such impeller and between the impeller and casing, of means for controlling leakage from the flow passage of such casing to said balancing chamber comprising labyrinthine packing rings, one carried by the casing and the other by the impeller, and one provided with a cylindrical flange and the other with a corresponding cylindrical groove adapted to receive such flange, there being end clearance between the end of such flange and the base of such groove, that side of the impeller labyrinthine ring which coacts with the casing labyrinthine ring facing toward the impeller, a duct permitting escape from such balancing chamber, and a throttling ring axially movable with the impeller, and arranged to restrict variably flow through such duct.

5. A centrifugal pump comprising in combination a casing having an inlet duct and a flow passage, and a single suction impeller within said casing mounted for slight axial motion therein, as well as for rotary motion, there being a balancing chamber on the rear side of such impeller and between the impeller and casing, labyrinthine packing on the inlet side of the impeller comprising

intermeshing labyrinthine rings, one carried by the impeller and the other by the casing, labyrinthine packing on the rear side of the impeller controlling leakage from the flow passage of the casing to said balancing chamber and comprising labyrinthine packing rings having the one a cylindrical flange and the other a corresponding cylindrical groove adapted to receive such flange, one of such rear labyrinthine rings being carried by the casing and the other by the impeller, the working face of such latter ring facing the impeller, there being end clearance between said rings, such rear labyrinthine impeller ring being of greater area than the front labyrinthine packing ring.

6. A centrifugal pump comprising in combination a casing having an inlet duct and a flow passage, and a single suction impeller within said casing mounted for slight axial motion therein, as well as for rotary motion, there being a balancing chamber on the rear side of such impeller and between the impeller and casing, labyrinthine packing on the inlet side of the impeller comprising intermeshing labyrinthine rings, one carried by the impeller and the other by the casing, labyrinthine packing on the rear side of the impeller controlling leakage from the flow passage of the casing to said balancing chamber and comprising labyrinthine packing rings having the one a cylindrical flange and the other a corresponding cylindrical groove adapted to receive such flange, one of such rear labyrinthine rings being carried by the casing and the other by the impeller, the working face of such latter ring facing the impeller, there being end clearance between said rings, such rear labyrinthine impeller ring being of greater area than the front labyrinthine packing ring, and a balancing duct connecting such balancing chamber with the inlet duct of the pump.

7. A centrifugal pump comprising in combination a casing having an inlet duct and a flow passage, and a single suction impeller within said casing mounted for slight axial motion therein, as well as for rotary motion, there being a balancing chamber on the rear side of such impeller and between the impeller and casing, labyrinthine packing on the inlet side of the impeller comprising intermeshing labyrinthine rings, one carried by the impeller and the other by the casing, labyrinthine packing on the rear side of the impeller controlling leakage from the flow passage of the casing to said balancing chamber and comprising labyrinthine packing rings having the one a cylindrical flange and the other a corresponding cylindrical groove adapted to receive such flange, one of such rear labyrinthine rings being carried by the casing and the other by the impeller, the working face of such latter ring facing the impeller, there being end clearance between said rings, such rear labyrinthine impeller ring being of greater area than the front labyrinthine packing ring, and a balancing duct connecting such balancing chamber with the inlet duct of the pump, and means axially movable with the impeller for variably restricting flow through such balancing duct.

8. A multistage centrifugal pump comprising in combination a casing formed in a plurality of stages with flow passages therethrough, and an inlet duct communicating with one stage and an exit duct communicating with another stage, and a rotary impeller structure within such casing comprising an impeller for each such stage, there being a balancing chamber on the rear side of the last impeller and between that impeller and the casing, of leakage preventing means between the outlet duct and inlet duct of each impeller, leakage preventing means between the balancing chamber on the rear side of the last impeller and the casing, comprising labyrinthine packing rings one carried by the casing and the other by the impeller, and the one provided with a cylindrical flange and the other with a corresponding cylindrical groove adapted to receive such flange, such rear impeller labyrinthine ring facing toward the corresponding impeller, and a balancing duct connecting such balancing chamber with the inlet duct of the pump.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

PER ARVID PETERSON.

Witnesses:
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GEO. B. PAGE.