

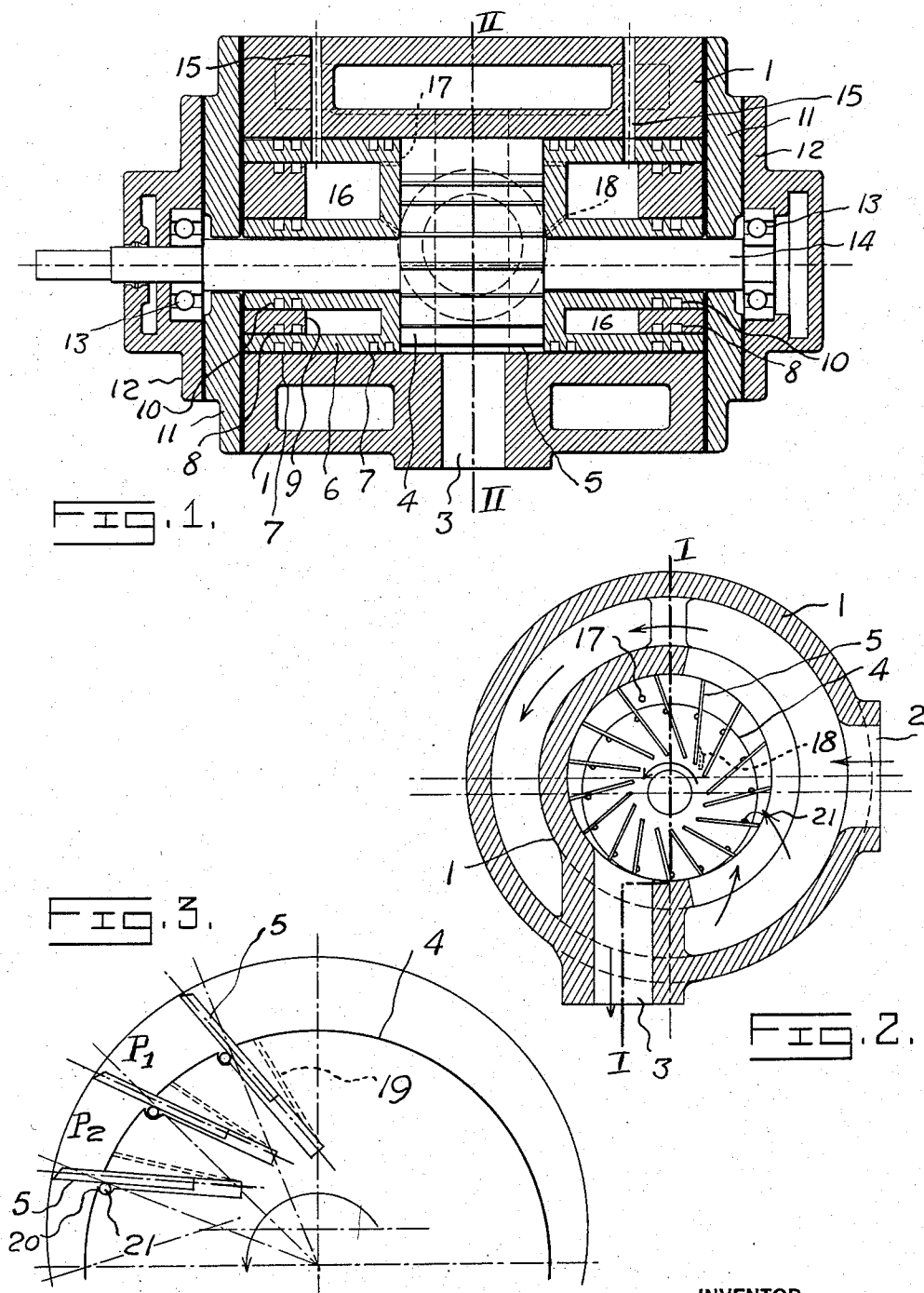
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FLUID PRESSURE PUMP OF THERMIC-DYNAMICAL ACTION

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FLUID PRESSURE PUMP OF THERMODYNAMICAL ACTION

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The present invention refers to pressure pumps for the compression of fluids.

The main object of the invention is to provide means whereby the endwise sealing of the compression chamber is effected by means of floating pistons which are provided with piston rings so as to provide for effective sealing. These floating pistons are mounted axially of the rotor and are so mounted in the fixed casing as to be prevented from rotating and at the same time, they are left free to move inwardly and outwardly within certain limits along the axis of the rotor. These floating pistons are subjected, on one side, to the pressure of the fluid in the compression chamber, i. e., to the main fluid pressure, and on the opposite side, to the pressure of an auxiliary fluid or compensating pressure. The main fluid pressure and the compensating pressure act upon each of the floating pistons in opposite directions and with different net values depending, respectively, on the unit pressure of the main fluid and the area of the floating piston in contact with the said main fluid, and the unit pressure of the auxiliary fluid and the area of the floating piston in contact with said auxiliary fluid. The areas of the floating pistons are proportionated in accordance with the unit pressures of the fluids in contact therewith, so as to have the resultant pressure in the proper direction to move and tighten the floating pistons against the rotor with a force sufficient for assuring effective sealing for the compression chamber, without, however, being undesirably high, so that the rotor may be left free to rotate without appreciable loss of efficiency by friction. The pump of the invention is thus provided with a highly effective endwise sealing of its compression chamber.

In this manner, the present invention affords a solution to one of the most serious problems met with in pressure pumps of the rotative type, especially when it is desired to reach unit pressures above certain values, which are in reality yet relatively low.

A further object of the invention is to provide for effective sealing between the slidable blades and the rotor slots wherein the blades move. As is known, even in a new apparatus there will always be a certain play, though small, between the blades and the slots wherein they move. Such play, which is small when the apparatus is new, will increase by wear during the use of the apparatus, specially due to the fact that the blades are generally made of a much harder material than that of the body of the rotor

wherein the slots are cut. As this play is increased, there is also an increased leakage of the compressed fluid, which passes back from the points of higher pressure to the points of lower pressure through the said spaces between the blades and their respective slots. According to the invention, the front walls of the rotor slots, i. e., the walls adjacent the high pressure side are provided, adjacent the outer or open end thereof, with a recess, preferably in the form of a circular arc in cross section, and a preferably cylindrical rod is lodged in said recess, said rod extending throughout the whole breadth of the blade and being held in position in its recess by the said blade. The inner or closed portion of the slot is preferably made to communicate with the adjacent region of lower pressure, said communication being effected, for instance, by means of a narrow passage formed in the body of the rotor or a groove cut in the blade or in any other suitable way. The fluid pressure which is thereby admitted into the inner or closed portion of the slot adds itself to the centrifugal force acquired by the said rod due to the rotational movement of the rotor, in such a way that the resultant of the forces acting upon the said rod will have the effect of forcing the latter outwardly, so that, owing to the mobility of the rod within the recess or seat thereof, the rod is tightened between its seat and the adjacent wall of the blade, thereby providing for an effective sealing against the flow of fluid from the side of higher pressure to the side of lower pressure. This arrangement and combination of parts has the further important advantage that it presents an automatic, continuous and effective compensation for the wear of the contacting parts, namely, the slots, blades, rods and rod seats, since the rods, by being forced tightly as previously described against their seats and the adjacent walls of the blades, will continuously and automatically neutralize any play that may result from wear of the contacting parts and will consequently maintain effective sealing between said contacting parts. The rod has also the effect of keeping the blade always parallel to or aligned with its respective slot, preventing the blade from getting inclined within the slot and relatively thereto, owing to the moment of force on the projecting portion of the blade due to the action of the fluid on the higher pressure side. Such an inclination, which is prevented by the use of the rod as above explained, would result in a cutting action of the front inner edge of the blade against the front wall of the slot and

by the rear outer edge of the slot against the rear face of the blade. The use of the said rods has still another effect, and as a matter of fact constitutes a specific object of the invention of a different nature, which will be disclosed hereinafter. The recess or seat for the said rod may be formed at any convenient distance from the outer or open end of the slot, it being obviously not essential to locate the same immediately adjacent the said outer or open end.

A further object of the invention is to provide a special system of neutralizing to the desired extent the high pressure that the rotor blades tend to exert against the walls of the fixed casing owing to the centrifugal force of the blades due to the high rotative speed of the rotor. It has been heretofore proposed to mount the blades in slots arranged at an angle to the true radial direction so that the centrifugal force may thus be neutralized, and according to the present invention, this same object of neutralizing in the desired extent the effect of the centrifugal force of the blade may be obtained by a utilization for such purpose of the wedge effect of the rods already referred to, even in those cases where the rotor slots are formed in the radial direction, instead of in an inclined direction to act as inclined planes of retarding effect. As seen above, the rods are forced outwardly against and tightened between their respective seats and the adjacent faces of the corresponding blades, and in this way it is evident that they exert a wedging action tending to neutralize the effect of the centrifugal force of the blades. The magnitude of this wedging action depends on various factors, as for instance, the centrifugal force of the blades due to the rotative speed of the rotor, the friction coefficient for the contacting parts, the actions of the higher pressure and the lower pressure in adjacent cells, the former acting to oppose the outward movement of the rod and the latter acting to help this said outward movement, thus adding itself to the centrifugal force of the rod. By taking due consideration of these factors together with any experimental data such as are usually necessary in connection with problems of this nature, it will be possible to correctly determine beforehand the magnitude of the resultant retarding force which will be sufficient to neutralize in the desired extent the effect of the centrifugal force of the blades. A further specific object of the invention, therefore, is also to use this wedging action of the rods for the specific purpose of neutralizing in a desired extent the effect of the centrifugal force of the blades, independently of, or in addition to, the specific object of the use of the rods as a sealing means against leakage of fluid as previously set forth. According to the present invention, therefore, the neutralization of the centrifugal force of the blades in any desired extent may be obtained either by forming the rotor slots in an inclined direction relatively to the radial direction of the rotor so as to have the rotor slot act upon the blade after the manner of an inclined plane of retarding effect, or by forming the rotor slots in the radial direction of the rotor as usual and using the retarding effect of the wedging action of the rods as set forth above, or still by employing the combined action of a retarding inclined plane and a wedging action of the rods such as disclosed above, i. e., forming the rotor slots in an inclined direction relatively to the radial direction of the rotor and at the same time using the rods to act with a

wedging action of retarding effect against the movement of the blades.

A further object of the invention is to utilize the thermic effect undergone by the compensating fluid, i. e., the fluid which operates the floating pistons of the endwise sealing system, for the purpose of causing a certain degree of compression on this same fluid which, once thus thermally compressed, is then delivered into the compression chamber at a point of corresponding pressure. This means therefore a threefold advantage, since, according to this principle, the said compensating fluid acts simultaneously to operate the floating pistons of the sealing system, to help in cooling the apparatus, and from the thermic effect above mentioned, to utilize the heat thus removed from the apparatus to compress the said fluid to a certain degree, the said fluid being then delivered into the compression chamber, thereby bringing about a substantial economy of work.

Other objects of the invention will become apparent as the description proceeds.

For the sake of clearness, by way of example only and without any limitation on the spirit and scope of the invention, the latter will now be described in connection with a preferred embodiment thereof, which is illustrated in the accompanying drawing.

In the drawing:

Fig. 1 is a view illustrating a preferred embodiment of the apparatus of the invention, in section along the line I—I of Fig. 2;

Fig. 2 is a vertical cross-sectional view along the line II—II of Fig. 1;

Fig. 3 is a fragmentary view in an enlarged scale, showing details of the apparatus.

With reference to the drawing, the apparatus therein illustrated comprises a fixed housing 1, which is preferably made of cast iron. The housing 1 is centrally formed with a cylindrical hollow space within which are lodged the rotor and the floating pistons, said central hollow space being closed at each end by closure elements 11 and 12. The closure elements 11 and 12 are provided at one or both ends with suitable central openings for the passage of the rotor axle and for the fitting therein of suitable bearings for said axle. The fixed casing 1 is also formed around its central hollow space with a suitable jacket for a cooling medium, for the cooling of the compression chamber.

A rotor 4 is mounted on an axle 14 within the central cylindrical hollow space of the casing 1 in an off-center position, the axle 14 being mounted on ball bearings 13. The rotor 4 is preferably made of cast iron and is provided with a series of slots spaced at equal intervals along the circumferential periphery thereof and a slidable blade 5 is slidably mounted within each of said rotor slots, the blades 5 being preferably made of steel.

For the purpose of sealing or closing in a fluid proof manner the compression chamber endwise thereof or axially of the rotor, the invention provides the telescopic floating pistons 6—9 equipped with the piston rings 7, 8, 10. The floating pistons 6 are applied over each end of the rotor axle 14, and are inserted into the central cylindrical hollow space of the casing 1, similarly to the rotor 4. Each floating piston 6 is so built as to leave between its walls a space or chamber open at one end, as clearly shown in Fig. 1, and through this open end of the said chamber of piston 6 is telescopically inserted the floating

piston 9 which thereby closes the said open end, thus providing each piston 6 with a closed chamber 16, as illustrated in Fig. 1. The piston rings 7 are applied externally over the pistons 6 to act as a sealing means between the pistons 6 and the fixed casing 1, the piston rings 8 are applied externally over the pistons 9 so as to act as a sealing means between the pistons 9 and the pistons 6, and the piston rings 10 are applied around the inner walls of the pistons 6 so as to act as sealing means between the pistons 6 and 9. The floating pistons 6 and 9 are mounted in the fixed casing 1 so as to be prevented from rotation, in such a way, however, that they are at the same time free to move along the axial direction, the pistons 6 moving axially over the axle 14 and the pistons 9 moving axially within the pistons 6. The chambers 16 formed between the pistons 6—9 communicate with a source of an auxiliary fluid through passages 15 formed in the walls of the pistons 6 and the wall of the fixed casing 1, and communicate with the compression chamber of the rotor through passages 17 and 18 formed in the bottom walls of the pistons 6.

Owing to the centrifugal force acquired by the blades 5 on account of the high rotative speed of the rotor, the said blades are forced out of their slots and against the wall of the fixed casing 1, giving rise to the formation of a certain number of cells defined by the blades 5, rotor 4, fixed casing 1 and floating pistons 6. Owing to the off-center position of the rotor 4 within the central cylindrical hollow space of the fixed casing 1, the volumetric capacity of each of these said cells varies from a maximum at the point of maximum projection of the blades 5 out from the rotor slots, to a minimum at the point of maximum retraction of the blades inwardly of the rotor slots, and again from a minimum to a maximum, which is repeated for each revolution of the rotor, and from such variation results a suction of the fluid through the inlet port 2, compression of the drawn-in fluid in the said cells of gradually decreasing volumetric capacity, and discharge of the compressed fluid through the outlet port 3.

The endwise or axial sealing of the rotor chamber has heretofore constituted a problem of difficult solution in connection with pressure pumps of this type. According to the present invention, however, a highly efficient solution is offered for such a problem through the use of the floating pistons 6—9, duly equipped with suitable piston rings.

As stated above, the chambers 16 formed between the floating pistons 6 and 9 communicate through the passages 15 with a source of an auxiliary or compensating fluid. This said auxiliary fluid may be any fluid other than the main fluid to be compressed, but will preferably be taken from the main fluid proper which is being compressed, as for instance, by providing a branch line equipped with reduction valve and leading from the high pressure piping to an auxiliary chamber which communicates with the said passages 15. As seen from Fig. 1, as the auxiliary fluid expands within the chambers 16, it will move the floating pistons 6 against the adjacent end face of the rotor 4 and the floating pistons 9 against the closure elements 11 of the fixed casing 1, with the result that the rotor 4 will be confined between, and tightened by, the two floating pistons 6, one at each end thereof. By suitably proportionating the areas of the

floating pistons 6 in contact with the main fluid in the rotor chamber and the auxiliary fluid in chambers 16, respectively, it will obviously be possible to secure effective sealing between said pistons and said rotor, without the pressure being unduly high so that it might cause appreciable losses by friction between the rotor and the pistons. As already stated, the piston rings 7 act as a sealing means between the pistons 6 and fixed casing 1, and the piston rings 8 and 10 act as a sealing means between the pistons 6 and 9. According to the present invention, therefore, a highly effective endwise or axial sealing is provided, without substantial friction being introduced.

Another difficult point in connection with rotative type compressors has been that involved by the proper sealing between the slidable blades and respective rotor slots. As is known, any two consecutive cells of the rotor will always contain fluid under different pressures, the pressure in any leading cell of the rotor in the direction of rotation of the latter being higher than the pressure in the cell that immediately follows the same. In Fig. 3, the higher pressure in a leading cell is indicated by P_2 , and the lower pressure in a lagging cell, immediately following the preceding one, is indicated by P_1 . It is obvious that when I thus refer to higher and lower pressures P_2 and P_1 , respectively, I only mean the relative values of one of said pressures with respect to the other, as it is evident that relatively to any other cell in advance of the above mentioned cell of pressure P_2 in the direction of rotation, the said pressure P_2 would be lower than the pressure in said advanced cell, in the same way that relatively to any other cell behind the above mentioned cell of pressure P_1 , the said pressure P_1 would be higher than the pressure in the said lagging cell. Such being the case, since the pressure P_2 , Fig. 3, is higher than the pressure P_1 , the fluid in the cell of pressure P_2 tends to pass into the cell of pressure P_1 through the space or play between the blade 5 and its respective slot, with loss of pressure for the apparatus. This loss of pressure becomes more serious with usage of the apparatus, since the wear of the parts increases the play between the blade and the slot, said wear being aggravated by the fact that the blades are generally made of a harder material than the material of the rotor, the blades being generally of steel and the rotor of cast iron. For the purpose of preventing or of reducing this loss of pressure through said play between blade and slot, the apparatus of the present invention includes for each blade 5 a rod 21, which is held in position between the blade 5 and a seat 20 formed for the said rod on the forward face of the rotor slot in the direction of rotation. The rod 21 extends throughout the whole breadth of the blade 5. The inner closed portion of each rotor slot may be made to communicate with the cell lying immediately behind the said slot, said communication being established by any convenient means, such for instance, as by means of a passage 19, Fig. 3. Under these conditions, during rotation of the rotor 4 the rods 21 will be forced outwardly due to their centrifugal force, to which may be added the effect of the pressure P_1 admitted into the inner portion of the slot through the passage 19 and which acts on the inner surface of the rod 21, as shown in Fig. 3. The pressure P_2 acts on the rod 21 in opposition to the above mentioned effect of the centrifugal force and pressure P_1 , 75

but by properly proportionating the mass of the rod 21, pressures P_2 and P_1 , the outer and inner surfaces of the rod, that is, the areas of the rod in contact with the pressures P_2 and P_1 , respectively, and the angular speed of the rotor, it is possible to obtain a resultant in the proper direction for the rod to be forced outwardly and tightened against the blade and the seat 20 of the rod with the desired force. The rods 21 may be made in any desired form and of any suitable material, preferably of drawn iron in the form of small light cylindrical rods cut out from a wire of suitable cross section. The seat 20 for the rod 21 is, of course, made in the proper shape to efficiently cooperate with the rod. The outward forcing of the rod 21 in the manner described against the blade 5 and the seat 20, produces an effective sealing against leakage of fluid from a cell of higher pressure P_2 into a cell of lower pressure P_1 through the play between the blade and the slot, and a great advantage inherent to this construction is that it offers automatic compensation for the wear of both the blade and the slot from usage of the apparatus, since, as it is easily seen from the construction indicated in Fig. 3, the co-action between the blade 5, rod 21 and seat 20 is such that the rod 21 will always be advanced into new positions within its seat, which will permit the rod to always keep continuous and tight contact, independently of the wear of the contacting parts. Accordingly, the present invention offers a practical, simple and efficient solution for the problem of providing proper sealing between the blade and the respective rotor slot, with the conspicuous advantage of an automatic compensation for the wear of the contacting parts.

As previously stated, the rods 21 exert a further important function and constitute a further specific object of the present invention, as will be set forth hereinafter.

As previously stated, another serious problem in connection with pressure pumps of this type is the undesirably high pressure that, in the absence of any special means to prevent it, would be exerted by the blades against the walls of the fixed casing, due to the centrifugal force of the blades arising from the high rotative speed of the rotor. Besides large frictional losses, this also causes excessive wear of the rubbing parts. To meet this objection the blades may be arranged as shown at an angle to the radial position in order to neutralize the centrifugal force.

According to the present invention, however, by the utilization of the wedging action of the rods 21 this same result of neutralizing in the desired extent the effect of the centrifugal force of the blades 5 may be obtained independently from any inclination of the rotor slots relatively to the radial direction of the rotor, that is, even in the case of the rotor slots being formed as usual in the radial direction of the rotor. As previously stated, the inner and outer surfaces of the rods 21 in contact with the pressures P_1 and P_2 , respectively, and the mass of the rods, may be so proportionated with respect to the angular speed of the rotor, friction coefficients and experimental factors, that the resultant of the forces acting upon the rods will be such as to cause the latter to move outwardly and tighten the same with any desired tightening pressure between their seats 20 and the corresponding blades 5. Fig. 3 shows clearly how the rods 21, when thus forced in an outward direction, will exert a wedging action tending to reduce the

effect of the centrifugal force which acts on the blades 5 to move the latter outwardly. By predetermining, as above stated, the said resultant which forces the rod 21 outwardly and causes the same to be tightened as explained, it is possible to predetermine the magnitude of the said wedging action and consequently to predetermine the desired extent to which the action of the centrifugal force on the blade 5 will be neutralized. This method is also simple and efficient.

This application of the rods 21 to act with a wedging action for the purpose of neutralizing or reducing the effect of the centrifugal force upon the blades 5, is very important, and, though preferably used to act at the same time as a sealing means and as wedging retarding means, the rods 21 may, if desired, be used for either of said purposes independently from the other.

A further characteristic advantage of the invention is the thermic compression of the fluid, which acts in cooperation with the dynamical or mechanical compression of the rotor, and which will now be described in connection with its application to the preferred embodiment of the invention herein described and illustrated.

As stated above, the auxiliary or compensating fluid is admitted through the passage 15 into the chambers 16 of the floating pistons 6 and 9. Since each piston 6 is in contact with the main fluid in the chamber of the rotor, that is, the compression chamber, the high temperature of the main fluid, arising from the compression of the same, will transmit itself through the walls of the pistons 6 to the auxiliary fluid in chambers 16, thereby increasing the pressure of the latter due to the thermic effect of the higher pressure. If the auxiliary fluid is of the same nature as the main fluid, such as is the case in the preferred embodiment of the invention herein described and illustrated, the said auxiliary fluid thus thermally compressed in chambers 16 may be discharged from the latter into a cell of corresponding pressure in the compression chamber, which may be performed, for instance, by means of a passage such as passage 17, Figs. 1 and 2. Under these conditions, the thermal compression undergone by the auxiliary fluid will not be lost, but will be utilized to help or cooperate with the primary mechanical compression of the rotor. The auxiliary fluid will then perform a triple function, namely, to operate the floating pistons 6 and 9 for the endwise sealing of the compression chamber, to cool the apparatus, and, owing to the thermal compression thereof, to cooperate with primary mechanical compression of the apparatus.

The internal lubrication of the apparatus is executed by oil mixed with and carried by the auxiliary fluid, which through passages 17 and 18 carries the oil to the rotor chamber. As illustrated in Fig. 2, the passage 18, contrary to the case of passage 17, leads to a cell of no compression, for the purpose of delivering oil to the blades 5 in the retracted position of the latter, for efficient lubrication along the blades. After having exerted its lubricating function, the oil is discharged together with the compressed fluid through the outlet port 3, and, after being duly separated by suitable separators or strainers, the oil is again mixed to the auxiliary fluid to be cyclically returned to the chambers 16 through the passages 15, in admixture with the auxiliary fluid.

As previously stated, the embodiment of the invention herein particularly described and il-

illustrated in the accompanying drawings has been given by way of example only, for the sake of clearness, and it is to be understood, therefore, that the invention is not limited to said particular detailed embodiment thereof, as it is evident that many changes and alterations may be introduced without departure from the spirit and scope of the invention.

Having thus particularly described and ascertained the nature of my said invention and the manner in which the same is to be performed, I claim:

1. A pressure pump for fluids, comprising a casing, inlet and outlet ports therein, a rotor mounted in off-center relation within the casing, slots formed in the rotor, slidable blades mounted in the slots, means for the axial sealing of the rotor and blades, a rod engaging each blade, a wall formed in each slot and engaging said rod, the wall being so formed that outward movement of the rod due to centrifugal force moves the rod into close contact with the blade to retard outward movement of the blade under centrifugal force and to prevent tilting of the blade within its slot and to compensate for wear of the blade and slot.

2. A pressure pump for fluids, comprising a casing, inlet and outlet ports therein, a rotor mounted in off-center relation within the casing, slots formed in the rotor, slidable blades mounted in the slots, an axially arranged rod engaging each blade, an inclined wall formed in each slot and engaging said rod, the wall being so formed that outward movement of the rod under centrifugal action forces the same into close contact with the blade and retards outward movement of the blade under centrifugal force and prevents tilting of the blade within its slot and compensates for wear of the blade and slot.

3. A pressure pump for fluids, comprising a cylindrical casing, inlet and outlet ports therein, an off-center rotor within the casing, slots formed in the rotor, blades mounted in the slots and engaging the internal wall of the casing, members extending the full length of the rotor and engaging the high pressure faces of the blades, a tapering wall formed in each slot for engaging the said member and wedging the same against the blade to retard the outward movement of the blade under centrifugal force and to compensate for wear and prevent looseness of the blade within its slot.

4. A pressure pump for fluids, comprising a cylindrical casing, inlet and outlet ports therein, an off-center rotor within the casing, slots formed in the rotor, blades mounted in the slots and engaging the internal wall of the casing, means for the axial sealing of the rotor, members extending the full length of the rotor and engaging the blades, an arcuate wall formed in each slot for engaging the said member to wedge the same against the blade to prevent excessive outward pressure of the blades under centrifugal force when the pump is operated at high speeds.

5. A pressure pump for fluids, comprising a fixed casing, inlet and outlet ports therein, a rotor mounted in off-center relation within the casing, a plurality of slots formed in the rotor, blades mounted in said slots, means for ensuring axial sealing of both ends of the rotor and blades, and a member of round cross-section extending the full length of the rotor and cooperating with each blade to engage the same by a wedging action permitting slidable movement of the blade in its slot and retarding excessive outward pressure of the blade under centrifugal force.

6. A pressure pump for fluids, comprising a fixed casing, inlet and outlet ports in the casing, a rotor mounted in off-center relation within the casing, a plurality of slots formed in the rotor, blades mounted in said slots, means for ensuring axial sealing of both ends of the rotor and blades, an arcuate recess formed in each slot, a rolling member located in each recess and cooperating with each blade to engage the same by a wedging action and permit sliding movement of the blade, in its slot, and to effectively seal the blades in their slots.

7. A pressure pump comprising a cylindrical casing, inlet and outlet ports therein, an off-center rotor mounted within the casing, slots in the rotor, blades in the slots, wedging means for ensuring sealing and sliding contact of each blade within its slot, and for preventing excessive outward pressure of the blades under centrifugal force, pistons for sealing the axial ends of the rotors and blades under fluid pressure supplied by the pump, passages for supplying the fluid pressure to the pistons, and other passages for leading thermally compressed fluid from the pistons to the pump casing to cooperate with the pressure generated mechanically by the pump.

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