Aug. 15, 1933. G. E. T. EYSTON 1,922,797

ROTARY PUMP MACHINE

Filed May 24, 1929 4 Sheets-Sheet 1

Fig. 1.

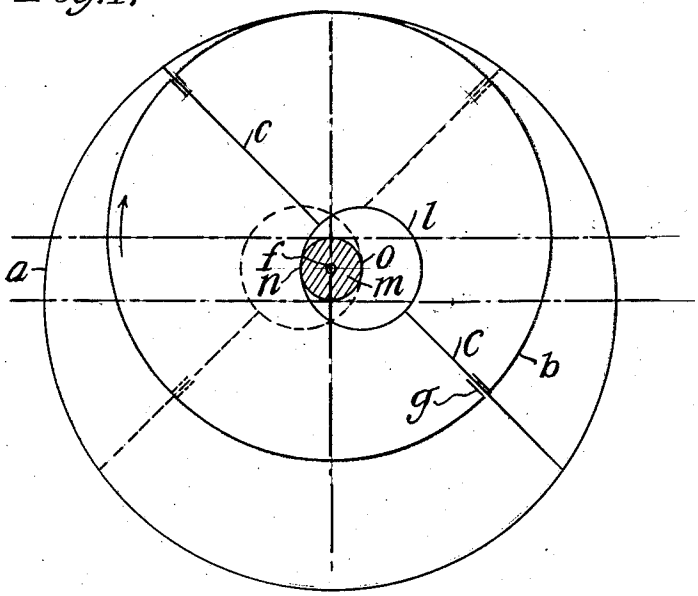
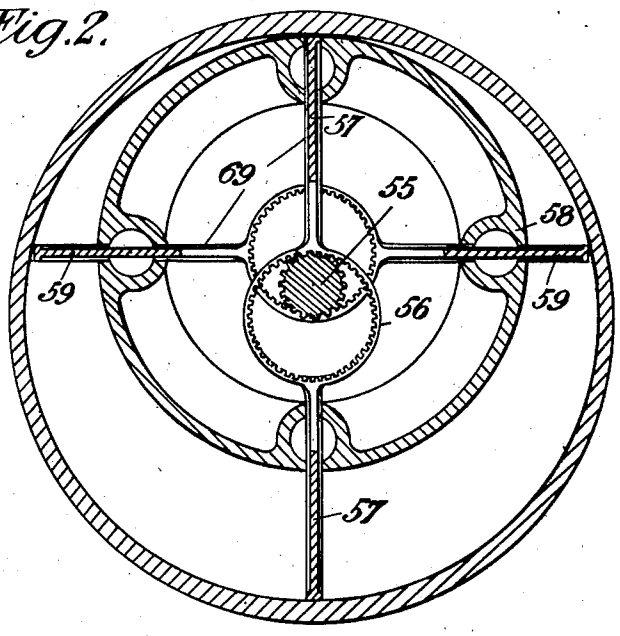


Fig. 2.



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Aug. 15, 1933. G. E. T. EYSTON 1,922,797

ROTARY PUMP MACHINE

Filed May 24, 1929 4 Sheets-Sheet 2

Fig. 3.

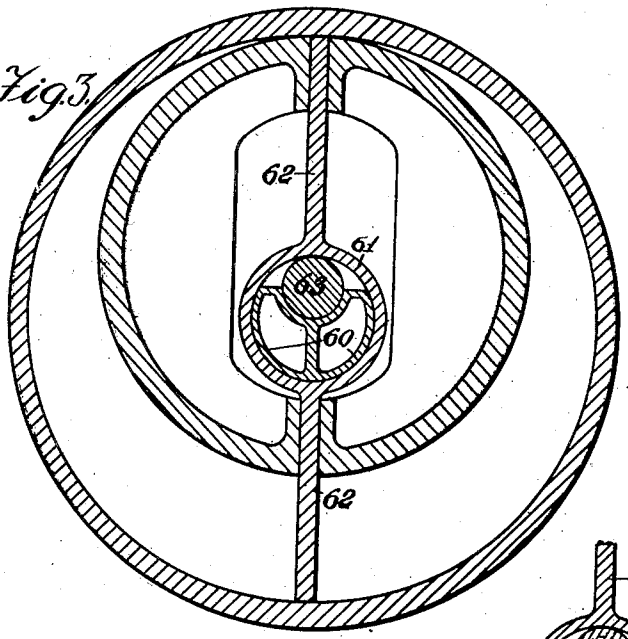


Fig. 4.

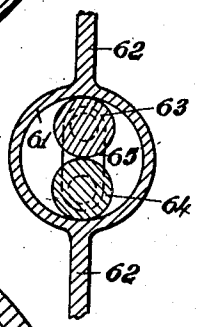
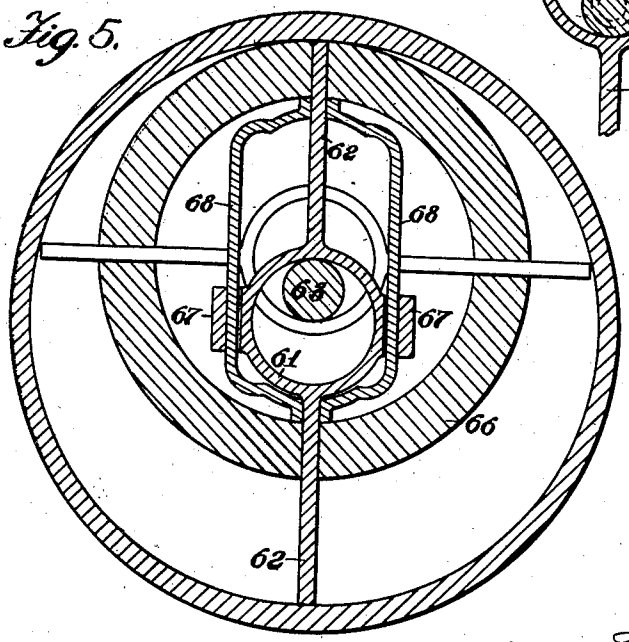


Fig. 5.



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Aug. 15, 1933. G. E. T. EYSTON 1,922,797

ROTARY PUMP MACHINE

Filed May 24, 1929 4 Sheets-Sheet 3

Fig. 6.

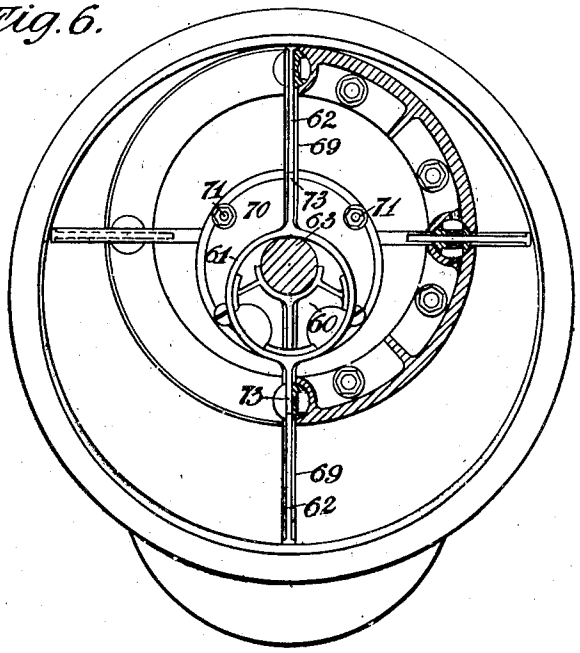
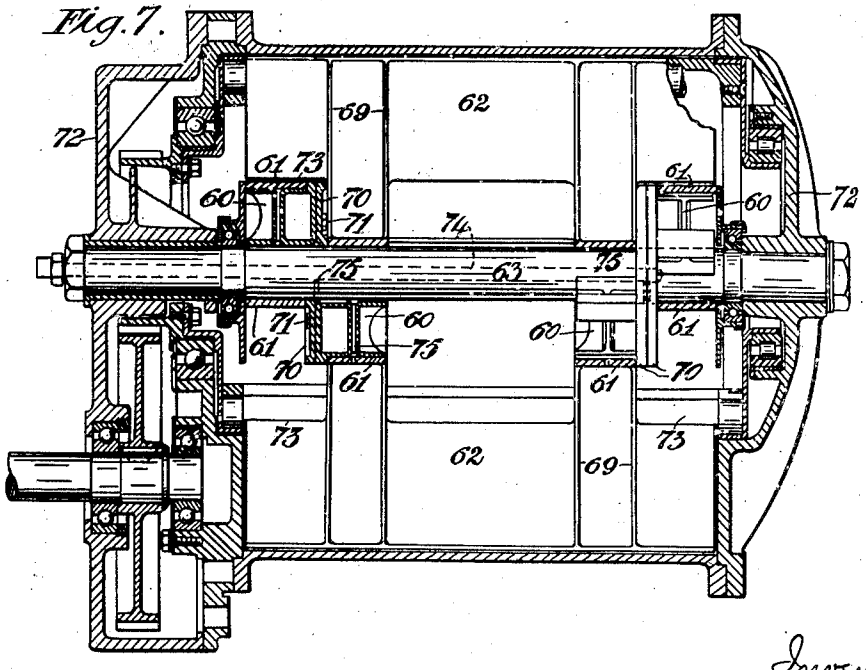


Fig. 7.



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Aug. 15, 1933. G. E. T. EYSTON 1,922,797

ROTARY PUMP MACHINE

Filed May 24, 1929 4 Sheets-Sheet 4

Fig. 8.

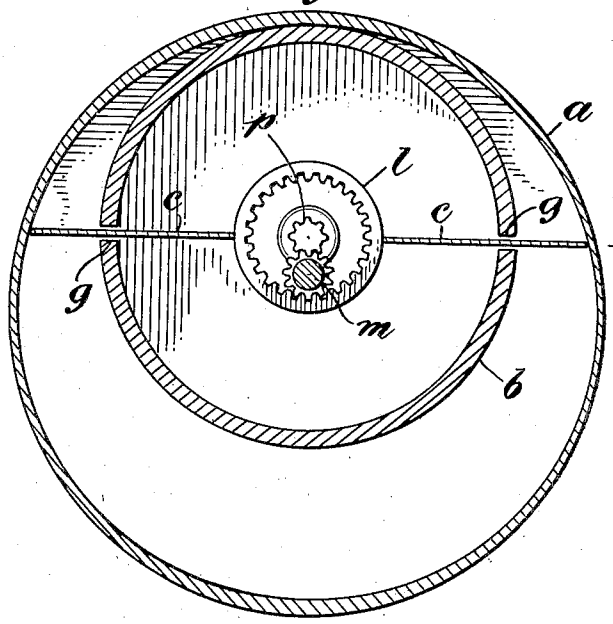


Fig. 9.

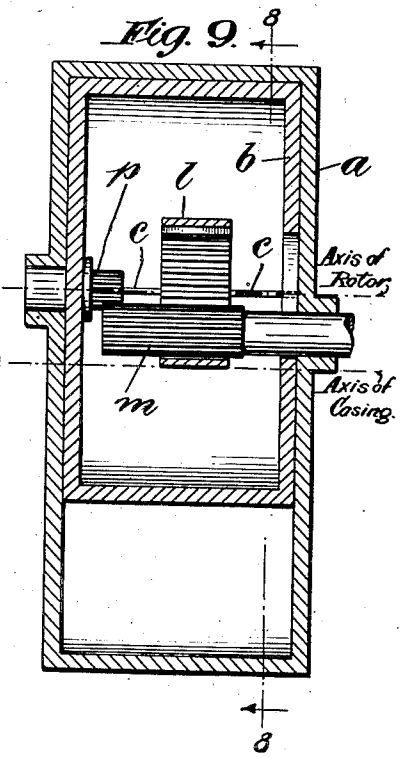
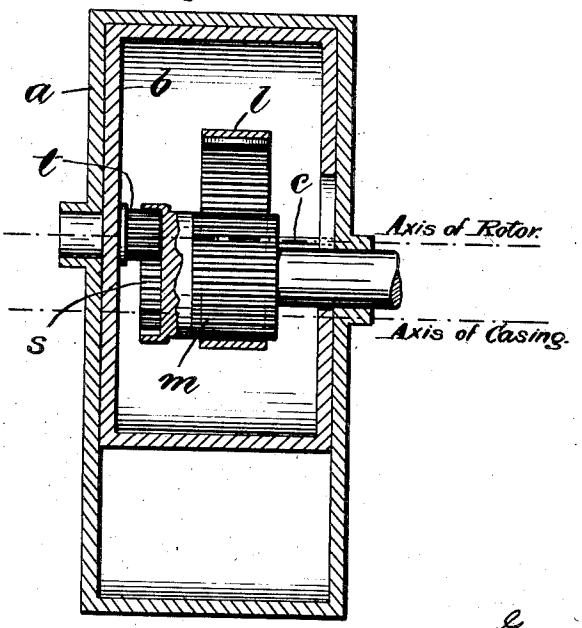


Fig. 10.



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Patented Aug. 15, 1933 1,922,797

UNITED STATES PATENT OFFICE

1,922,797

ROTARY PUMP MACHINE

George Edward Thomas Eyston, London, England, assignor to Powerplus (1927) Limited, London, England, a Company of Great Britain

Application May 24, 1929, Serial No. 365,648, and in Great Britain July 11, 1928

16 Claims. (Cl. 103—144)

This invention comprises improvements in and relating to rotary pump machines and is concerned more particularly with machines of the so-called crescent-chamber class comprising a rotor mounted eccentrically in an outer casing and fitted with piston vanes or blades.

In machines of this class, the vanes are often controlled by the use of means, such as rings, revoluble about an axis disposed centrically in the outer casing and the general arrangement is for such means to take the centrifugal stresses exerted by the vanes and prevent contact between the tips of the vanes and the inner surface of such casing. In the operation of such machines, the vanes or blades are projected relatively to the rotor as the latter revolves and owing to the eccentric mounting of the rotor, the movement of the vanes is of an eccelerative and decelerative nature with the result that reactionary stresses are exerted between the rotor and the vanes which in some cases are considerable and have deleterious effect on the vanes and their bearing surfaces in the rotor and set up undue friction.

An important object of this invention is to provide constructions of machine in which the centrifugal stresses are taken up with reduction or minimum of friction and in which accelerative and decelerative movements of the vanes or blades may be avoided. A further object is to attain improved balance of the vanes during the working of the machine.

According to this invention the piston members are adapted, in revolving, to roll bodily in cycloidally rolling contact engagement with a control member disposed on a fixed axis in the casing of the machine. A cycloidally rolling member, as is known, moves without rubbing contact in engagement with its companion member, and by adopting cycloidally rolling vane structures in accordance with this invention, it is possible to take up centrifugal stresses on the vanes substantially without friction giving considerable advantage in the efficient working of the machines. The vanes may conveniently have hollow formations comprising circular surfaces movable in cycloidally rolling contact engagement with a shaft disposed on a fixed axis lying midway between the axes of the rotor and outer casing of the machine. It will be seen hereinafter that constraint is thus exercised on the vanes at a point or axis having actually or in effect an orbital motion around the axis of said shaft and that the peculiar operation of the parts may be effective in eliminating reactionary stresses and minimizing or reducing friction losses caused thereby.

The machine may comprise any even number of vanes, such as two, four or six, arranged in pairs disposed diametrically in slots or recesses in the rotor, and each pair may be interconnected so as to form a symmetrical whole or be mounted in a frame or members which with the vanes constitute a symmetrical whole. The engagement of such a vane pair with the control means would be at the middle of the diametrical length of the vanes and the vane pair is constrained to operate so that the axis of gravity thereof moves orbitally round the centre of the control shaft in a circle which may have a diameter equal to half maximum blade throw. The vane pair, however, has a true centre of rotation lying at any instant diametrically opposite the centre of gravity on this same circle. Thus, the vanes rotate with constant angular velocity and there is no inertia torque due to acceleration and deceleration of the vanes.

The path described by the blade tips departs a little from the circular, being somewhat elliptical, that is conchoidal, symmetrically about a plane containing the rotor axis and the centre of rotation of the control means, and it is desirable for the outer casing to be constructed to conform to this shape. The vane pair or pairs partake of a constrained to and fro motion relative to the rotor as the latter revolves, so that a constant running clearance may be maintained between the tips of the vanes or blades and the inside of such an elliptical-shaped outer casing.

The vane pairs substantially balance themselves against centrifugal force. In the case of machines with only a single vane pair it may be necessary to provide suitable weights to counteract the slight out of balance force due to centrifugal action on the revoluble control means, but if more than one vane pair be used, the pairs can be arranged to balance this force amongst themselves.

The vanes in a machine comprising a single vane pair, may be of piston form and if desired such a piston may be provided at the outer end with extended surfaces to give increased vane area. The extension of the piston may advantageously take the form of a hood or skirt adapted to fit into a recess or slot in the rotor to prevent escape of oil into the working chamber. These extensions of the piston surface also operate to strengthen the piston vane structure against the working stresses.

Multiple vane pairs are of advantageous use

in high speed machines and in such cases the vanes may take the form of pistons or, preferably, flat blades which latter may consist of a built-up structure comprising plates fitted on a flat frame. A flat form of blade may, of course, also be used in machines comprising single vane pairs and in any case, oil guards may be fitted to prevent leakage of lubricant into the working chamber from the rotor.

The drive for the machine may be applied to one or another of the rotary elements of the machine. Also different elements may be inter-geared in accordance with the gear ratio appropriate for their individual operations. If power is applied to the rotor for driving the machine, the the rotor, in turn, will drive the vanes or blades and produce the required movement of the control means. On the other hand, if the driving power is applied to the control means, motion of the vanes is produced due to their reaction with the rotor slots and the vanes also produce revolution of the rotor. In certain cases, this latter method of driving is preferable as the slots in the rotor are thereby relieved of any side thrust due to the fluid pressure in the machine. If different rotary elements of the machine are also inter-geared with one another the rotor slots can be further relieved of any stresses due to the geometry of the assembly as will be described.

In effecting the control of the vanes or blades by hollow formations having cycloidally rolling contact engagement with a shaft as aforesaid, the shaft is suitably of a diameter equal to the diameter of the circle described by the centre of gravity of the vane structure and the latter conveniently comprises a circular sleeve or ring part of twice the diameter of the shaft and placed over the shaft so that as the rotor revolves, the internal surface of this sleeve part rolls on the shaft and the vanes are constrained to take the motion designed for them. A more positive control may be obtained by the formation of gear teeth on the inter-engaging surfaces of the shaft and the sleeve part of the vane structure. For the sake of simplicity, however, it is preferred to insert a floating crescent-like bush between the interior of the sleeve and the shaft and this arrangement presents the further advantage that positive engagement between these parts is maintained even when the machine is stationary or when the centrifugal force developed in the operation of the machine is insufficient for the purpose, or in cases where the machine is likely to be used in inverted position. A rolling pin could be used as an alternative to the floating bush and in either case the pin or bush might be mounted swivel fashion on the shaft and counterweighted to prevent unbalanced centrifugal stresses. In machines with multiple vane pairs, the bushes or rolling pins could be balanced one against another, rendering counterweights unnecessary.

In order to enable the invention to be readily understood, reference is directed to the accompanying drawings in which:—

Figure 1 is a diagram illustrating the cycloidally rolling contact control of the vanes.

Figure 2 is a transverse section of a construction of machine embodying the control illustrated by Figure 1.

Figure 3 is a like view of a modification.

Figure 4 illustrates a modification of the construction seen in Figure 3.

Figure 5 illustrates another construction in transverse section.

Figure 6 is a transverse sectional view of another form of machine.

Figure 7 is a longitudinal section of Figure 6.

Figure 8 is a diagrammatic view of another construction.

Figure 9 is a side sectional view of Figure 8; and

Figure 10 is a view similar to Figure 9 of a further modification.

In the diagram, Figure 1, *a* is assumed to represent the outer casing of a machine of the cresent-chamber class aforesaid, *b* the rotor and *c c* a pair of vanes disposed in diametrically aligned slots *g* of the rotor. A sleeve or ring formation *l* joins the vanes *c c* into a rigid pair, and a non-revoluble shaft *m* is mounted on a fixed axis *f* which is disposed midway between the axes of the outer casting *a* and the rotor *b* and has a diameter equal to the distance between the last-mentioned axes which in turn corresponds to the eccentricity of the machine and is equal to half the maximum vane throw. The vane pair *c c* has sliding motion in the slots *g* of the rotor and assuming that drive is imparted to the rotor in the direction shown by the arrow, it will be understood that the vanes will be carried round and that the ring part *l* will move correspondingly. The full lines indicate one position of the vane pair and the dotted lines another position. The diameter of the sleeve or ring formation *l* is twice the diameter of the shaft and as it is placed centrally in the length of the vane pair, it engages the shaft at one point or other according to the position of revolution of the rotor. For example, the ring *l* of the vane pair shown engages the shaft at the point *n* and when the vane pair reaches the dotted position, the ring will engage the shaft at the point *o*. The point of engagement in fact describes an orbital movement about the point *f*, the ring rolling cycloidally with the vane pair round the shaft as will be understood. The centre of gravity of the vane pair has a similar motion as will be realized but always is diametrically opposite to the point of engagement of the ring with the shaft. It will be realized that the ring *l* can only have one position for any particular position of the rotor and thus advantageous constraint or control is exercised on the vane pair at its point of engagement with the shaft *m*, so that the position of the vane pair is quite predetermined by the shaft whatever may be the position of rotation of the rotor *b*. The path described by the vane tips, however, is not a circle but somewhat elliptical or conchoidal and therefore it is advisable to shape the outer casing to correspond with the motion of the vane tips, as illustrated. With an outer casing of this shape and owing to the constraint exercised on the vanes by the shaft *m*, constant vane tip clearance is maintainable with consequent elimination of tip friction. The orbital motion of the centre of gravity of the vane pair about the axis *f* is clearly apparent from the diagram. The centre of rotation of the vane pair at any instant is diametrically opposite the point *o*, namely at the point *n* for the vane position shown in full lines It moves round in a circle similarly to the point *o*. The motion of the vanes is thus a sort of rolling motion, and if the geometry of the structure be followed, it will be seen that the angular velocity of the vane pair is constant throughout

the revolution of the rotor and therefore there is no inertia torque due to acceleration and deceleration of the vanes. The construction further gives the advantage that the rolling contact engagement between the shaft and ring does not present any sliding friction so that control of the vanes may be exercised substantially without friction. Owing to the fact that the vanes or blades are free from inertia stresses, a robust construction thereof can be employed. Frictional stresses are minimized and the only limiting factor is the centrifugal loading at the point of engagement of the vanes with the shaft *m*. The machine as a whole may be balanced by counterweights placed at the centre of rotation of the vane pair, or if a plurality of vane pairs were used, these could be made of equal weight and arranged to balance themselves.

Figure 2 shows a construction of machine in accordance with Figure 1, but in which the control shaft 55 and the ring portion 56 of the vane pair 57, 57 are inter-geared epi-cyclically to prevent slip at low speeds or at starting. The gear engagement would also improve the running particularly of large machines. It will be noted that in Figure 2, the machine is shown with two vane pairs 57, 59, both geared as aforesaid with the shaft 55. There may, of course, be any suitable number of vane pairs all geared to the shaft 55 in like manner. With appropriate diameter ratios between the shaft 55 and rings 56, drive of the machine may be effected by rotating the shaft while still retaining the cycloidally rolling contact engagement between the parts. The shaft will then in turn cause motion of the vanes due to their reaction with the rotor slots and the vanes will consequently produce revolution of the rotor. One result of this method of driving is to relieve the slots of the rotor of lateral stresses due to the fluid pressure. The gear engagement between the shaft and rings would also have the effect of preventing jamming, as for example when starting the machine in a dead-centre position with only one vane or blade effective. If desired, gearing may also be interposed between the shaft and the rotor so that all three elements, namely shaft, vanes and rotor, may be intergeared by gearings of appropriate ratio. By the construction shown in Figs. 8–10 the rotor slots will be relieved of stresses due to the geometry of the assembly and the vanes relieved of the duty of driving the rotor, the only remaining stresses being those due to the simple sliding friction of the vanes in the slots of the rotor which can be minimized by appropriate bearing surfaces. In all cases a constant clearance machine can be produced, if the outer casing is of the somewhat elliptical or conchoidal form aforesaid. Power losses are also reduced and lubrication can be confined more or less to the gears.

Examples of revoluble shaft constructions are shown in Figures 8–10. In these figures reference character *a* denotes the casing of the pump and *b* the rotor having slots *g*. A pair of vanes *c* are connected together at their inner ends by internally geared ring *l* within the rotor and the vanes extend through and slide in the slots *g*. The rotor *b* is mounted in the casing *a* on an axis eccentric of the axis of the casing as is indicated by the legends in Figures 9 and 10. A shaft extends through an end wall of the casing and through an enlarged opening in an end wall of the rotor and has a concentric gear *m* disposed on its inner end. The axis of this shaft is preferably half-way between the axis of the rotor and axis of the casing. In Figure 9 it is shown that the gear *m* is engaged with the teeth within the ring *l* and also is engaged at its extreme end portion with a pinion *p* at the axis of the rotor. The sizes of the geared elements in Figure 9 must be made such as to drive the respective elements at the proper speeds. In operation the ring *l* rolls about the gear *m* in cycloidally rolling contact. If the diameter of gear *m* is less than half the diameter of vane ring *l*, the gear *m* must move oppositely to the direction of rotation of the vane ring and rotor. If the diameter of gear *m* is greater than half the diameter of vane ring *l*, its direction of turning will be the same as vane ring *l* and rotor *b*.

In Figure 10 the gear *m* engages within vane ring *l* and the end of this gear has an interiorly geared flange *s* extending in the direction of the axis of the gear and engages with pinion *p* to drive the rotor.

Figure 3 represents a further form of machine of the nature described with reference to the diagram in Figure 1. It will have been realized that the gear connection between the shaft 55 and the vane pairs in Figure 2, enables a more positive control of the vanes to be obtained as there is no likelihood of slip between the parts. Figure 3 comprises a somewhat simpler arrangement for giving an equally positive control, a floating crescent-like bush 60 being employed, which is inserted between the interior of the ring or sleeve formation 61 of the vane pair 62 and the control shaft which is marked 63. The bush, as will be seen, acts to keep the shaft 63 and the vane ring 61 in positive engagement. The arrangement, moreover, presents the further advantage that positive engagement between these parts is maintained even when the machine is stationary or used in inverted position, or when the centrifugal force developed in the operation of the machine is insufficient for the purpose. As an alternative to the floating bush, and as shown by Figure 4, a rolling pin 64 mounted swivel-fashion about the shaft 63 on a link or links 65 may engage between the sleeve 61 and the shaft 63. Both the bush 60 and the pin 64 may be floatingly mounted or they may be driven, the drive being, of course, at twice the speed of the rotor. According to a further modification illustrated by Figure 5, the ring or sleeve part 61 of the vane structure 62 may have drive imparted to it from the rotor 66, as by forming it with diametrically oppositely disposed ears or lugs 67 which are slotted to engage elongated driving members 68 disposed in the rotor in fixed relation thereto and threading the slots of the lugs in a direction parallel to the vane structure. Similar construction would also be adopted for the second vane pair in Figure 5 but illustration thereof is omitted so as not unduly to complicate the drawings.

The shaft 55 (Figure 2) or 63 (Figures 3–5) may be mounted in any suitable manner in the outer casing of the machine. It may be fixed by one end in one end cover of the machine and its other end be mounted in the rotor by means of an eccentric formation in a similar manner to the centric shaft described in the prior patent specification No. 1,616,285. Or the shaft could be stationarily mounted between the end covers of the machine. With machines having multiple

pairs of vanes, the ring or sleeve parts of the vane pairs, e. g. 56 in Figure 2 or 61 in Figure 5, would be placed side by side about the shaft 55 or 63 and the vanes would be cut away where necessary to clear the sleeve parts of the other pair or pairs. As shown in Figure 2, the vanes may, if of relatively thin material, have thickened parts or ribs as at 69 for strengthening purposes where they are joined to the rings such as 56.

Some of the features described in the last paragraph will be more readily understood on reference to Figures 6 and 7 though the principal object of these figures is to show how, in machines comprising multiple vane pairs, the floating bushes or rolling pins such as 60 or 64 in Figures 3 and 4 may be balanced one against another to avoid unbalancing stresses. For single vane machines, counterweighting may be adopted for balancing the bush or rolling pin as will be readily understood. In Figures 6 and 7, where the vane pairs and parts and the bushes are lettered in the same manner as in Figure 3, each vane pair 62 has a sleeve formation 61 with corresponding bush 60 at or near each end. The bushes are hollowed and cut-away at various places for sake of lightness and, to balance them, the adjacent bushes of the respective vane pairs are formed on, or with, disc parts 70 which are bolted together by bolts 71. The discs are perforated to pass over the shaft 63 and they and the inner curved faces of the bushes are adapted to fit revolubly on the shaft. As the bushes of each pair are spaced at 180° apart they balance each other against centrifugal force. In addition, owing to the fact that both bushes of each pair fit or bear on the central shaft 63, which is stationarily mounted between the end covers 72 of the machine, and that this bearing is on opposite sides of such shaft, there is no possibility of lateral unbalance or cant of the bushes. The central disc parts 70 may, of course, have clearance around the shaft if desired so that only the bushes 60 take a bearing thereon. When single vane pairs are used with counterweights for the bushes, these counterweights could be situated and seated on the fixed shaft 63 similarly to the bushes to give lateral balance. In either case, the bushes are balanced in all directions, and therefore extremely efficient operation of these devices is obtained with consequent improvement in the working and smooth running of the machines. Each vane structure is cut away at 73 in Figures 6 and 7 so as to clear the ring parts 61 of the other vane structure as the rotor revolves. Thickenings or ribs 69 for strengthening the vanes where they are joined to the ring parts 61 are also seen in Figures 6 and 7. Lubrication of the parts may be effected by the duct 74 in the shaft 63 and branch ducts such as 75 leading to the various bearing surfaces. Oil may be passed directly into the rotor by a pipe depending from the shaft 63 in the middle and connected with the duct 74. If the shaft were rovoluble the pipe would be telescopic.

The invention represents considerable improvement in the construction of machines of the class referred to, as it provides advantageous operation or control of the vanes or blades with reduction or elimination of reactionary stresses while also enabling lubrication to be confined more or less to the centre of the machine. In some cases, the parts requiring to be lubricated could be placed in or formed to provide isolated chambers at the ends of the machine so that oil would be prevented from gaining access to the interior of the rotor and the working chamber. Finally, as drive may be applied to the vanes through the control means, the rotor may be of quite small diameter, thus making a greater pumping space available.

Cross reference is made to my Patent No. 1,887,884 for rotary pump machine, dated Nov. 15, 1932 and to my patent application, Serial No. 466,298 for rotary pump machines filed July 7, 1930.

I claim:—

1. A rotary pump or like machine comprising a revoluble member and a control member disposed on a fixed axis and a gear connection between a curved surface of said revoluble member and said control member whereby as said revoluble member turns, said curved surface rolls in cycloidally rolling contact engagement with said control member.

2. A rotary pump or like machine comprising a revoluble piston member and a control member disposed on a fixed axis and a gear connection between a curved surface of said piston member and said control member whereby as said piston member turns, said curved surface rolls in cycloidally rolling contact engagement with said control member.

3. A rotary pump or like machine comprising a casing, a control surface disposed fixedly in said casing and a pistion device revoluble in said casing and having a companion control surface geared with the first-mentioned control surface and constructed to roll bodily with said piston device in cycloidally rolling contact engagement with said first-mentioned control surface.

4. A rotary pump or like machine comprising an outer casing, a circular member disposed on a fixed axis in said casing, and a piston device revoluble in said casing and provided with a circular surface which encircles said circular member and is adapted to roll bodily with said piston device in cycloidally rolling contact engagement with said circular member.

5. A rotary pump or like machine comprising an outer casing, a shaft disposed on a fixed axis in said casing, and a piston device revoluble in said casing and provided with a circular surface which encircles said shaft and is adapted to roll bodily with said piston device in cycloidally rolling contact engagement with said shaft.

6. A rotary pump or like machine comprising an outer casing, a circular member fixedly supported in said casing, and a piston device revoluble in said casing and provided with a circular surface of a diameter exactly twice that of said circular member which is mounted so that said circular surface rolls bodily with said piston device in cycloidally rolling contact engagement with said circular member as the piston device revolves.

7. A rotary pump or like machine comprising a casing, a rotor mounted eccentrically therein, a shaft disposed on a fixed axis lying midway between the longitudinal axes of said casing and rotor, a pair of piston vanes mounted in slots of said rotor, and a circular member connected between said vanes and constructed to be movable in cycloidally rolling contact engagement with said shaft as the vanes revolve in the casing.

8. A rotary pump or like machine comprising a casing, a shaft disposed on a fixed axis displaced from the longitudinal axis of said casing, a pair of piston vanes revoluble in said casing and connected as a rigid structure by means adapted to roll bodily with said vane pair in cycloidally rolling contact engagement with said shaft as the vanes revolve, and means inhibiting slip in the rolling contact engagement.

9. A rotary pump or like machine comprising a casing, a rotor mounted eccentrically in said casing, a shaft disposed on a fixed axis lying midway between the longitudinal axes of said casing and rotor, a pair of piston vanes mounted in slots of said rotor, a circular member connected between said vanes and adapted to roll bodily with said vane pair in cycloidally rolling contact engagement with said shaft as the vanes revolve in the casing, and means operative in the crescent-shaped space between said circular member and shaft and acting to inhibit slip in the rolling contact engagement.

10. A rotary pump or like machine comprising a casing, a rotor mounted eccentrically in said casing, a shaft disposed on a fixed axis lying midway between the longitudinal axes of said casing and rotor, a pair of piston vanes mounted in slots of said rotor, a circular member connected between said vanes and constructed to be movable in cycloidally rolling contact engagement with said shaft as the vanes revolve in said casing, and a floating bush disposed in the crescent-shaped space between said circular member and shaft and acting to inhibit slip in the rolling contact engagement.

11. A rotary pump or like machine comprising a casing, a shaft disposed on a fixed axis displaced from the longitudinal axis of said casing, a plurality of pairs of piston vanes revoluble in said casing and each pair connected as a rigid structure by means adapted to roll bodily with the vane pair in cycloidally rolling contact engagement with said shaft as the vanes revolve, and members adapted to restrain slip in the rolling contact engagement of each pair of vanes and arranged so that one member counterbalances another.

12. A rotary pump or like machine comprising a casing, a rotor mounted eccentrically in said casing, a plurality of pairs of piston vanes mounted in slots of said rotor, a fixed shaft mounted with its axis disposed midway between the longitudinal axes of said casing and rotor and equal in diameter to the distance between these axes, a circular member connected between the vanes of each pair and encircling said shaft, said members having an internal diameter twice that of the shaft and being movable in cycloidally rolling contact engagement with such shaft as the vanes revolve in said casing, and floating bushes disposed in the crescent-shaped spaces between said circular members and shaft to inhibit slip in the rolling contact engagement, these bushes being balanced one against another.

13. A rotary pump or like machine comprising an outer casing, a circular member disposed on a fixed axis in said casing, a piston device revoluble in said casing and provided with a circular surface which encircles said circular member and is adapted to roll bodily with said piston device in cycloidally rolling contact engagement with said circular member, and means operative between said circular surface and member to inhibit slip in the rolling contact engagement.

14. A rotary pump or like machine comprising an outer casing, a circular member disposed on a fixed axis in said casing, a rotor mounted eccentrically in said casing, a pair of piston vanes slidably mounted in relatively fixed slots of said rotor and comprising a circular surface adapted to roll bodily with said vane pair in cycloidally rolling contact engagement with said circular member, and gear parts operative between said circular member and said rotor.

15. A rotary pump or like machine comprising an outer casing, a circular member disposed on a fixed axis in said casing, a rotor mounted eccentrically in said casing, a pair of piston vanes slidably mounted in relatively fixed slots of said rotor and comprising a circular surface adapted to roll bodily with said vane pair in cycloidally rolling contact engagement with said circular member, and gear parts operative between said circular member and said vane pair.

16. A rotary pump or like machine comprising an outer casing, a rotor mounted eccentrically in said casing, a circular control member revolubly mounted on a fixed axis disposed midway between the longitudinal axes of said casing and rotor, a pair of piston vanes mounted in slots of said rotor, and a circular member connected between said vanes and adapted to roll bodily with said vane pair in cycloidally rolling contact engagement with said control member as the vanes revolve in the casing.

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