

Aug. 31, 1965

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Fig. 1

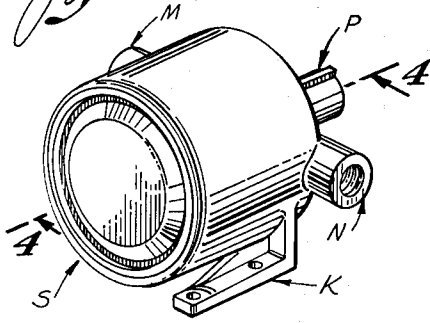


Fig. 2

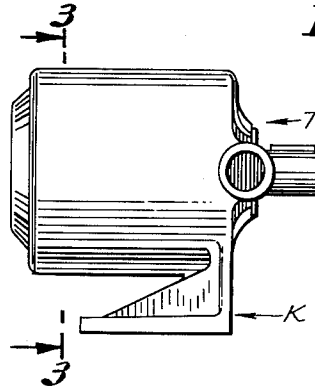
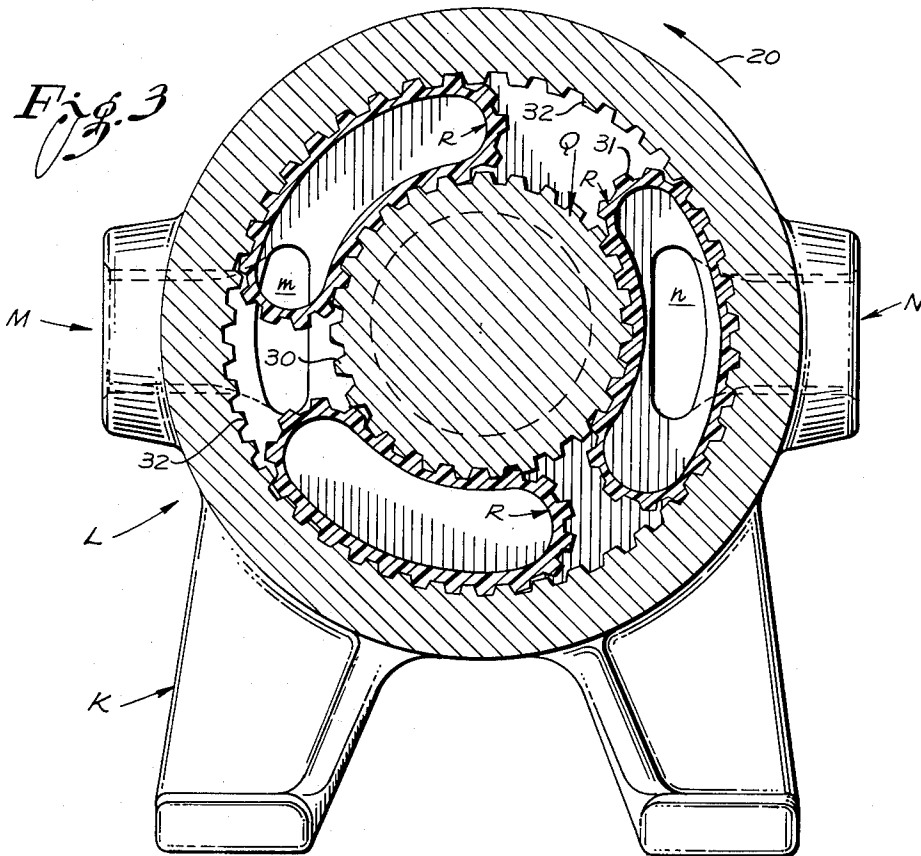


Fig. 3



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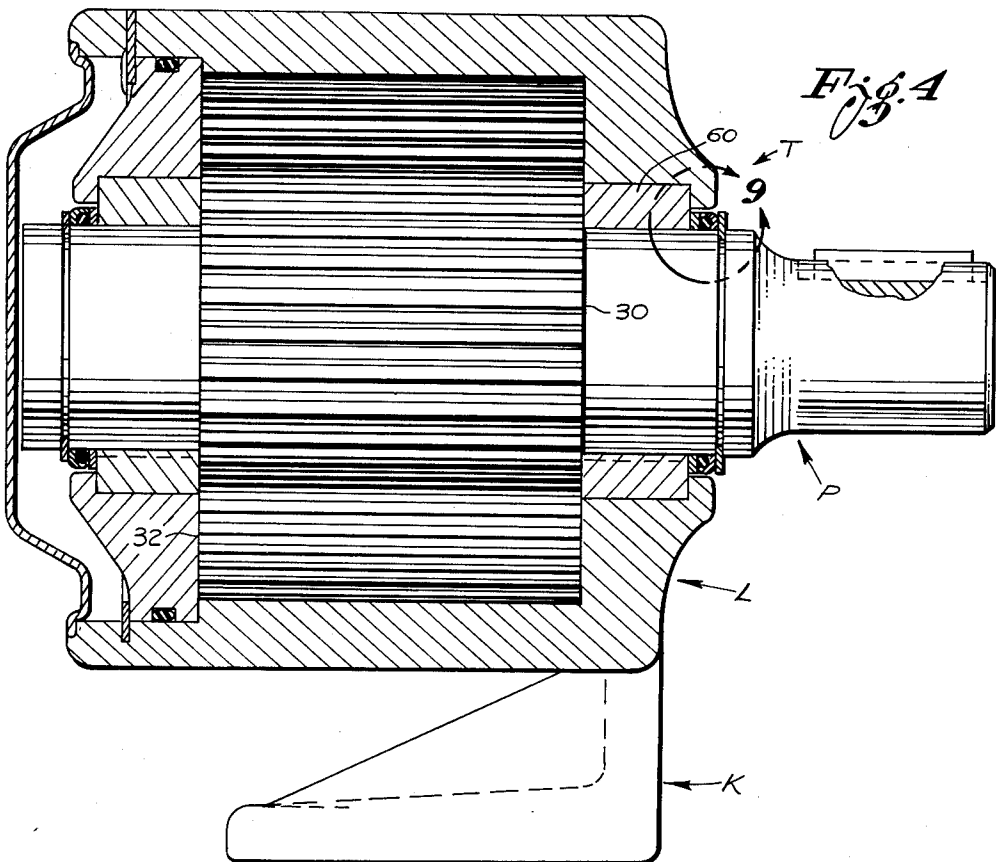
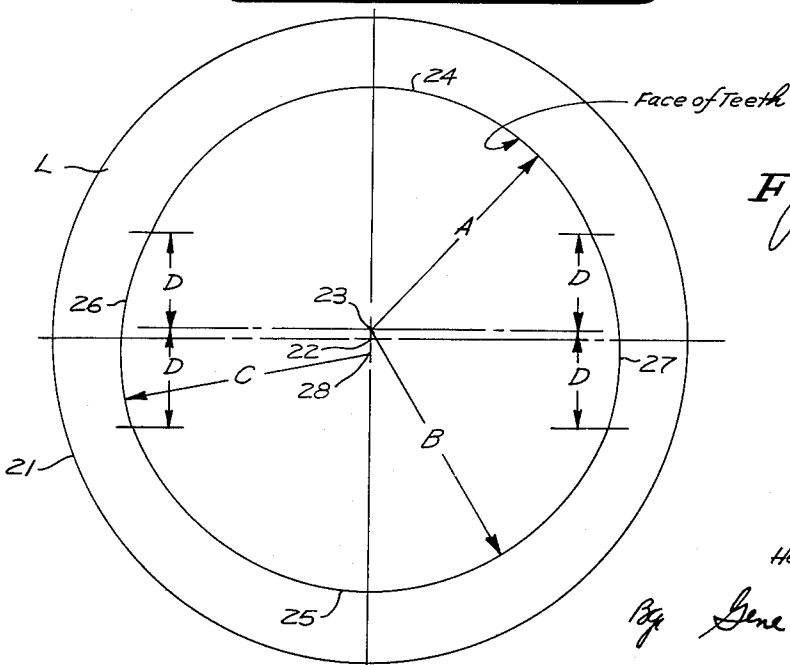
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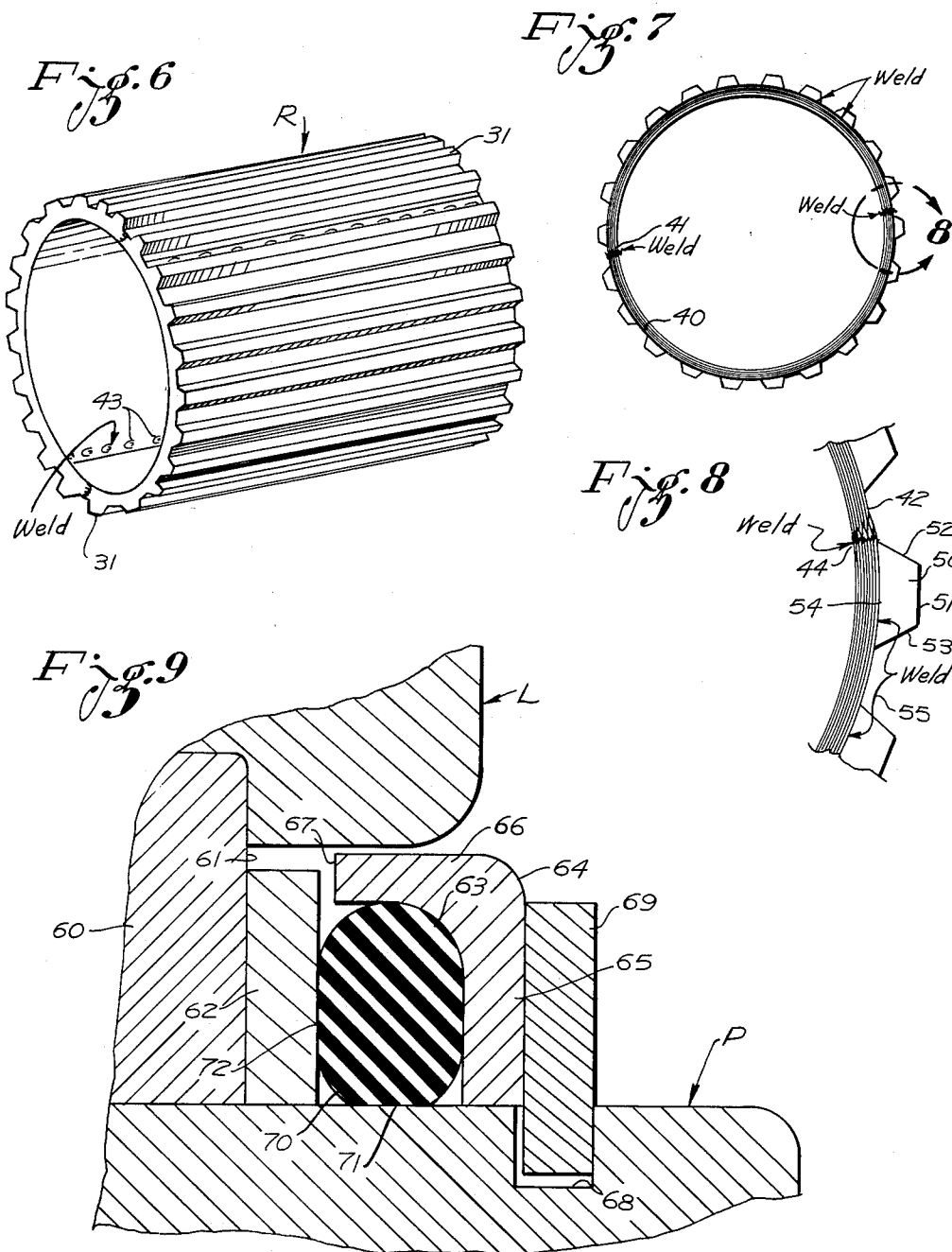
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3 Sheets-Sheet 3



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The present invention relates to a pump of the rotary type.

A difficult problem in pump design is to obtain a relatively simple and inexpensive pump structure which will produce a high head or output pressure. Another consideration of utmost importance is the operating efficiency of the pump from the energy standpoint.

One object of the invention, therefore, is to provide a rotary pump which is capable of producing a high head or output pressure.

Another object of the present invention is to provide a rotary pump which will make efficient use of the applied operating energy, even after the pump has started to wear.

Another object of the invention is to achieve a speed reduction inside the pump through the planetary gear principle, thus reducing the total cost, weight and space requirements for an installation.

A further object of the invention is to provide a rotary pump in which the pumping action is produced through the expansion and contraction of a hollow, flexible, fluid-holding body, and by the isolated quantities of fluid carried between these members to the discharge port.

Still another object of the invention is to provide a rotary pump utilizing an eccentric planetary arrangement, in which the planetary members are hollow and flexible and operate to successively expand and contract during their rotation so as to provide the pumping action.

An additional object of the invention is to provide an expansible hollow gear member, which partially compensates for pump wear.

Still a further, and somewhat unrelated, object of the invention is to provide a novel rotary fluid seal arrangement.

The above and other objects and advantages of the invention will be more readily apparent from the following description considered in conjunction with the accompanying drawings, in which:

FIGURE 1 is a perspective view of a presently preferred embodiment of my invention;

FIGURE 2 is an exterior side elevational view of the pump of FIGURE 1;

FIGURE 3 is a transverse cross-sectional view of the invention taken on the line 3-3 of FIGURE 2;

FIGURE 4 is a longitudinal cross-sectional view of the invention taken on the line 4-4 of FIGURE 1;

FIGURE 5 is a schematic diagram illustrating the eccentric arrangement of the rotor housing;

FIGURE 6 is a perspective view of one of the flexible planetary bodies;

FIGURE 7 is an end view of the flexible member of FIGURE 6;

FIGURE 8 is an enlarged fragmentary view of the flexible member taken within the circle 8 of FIGURE 7; and

FIGURE 9 is an enlarged fragmentary cross-sectional view taken within circle 9 of FIGURE 4, illustrating the rotary seal arrangement.

Referring now to the drawings, the invention generally includes a base K from which a housing L is supported, the exterior configuration of the housing L being substantially cylindrical. Inlet and outlet ports M and N project from the housing L, as well as a drive shaft P. Inside the housing the drive shaft P carries a rotor Q.

The configuration of the rotor Q is cylindrical, but the

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interior surface of housing L is only approximately cylindrical, being intentionally provided with an eccentric configuration as will be more particularly described in connection with FIGURE 5. The inlet and outlet pipes M and N communicate with the interior of housing L through respective openings *m* and *n*, which communicate directly with that portion of the interior of the housing that surrounds the rotor Q. Three flexible planetary members R are disposed within the housing L, in circumferentially spaced positions around the rotor Q. Each planetary member R has a normally cylindrical configuration, but is compressed radially of rotor Q so as to assume an approximately elliptical shape.

The end structures of the housing L which, include both means for rotatably supporting the shaft P and also means for sealing against leakage along the shaft, are respectively designated as S and T.

Although direction of rotation is optional, FIGURE 3 shows the rotor Q rotating counterclockwise, indicated by an arrow 20. Each of the planetary members R has a hollow interior, and its running height is increased at it passes the inlet opening *m*, drawing fluid through the inlet opening *m* from the inlet pipe M. The planetary member then revolves around the lower side of rotor Q, and as it approaches the outlet opening *n* its running height decreases, or is flattened, causing it to discharge fluid through the outlet opening *n* and hence to the outlet pipe N. The configuration of the interior surface of housing L is such that after each planetary member passes upward beyond the outlet opening *n*, its running height remains constant while it revolves over the rotor Q and descends on the other side and starts to overlap the inlet opening *m*. Also, after passing below the inlet opening *m* its running height remains constant while it revolves across the underside of rotor Q and starts to overlap the outlet opening *n*. In other words, each planetary member R experiences a change in its running height only during the time when it is at least partially overlapping one of the openings *m* and *n*.

Reference is now made to FIGURE 5 in order to more completely describe the interior configuration of housing L and the positioning of rotor Q relative thereto. In FIGURE 5 the exterior circumference of housing L is identified as 21, and its axis is identified as 22. The center line of shaft P and rotor Q is identified as 23. The inner wall of housing L includes an upper fixed radius portion 24, a lower fixed radius portion 25, a left-hand tapered portion 26, and a right-hand tapered portion 27. Upper wall portion 24 has a fixed radius A about the center point 23. Lower wall portion 25 has a fixed radius B about the center point 23, the radius B being larger than radius A.

Upper wall portion 24 extends from a point located a vertical distance D above the center point 23, around the top of housing L to another point which is the same distance D above center point 23. Lower wall portion 25 extends from a point a distance D below the center 23, at the left of housing L, to a point the same distance below center 23 at the right of housing L. Tapered portions 26 and 27 join the corresponding ends of the fixed radius portions 24 and 25 together. Each of the tapered portions 26 and 27 has a radius value C, which is greater than radius A but less than radius B. The center point 28 for radius C of the tapers 26 and 27 is located somewhat below the center point 23 of the rotor Q.

In the illustrated embodiment of the invention the various dimensions are as follows: radius A, 1.885 inches; radius B, 2.035 inches; radius C, 1.969 inches; distance D, 0.750 inch. The vertical offset between center points 23 and 28 is about 0.193 inch.

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In the illustrated embodiment of the invention the rotor Q is provided with circumferentially spaced teeth 30, the planetary members R with teeth 31, and the inner circumferential surface of housing L with teeth 32. The housing surface portions 24-27 as illustrated in FIGURE 5 establish the locations of the faces of teeth 32. In the illustrated embodiment of the invention the basic circular pitch of the housing teeth 32 is about 0.285 inch. It is interesting to note that for design reasons the circular pitch of the teeth in the upper or small radius portion 24 of the housing inner surface is about one-half percent greater than the basic value. Also, that the circular pitch of the flexible member matches perfectly with both the rotor and housing in the stressed position; but not in the unstressed state.

It will be seen that the end radii of each of the flexible planetary members R change while moving past either of the tapered radius portions 26 or 27 of the housing L. As seen in FIGURE 3 the planetary members R are compressed to an approximately elliptical configuration, so that while the pump is operating the radius value of each planetary member R measured with reference to the center axis 23 of rotor Q is somewhere between one-third and one-half the radius value that the planetary member R would have in an unstressed cylindrical form as illustrated in FIGURE 6. Not only do the end radii of the planetary members experience a change as they pass the openings m and n, located respectively adjacent to the tapered radius portions 26 and 27 of housing L, but they also experience a slight change in forward speed. That is, in traveling above the rotor Q, under the small radius portion 24 of housing L, the planetary member is moving around a smaller circular path, and therefore travels at higher lineal velocity. In traveling underneath rotor Q past the large radius portion 25 of the housing the planetary members travel at a slightly slower velocity. In traveling past the tapered radius portions adjacent the inlet and outlet openings each planetary member therefore experiences some change in forward or rotational velocity as well as in its mean radius and hence in its fluid carrying capacity.

The three planetary members R are identical, and reference is now made to FIGURES 6 and 8, inclusive, for the purpose of describing the structure thereof. A thin rectangular spring steel sheet member 40 is rolled into a multi-layer cylinder. Adjacent the inner end 41 of the sheet member 40 a longitudinally spaced series of welds 43 are made, which not only bond the inner end 41 to the immediately adjacent layer of member 40, but also bond all of the layers of member 40 together. Welds 43 are preferably achieved by electric spot welding technique. Adjacent the outer end 42 of member 40 a similar series of welds 44 are formed. Again, welds 44 pass through all of the layers of member 40, and are preferably formed by electric spot welding.

A plurality of elongate rigid members 50 provide the teeth for flexible planetary members R. Each member 50 is formed of metal and has a length approximately equal to the width of steel sheet member 40 (and hence equal to the length of the cylinder formed by sheet member 40). Each member 50 has a transverse cross-sectional configuration which is approximately trapezoidal, including a flat outer face 51, and sloped side faces 52 and 53. Undersurface 54 is welded at 55 to the outer surface of the multi-layer cylinder formed by sheet member 40.

While in connection with the present invention it is necessary for the teeth members 50 to be on the outer surface of the multi-layer cylinder formed by sheet member 40, nevertheless in other applications it would be possible to utilize the same flexible gear construction but with the teeth members 50 mounted on the inner circumferential surface of the cylinder.

It is preferred to coat the entire flexible member with Teflon. This results in a better operation of the system.

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Reference is now made to FIGURE 9 in order to describe the structure and operation of the rotary seal arrangement T. A cylindrical insert of sleeve 60 is carried in the associated end of housing L, and shaft P rotates within a cylindrical bearing surface formed by the bearing member 60. The interior of housing L lies to the left of bearing member 60, as shown in FIGURE 9, and hence during normal operation of the pump a supply of pressurized fluid exists on the left hand side of the bearing member 60. On its right hand side bearing member 60 has a flat outer surface 61 which extends circumferentially about the shaft P and is aligned perpendicular thereto. A thrust washer 62 is loosely fitted on shaft P and circumferentially engages the flat outer surface 61 of the bearing member 60 in rotatable and fluid-sealing relationship therewith. An elastomeric O-ring 63 encircles shaft P in tight circumferential engagement therewith, and also in circumferential engagement with the other side of washer 62, which is not in contact with surface 61 of the bearing member 60.

A retaining cup 64 is carried by shaft P on the other side of O-ring 63, or to the right as seen in FIGURE 9. Retaining cup 64 has a base portion 65 which extends radially outwardly from shaft P, perpendicular to the longitudinal axis thereof, with the inner circumferential surface of base portion 65 tightly engaging the circumferential surface of shaft P. Retaining cup 64 also includes an outer flange portion 66 which, together with the base portion 65, forms a substantially L-shaped cross-section for the retaining cup 64, taken radially with respect to the shaft P. Flange portion 66 is aligned substantially parallel to the longitudinal axis of shaft P, and encloses the outer circumferential extremity of O-ring 63. The extreme circumferential edge 67 of flange portion 66 extends to the left of the center of O-ring 63, as seen in FIGURE 9, and is disposed adjacent to but not in engagement with the thrust washer 62. A circumferential groove 68 on the shaft P carries a retaining ring 69, which engages the retaining cup 64 on the outer side thereof, or the right-hand side as seen in FIGURE 9.

Since sealing arrangement S at the other end of housing L is similar to sealing arrangement T, the cooperative functioning of the two sealing arrangements is such that the shaft P maintains a substantially fixed longitudinal position relative to housing L, and therefore, relative to bearing member 60 as well. It will be seen in FIGURE 9 that there is a definite end loading of the seal, that is, the "sandwich" consisting of O-ring 63, thrust washer 62, and retaining cup 64 is compressed longitudinally between the bearing surface 61 of bearing member 60 and the retaining ring 69.

The operation of the rotary seal is as follows. Pressurized fluid flowing from the left-hand side of bearing member 60 passes between bearing member 60 and shaft P, and then flows beneath the inner circumferential edge of thrust washer 62, which has a loose fit upon the shaft P. The pressurized fluid continues to flow longitudinally of shaft P and exerts pressure on the nearest circumferential surface portion 70 of the O-ring 63. O-ring 63 is therefore caused to deform in a direction toward the juncture of base portion 65 and flange portion 66 of the retaining cup 64, so that the circumferential surface portion 71 of the O-ring presses more tightly in a radially inward direction upon the circumferential surface of shaft P, and the circumferential surface portion 72 of the O-ring in engagement with thrust washer 62 applies a greater force upon the thrust washer in a direction parallel to the longitudinal axis of the shaft P. This also causes a greater pressure to be exerted by the thrust washer 62 upon the bearing surface 61, thus minimizing the possibility of fluid escaping therebetween. The spacing of extremity 67 of the retaining cup from thrust washer 62 is necessary in order to permit the O-ring 63 to deform, but at the same time the spacing must be rather small in order to preclude the possibility that the

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O-ring might flow out between the thrust washer and the retaining cup.

The invention has been described in considerable detail in order to comply with the patent laws by providing a full public disclosure of at least one of its forms. However, such detailed description is not intended in any way to limit the broad features of principles of the invention, or the scope of patent monopoly to be granted.

I claim:

1. A pump comprising a housing have a somewhat cylindrical interior chamber; a shaft journaled in both ends of said housing in axial alignment therewith and extending through said interior chamber; a cylindrical rotor carried concentrically on said shaft and adapted to be driven thereby, said rotor having longitudinally extending teeth uniformly spaced about its entire circumference; the length of said interior chamber being only slightly greater than the length of said rotor, the circumferential wall of said chamber having one circumferential portion which is concentric to said shaft and spaced by a first radius distance from the axis of said rotor, a second and oppositely disposed circumferential portion which is also concentric to said shaft but at a second and larger radius distance from the axis of said rotor, and first and second tapered-radius portions which are oppositely disposed to each other and which interconnect said fixed-radius portions; at least two flexible members disposed in circumferentially spaced positions within said chamber, each of said flexible members being normally of a substantially cylindrical configuration and of substantially the same length as said rotor, but being depressed between the periphery of said rotor and said chamber wall into an approximately elliptical form, each of said flexible members having teeth on its exterior surface which engage said rotor teeth; the circumferential wall of said chamber having teeth formed thereon which are engaged by the teeth of said flexible members; a first opening in an end of said housing communicating with said first tapered-radius portion of said chamber; and a second opening in an end of said housing communicating with said second tapered-radius portion of said chamber.

2. A pump comprising:

- (a) a housing and a rotor disposed eccentrically therein, said housing and rotor having confronting walls defining therebetween an annular chamber;
- (b) an inlet and an outlet for said chamber;
- (c) each of said confronting walls having alternate ribs and grooves to form a ring of interlocking elements;
- (d) and a plurality of flexible bands having, externally, alternate ribs and grooves forming a ring of interlocking means;
- (e) each of said flexible bands being interposed between said confronting walls to dispose a group of said interlocking means in intermeshing engagement with a group of the intermeshing elements of said rotor wall and said housing wall whereby said flex-

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ible bands are interlocked against sliding movement with respect to said housing wall and said rotor wall; (f) said flexible bands being adapted, on rotation of said rotor, to roll between said confronting walls and cause succeeding groups of said elements and means to interlock, whereby said flexible bands form fluid pressure resisting partitions movable between said inlet and outlet.

3. A pump, comprising:

- (a) a housing defining an approximately cylindrical chamber;
- (b) a ring of teeth formed on the peripheral wall of said chamber;
- (c) a rotor disposed eccentrically within said chamber and defining with said housing an annular space of varying radial dimension;
- (d) a ring of teeth on the peripheral wall of said rotor and confronting the teeth in the peripheral wall of said chamber;
- (e) a plurality of flexible annular containers each having a normal diameter greater than the radial dimension of said annular space;
- (f) a ring of teeth on the peripheral wall of each container externally thereof;
- (g) said containers being distortable to fit in said annular space with groups of its teeth intermeshing with groups of said rotor teeth and housing teeth thereby to provide positive drive connections with said containers on rotation of said rotor and effect circular movement of said containers in said annular space;
- (h) said housing having an inlet opening, and an outlet opening communicating axially with said annular space, the radial dimension of said annular space being of increasing value in the direction of rotation of said rotor in the vicinity of said inlet opening and of decreasing value in the vicinity of said outlet opening, whereby said containers, on passing said inlet opening draws fluid from said inlet, and on passing said outlet opening expels fluid therefrom.

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